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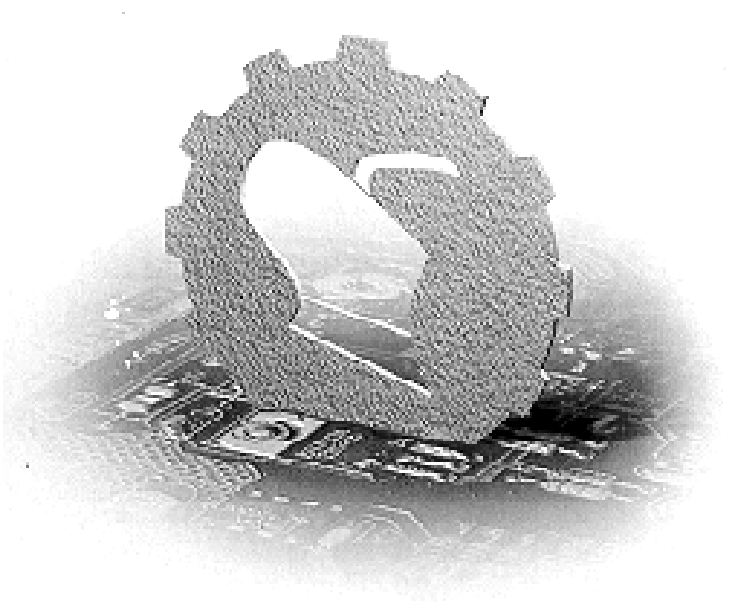

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DIREKTNE METODE ZA ODREĐIVANJE ČVRSTOĆE LJUSKE JAJA

Ranko Koprivica[1], Biljana Veljković[*1], Simeon Rakonjac[1], Miloš Božić[2], Vojislav Vujičić[2], Dušan Radivojević[3], Dušan Marković[1], Goran Topisirović[3]

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Sažetak: U toku manipulacije kokošijih jaja od farme do potrošača usled delovanja spoljašnjih sila i slabe mehaničke čvrstoće ljuske dolazi do lomljenja jaja. Cilj proizvođača jaja je da se u toku proizvodnje i plasmana smanje gubici pri lomljenju jaja i time povećaju prihodi. Svako jaje može da bude oštećeno delovanjem spoljašnjih sila čije su vrednosti veće od maksimalne čvrstoće ljuske jaja. Za utvrđivanje kvaliteta jaja (čvrstoće ljuske) koriste se direktne i indirektne metode. Direktnim metodama čvrstoća ljuski se može odrediti na osnovu merenja sile probijanja, sile udara, sile kvazistatičke kompresije i sile slobodnog pada na poznatu podlogu. U našim istražvanjima za realizaciju ogleda konstruisan je uređaj i primenjena direktna metoda za određivanje čvrstoće jaja na osnovu izmerene sile probijanja ljuske. Uređaj za merenje čvrstoće jaja direktnom metodom probijanja jaja konstruisan je i primenjen na Fakultetu tehničkih nauka i Agronomskom fakultetu u Čačku.

U istraživanjima su korišćena kokošija jaja klase "M" proizvedena na farmi "Grbović" u okolini Čačka. Kokoši nosilje su hibrid Isa Brown starosti 41 nedelju.

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U toku istraživanja su određene fizičke osobine kokošijih jaja: dužina, širina, indeks oblika i masa jaja, kao i masa ljuske, udeo ljuske u ukupnoj masi jaja, debljina i sila probijanja ljuske.

Rezultati istraživanja pokazuju da je dužina jaja 57,00 mm, širina 44,59 mm sa koeficijentom varijacije 2,7- 1,4%. Debljina ljuske jaja je prosečno 0,39 mm, u opsegu 0,377-0,416 mm. Udeo ljuske je 10,54 % od prosečne mase jaja (62,43 g).

Kvalitet ispitivanih jaja je bio prilično ujednačen jer se sila probijanja ljuske jaja kretala od 20,35-23,97 N.

Rezultati istraživanja su značajni za konstrukciju kaveza, projektovanje opreme za prikupljanje jaja, dizajniranje ambalaže za jaja, a primenljivi i u selekciji za dobijanje novih genotipova kokoši nosilja sa povećnom otpornošću na lomljenje ljuske jaja.

Ključne reči: *Čvrstoća jaja, metode za utvrđivanje kvaliteta - čvrstoća jaja, sila probijanje ljuske, fizičke osobine jaja.*

UVOD

U procesu proizvodnje i prometa jaja oštećenja mogu da budu u vidu naprslina na ljusci i lom ljuske. Na farmama kokoši nosilja naprsline na jajima obično nastaju u kavezu udarom jaja jedno od drugo, ili od dela opreme za sakupljanje, dok lom jaja može nastati i od strane samih kokoši ili u toku pakovanja i transporta jaja. Oštećenja na ljuski jaja mogu da se kreću od 8 do 10% od ukupno snesenih jaja, što predstavlja veliki ekonomski gubitak na farmi [7]. Zbog toga je cilj proizvođača jaja da se smanje gubici nastali oštećenjem ljuski i da lom jaja u toku proizvodnje i plasmana bude što manji. Na kvalitet ljuske jaja značajno utiče sistem gajenja kokoši nosilja, genotip, starost koka, vreme nošenja jaja i mineralna ishrana sa dovoljno kalcijuma. Glavni razlog za oštećenje jaja je slaba čvrstoća ljuske i mala otpornost da se odupre silama koje deluju na nju prilikom manipulacije. Svako jaje može da bude oštećeno pod uticajem spoljašnjih sila ako one dovoljno jako deluju na njihovu ljusku i ako se pređe granica maksimalne čvrstoće.

Da bi poboljšali čvrstoću ljuske jaja genetičari ispituju koja karakteristika jaja određuje čvrstoću ljuske na pucanje, kao i strukturu same ljuske jaja. Za unapređenje proizvodnje istraživačima su potrebne pouzdane metode sa kojima se vrlo brzo i lako može meriti veliki broj uzoraka i ispitivati kvalitet jaja. Diskutabilno je da li se sa postojećim metodama, koje se koriste mogu tačno odrediti jačine sile čvrstoće na razbijanje ljuske jaja.

Postoji decenijsko interesovanje istraživača za utvrđivanje čvrstoće ljuske jaja, u tu svrhu je korišćen različit pribor, a postoje i elektronski uređaji pomoću kojih se utvrđuju mehaničke osobine ljuske jaja. Monogi autori su konstruisali razne uređaje i primenili metode za utvrđivanje čvrstoće jaja [17], [18], [6], [9], [5], [10], [7], [11].

Ispitujući kvalitet jaja primenom tri metode autori [17] su došli do zaključka: Čvrstoća jaja utvrđena kvazistatičkom kompresijom kretala se od 2,7 do 4,9 kg (sa kojeficijentom varijacije od 14 do 25%), sila probijanja 1,5 do 1,6 kg (sa kojeficijentom varijacije od 14 do 15%) i srednja deformacija ljuske od 0,037 do 0,076 mm (sa kojeficijentom varijacije od 10 do 29%).

Pri uporednom ispitivanju čvrstoće ljuske jaja metodom kvazistatične kompresije i metodom probijanja, prosečna vrednost sile razbijanja jaja izmerene testom kompresije je 3303,9 g, a sa testom probijanja 1491,5 g [6].

Radi utvrđivanja čvrstoće ljuske jaja autori [17] su među prvima primenili metodu probijanja. Prosečna vrednost sile probijanja je 1,6 kg, sa koeficijentom varijacije od 14,6 do 15,2%. Isti autori u sledećim istraživanjima [18] navode da je prosečna sila probijanja ljuske jaja kokoši 1739 g, sa variranjem od 1714 g do 1764 g.

Kod organski gajenih kokoški sila probijanja jaja je 20,57 N, kod kokoški gajenih u objektu sa ispustom 26,51 N, a kod kontrolne grupe gajenih u kavezima 30,17 N, pri debljini ljuske 0,308 mm 0,320 mm i 0,338 mm redom [9].

Metodom probijanja jačine ljuske priplodnih jaja može da se utvrdi na više mesta pre stavljanja jaja u inkubator, bez uticaja na % izleganja jaja. Sila probijanja ljuske jaja rase Leghorn kretala od 13,8-14,3 N, a kod Brojlera 16,1-16,9 N [5].

Kod kokoši Hisex Brown prosečna sila razbijanja jaja izmerena kvazi statičkom metodom kompresije na ekvatoru je 36,43 N, a na polovima 34,92 N, a varirala je od 10,03 N do 58,96 N [10].

Autori [11] su kvazi statičkom metodom utvrdili vrednosti sile loma (čvrstoće) ljuske hibrda Hises (4,31 kg i 4,71 kg) i Isa Brown (4,0 kg i 3,98 kg) kod jaja sakupljenih u periodu 5-7 h i 9-11 h, između kojih nije bilo statistički značajnih razlika.

Čvrstoća jaja kokoši je u korelaciji sa debljinom ljuske 0,48, masom ljuske 0,35 i učešćem ljuske u ukupnoj masi jaja [7].

Cilj rada je u doprinosu rešavanja problema merenja čvrstoće jaja, primenom direktne metode za utvrđivanje minimalne sile probijanja ljuske, odnosno, maksimalne čvrstoće pucanja jaja pomoću konstruisanog uređaja za ispitivanje.

Metode za ispitivanje čvrstoće ljuske jaja

Sve metode za utvrđivanje čvrstoće ljuske jaja uglavnom su podeljene u dve osnovne grupe i to: direktne i indirektne metode. Indirektnim metodama čvrstoća jaja se može utvrditi: metodom određivanja specifične težine jaja, metodom nerazorne deformacije ljuske i na osnovu fizičkih osobina jaja (debljinom ljuske). Prednost ovih metoda je u tome što se u toku eksperimenta jaja ne razbijaju, ali dobijene vrednosti čvrstoće jaja nisu dovoljno pouzdane.

Direktnim metodama čvrstoća ljuske se može utvrditi na osnovu merenja sile probijanja, sile udara, sile kvazistatičke kompresije i sile slobodnog pada na poznatu podlogu.

Autori su u ispitivanjima merenja čvrstoće ljuske jaja najviše koristili direktan metod kvazistatičke kompresije. Jaje čija se čvrstoća ispituje stavlja se između dve paralelne ploče. Na fiksnoj ploči se postavlja jaje, a potisnom pločom se vrši pritisak na ljusku jaja. Sile deluju na sredinu (ekvator) jaja, vršeći postepeno opterećenje ljuske sve dok ne dođe do potpunog razbijanja. Porastom veličine sile dolazi do lomljenja ljuske jaja, pri čemu se registruje minimalna vrednost sile razbijanja, odnosno maksimalna čvrstoća ljuske jaja [6], [5], [11], [10], [17].

Određivanje sile probijanja vrši se opisanim uređajem samo što se umesto pritisne ploče postavlja sonda određenog prečnika (2, 3, 4, 5 mm) kojom se deluje na ekvator ili pol jaja sve dok se ljuska ne probije. U tom momentu prestaje pritisak sonde i registruje se minimalna sila probijanja ljuske i najveća otpornost tj. čvrstoća jaja.

U početku je za ispitivanje čvrstoće jaja korišćena aparatura za ispitivanje mašinskih osobina materijala koja se koriste u metalnoj industriji određivanjem maksimalnih sila na pritisak, smicanje i probijanje.

Mašina kidalica za utvrđivanje mehaničkih osobina čelika bila je dosta skupa, a zbog većih dimenzija nije mogla da se prenosi, već je bila stacionirana u laboratoriji.

Autori [17] su konstruisali po dimenzijama manji prenosivi uređaj namenjen samo za utvrđivanje čvrstoće ljuske jaja**.** Uređajem je moguće testirati i do 180 jaja/sat jednom od metoda za merenje čvrstoće ljuske jaja (kvazistatičke kompresije, metodom probijanja ili nerazorne deformacije). Navedenim metodama čvrstoća jaja se može izmeriti na jednom te istom jajetu. Prvo se izmeri deformacija jaja, zatim sila probijanja i na kraju sila lomljenja jaja, pri čemu se precizno snimaju i registruju izmereni parametri.

Treća direktna metoda za merenje čvrstoće ljuske je utvrđivanje otpornosti jaja na udar. Sa različite visine ispušta se nekoliko puta čelična kuglica, određene mase na površinu ljuske jajeta, sve dok se ne razbije. Visina i broj udaraca potrebnih za razbijanje jaja koristi se kao indeks čvrstoće jaja [15], [2].

U primeni je i test slobodnog pada [16], gde su jaja ispuštana sa određene visine od 50-1500 mm na čvrstu podlogu od različitog materijala. Prilikom pada pomoću kamere merena je brzina pada, jačina udara o podlogu i kinetička energija pada.

Najčešće korišćene indirektne metode za ocenu jačine ljuske jaja su metoda nerazorne deformacije i test specifične težine (gravitacije). Navedene metode su prihvaćene i koriste se na farmama kokoši nosilja, zbog toga što su jeftine, izvode se vrlo brzo u više ponavljanja, i što se jaja u toku utvrđivanja čvrstoće ne razbijaju.

Metod nerazorne deformacije se sastoji u tome što se jaje u horizontalnom položaju-na ekvatoru izlaže određenom silom do granice elastičnosti ljuske jaja. Sve promene koje se dešavaju dejstvom određene sile na ljusku jaja registruje senzor deformacije. Prestankom delovanja sile na jaje pročitaju se izmerene vrednosti elastične deformacije izražene u μm. Pomoću instrumenta za merenje elastične deformacije može se ispitati od 900 do 1000 jaja na sat [19].

Merenje čvrstoće jaja metodom određivanja specifične težine jaja izvodi se tako što se jaja potapaju u više (3-5) slanih rastvora različite specifične težine. Jaje ima istu specifičnu težinu kao i rastvor u kome je prvo počelo da pluta na površini.

Najjednostavniji indirektan način merenja kvaliteta ljuske je na osnovu izmerenih fizičkih osobina jaja. Utvrđeno je da postoji korelacija između debljine ljuske i čvrstoće ljuske [18], [16], [7].

Naprsline ljuske jaja koja idu u promet mogu se utvrditi i drugim indirektnim metodma na primer pomoću snopa svetlosti (prosvetljavanjem) ili elektronskim detektorom za otkrivanje naprslina i loma jaja.

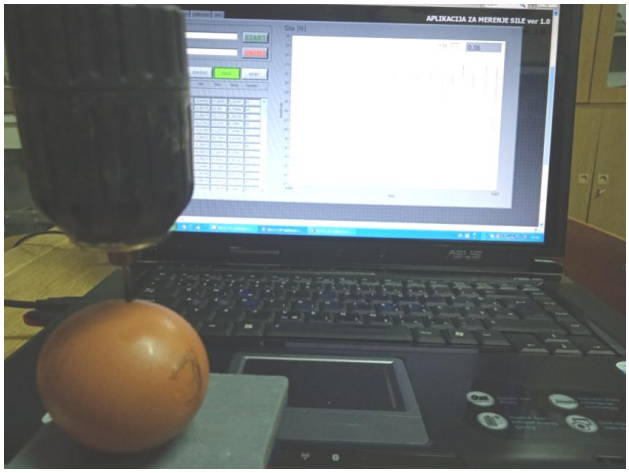
MATERIJAL I METOD RADA

U ispitivanju su korišćena jaja uzeta slučajnim uzorkom iz ambalaže i predstavljaju prosečan uzorak partije koja je upakovana za promet. Jaja "M" klase su proizvedena na farmi "Grbović" u okolini Čačka od hibridnih kokoši Isa Brown starosti 41 nedelja. Ukupno je za analizu uzeto po 10 komada jaja, koja su prethodno obeležena, a zatim su izvršena merenja: dužine, širine i mase jaja, kao i masa, debljina i čvrstoće ljuske.

Dužina, širina jaja i debljina suve ljuske merena su pomoću elektronskog pomičnog merila sa displejom Pro-max Sylvyc system sa tačnošću 0,01 mm. Masa jaja i ljuske sa opnom merena su na analitičkoj vagi Kern EMS 3000-2 sa tačnošću 0,01 g. Za realizaciju postavljenog cilja konstruisan je i primenjen uređaj za ispitivanje čvrstoće jaja direktnom metodom probijanja ljuske.

Postupak određivanja čvrstoće ljuske vrši se na taj način što se jaje postavi na oslonu ploču u horizontalnom položaju (po dužini) upravno na pravac dejstva sile (Sl.1). Sondom prečnika 2 mm vrši se probijanje ljuske na ekvatorijalnom delu jaja. U momentu probijanja ljuske registruje se minimalna sila probijanje izražena u N i predstavlja maksimalnu čvrstoću jaja. Podatke o izmerenim vrednostima maksimalne sile probijanja jaja, uređaj registruje i prikazuje u Exel tabeli i grafički (Slika 1). U tabelarnom izveštaju dobijaju se podaci o maksimalnim silama probijanja ljuske, kao i osnovni statistički podaci (minimum, maksimum, srednja vrednost, kojeficijent varijacije, standardna devijacija).

Uređaj za merenje čvrstoće jaja primenom direktne metode probijanja ljuske konstruisan je u Laboratoriji za mehatroniku Fakulteta tehničkih nauka u Čačku, a primenjen na Agronmskom fakultetu u Čačku. Pored merenja čvrstoće ljuske jaja uređajem se može meriti i sila otvaranja-pucanja plodova (uljane repice, soje, pasulja, žutog zvezdana i dr.), kao i sila kršenja i otkidanja plodova od grančica i peteljki. Detaljan opis merno akvizicionog sistema za merenje mehaničkih osobina prikazan je u radu [3].



Slika 1. Uređaj za merenje sile probijanja ljuske jaja
Figure 1. Device for measuring puncture force of egg shell

REZULTATI ISTRAŽIVANJA I DISKUSIJA

Glavni pokazatelj kvaliteta jaja ogleda se kroz vrednosti njegovih spoljašnjih osbina. Od spoljšnjih osobina jaja u istraživanjima su ispitivane dužina, širina, indeks oblika i masa jaja. Prosečna dužina jaja iznosila je 57,00 mm sa kojeficijentom varijacije 2,7%, a širina jaja 44,59 mm sa kojeficijentom varijacije 1,4 % (Tab.1).

Indeks oblika je jedna od najvažnijih osobina spoljašnjeg kvaliteta jaja, jer se na osonovu njega vrši klasiranje jaja i dizajniranje ambalaže za pakovanje jaja [8]. Po indeksu oblika jaja su podeljena u šiljasta (izdužena) kod kojih je indeks oblika manji od 72, zatim okrugla sa indeksom oblika većim od 76 i standardnog obilika sa indeksom od 72 do 76.

Najbolji indeks oblika kokošijih jaja je 74, jer je najmanja mogućnost da dođe do pucanja ljuske u toku sakupljanja, klasiranja, pakovanja i transporta jaja do potrošača.

Na osnovu rezultata prikazanih u Tabeli 1. indeks oblika iznosi 78,26%, što navodi na zaključak da su jaja okruglastog oblika. Dobijeni rezultati istraživanja za indeks oblika su u saglasnosti sa rezultatima koje navode [8], [1], [14], [4], [10], [13].

Tabela 1. Fizičke osobine jaja
Table 1. Physical properties of eggs

Osobine Properties	Prosečno Average	ST dev. ST dev.	CV (%) CV (%)	min.	max.
Dužina jaja (mm) Length of eggs (mm)	57,00	1,514	2,7	55,12	59,74
Širina jaja (mm) Width of eggs (mm)	44,59	0,644	1,4	43,7	45,79
Index oblika (širina/dužina jaja) u % Index of shape (width/length eggs) %	78,26	2,343	3,0	74,24	81,2
Masa jaja (g) Mass of eggs (g)	62,43	2,008	3,2	60,42	66,83

Osnovne osobine prikazane u radu koje su bitne za određivanje kvaliteta ljuske jaja su: masa ljuske, učešće ljuske u ukupnoj masi jaja, debljina i čvrstoća ljuski.

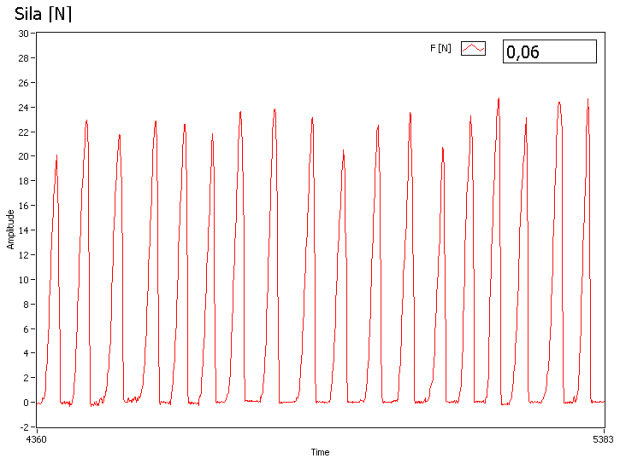
Rezultati ispitivanja navedenih osobina ljuske jaja prikazani su u Tabeli 2. Prosečna masa jaja je 62,43 g sa varijacijom od 3,2%, a masa ljuske 6,57 g uz kojeficijent varijacije od 4,7 %.

Vrednost prosečne debljina osušene ljuske sa opnom je 0,39 mm, varirala je od 0,373 do 0,416 mm.

Udeo ljuske u ukupnoj masi jaja prikazan u radu (10,54%) je manji od rezultata [12], [13].

Tabela 2. Fizičke osobine i sila probijanja ljuske jaja
Table 2. Physical properties and puncture force of eggs shell

Osobine ljuske Properties of shape	Prosečno Average	ST dev. ST dev.	CV (%) Cv (%)	min.	max.
Masa ljuske (g) Mass of shape (g)	6,57	0,306	4,7	6,06	7,09
Udeo ljuske u jaju (%) Share of shape/eggs (%)	10,54	0,516	4,9	9,8	11,34
Debljina ljuske sa opnom (mm) Shell with membrane (mm)	0,39	0,014	3,5	0,373	0,416
Sila probijanja ljuske jaja (N) The puncture force of eggs shell (N)	22,04	1,229	5,6	20,35	23,97



Grafik 1. Grafički izveštaj izmerene sile probijanja ljuski jaja na uređaju
Chart 1. Graphic report of the measured puncture force of egg shells on the device

Čvrstoća ljuske je jedan od najvažnijih pokazatelja kvaliteta jaja. Čvrstoća ljuske jaja predstavlja sposobnost ljuske da se odupre dejstvu spoljašnih sila koje teže da ga polome, razbiju ili mu promene oblik.

Na jačinu ljuske jaja utiču mnogi faktori: genotip, starost kokoši, način gajenja, ishrana, masa, zapremina, površina, ideks oblika jaja, mikrostruktura, debljina i udeo ljuske jaja itd. [10], [13].

Vrednosti sile probijanja ljuske kretale su se od 20,35 do 23,97 N što ukazuje na činjenicu da su ispitivana jaja bila prilično ujednačena po kvalitetu, čvrstoći (Grafik 1.) Prosečna sila probijanja ljuske jaja je 22,04 N sa malim kojeficijentom varijacije od 5,6%, što je još jedan od dokaza ujednačenosti kvaliteta jaja, odnosno čvrstoće ljuske. Prikazane vrednosti sile probijanja su manje od rezultata koje navodi [9], a veće od vrednosti koje navode [6], [17], [18], [5]. Vrednosti sile razbijanja jaja metodom kvazistatične kompresije do kojih su došli autori [10], [11] su veće od rezultata probijanja ljuski prikazanih u radu.

Neusaglašenost dobijenih rezultata za vrednosti sile probijanja prikazanih u radu sa rezultatima drugih autora su zbog gajenja različitih hibrida, uslova držanja, starosti kokoši, ishrane itd.

ZAKLJUČAK

Postoje razne metode za ocenu čvrstoće ljuske jaja koje su svrstane u dve grupe i to: direktne i indirektne. U direktne metode za utvrđivanje čvrstoće ljuske jaja spadaju metode za merenje: sile probijanja, sile kvazistatičke kompresije, sile udara i sile slobodnog pada na poznatu podlogu. Za praktičnu upotrebu na farmi može se koristiti metoda sa kojom se relativno brzo može uraditi veliki broj uzoraka. Pored toga metoda za merenje čvrstoće ljuske treba da bude jeftina, jednostavna i laka za upotrebu, ali dovoljno precizna i pouzdana.

Sve prethodno navedene činjenice poslužile su kao osnova za konstrukciju uređaja za utvrđivanje kvaliteta jaja primenom direktne metode probijanja ljuske jaja.

Primenom direktne metode probijanja ne dolazi do potpunog razbijanja jaja kao kod kvazistatične metode, već samo do probijanja jaja, pa se na jednom uzorku može utvrditi sila probijanja i razbijanja. Metodom probijanja čvrstoću jaja je moguće meriti na bilo kojem mestu, na ekvatoru i polovima što nije bio slučaj sa kvazistatičkom metodom.

Uređaj za merenje sile probijanja ljuske je lagane konstrukcije, pa se može prenositi i čvrstoća jaja meriti ne samo u laboratoiriji nego i na farmi. Rad na uređaju je vrlo jednostavan, a dobijeni rezultati sile probijanja ljuske su konkretni, precizni, pouzdani i uporedivi sa rezultatima drugih autora. Prvi rezultati istraživanja sile probijanja ljuske jaja na konstruisanom uređaju ukazuju da će se istraživanja nastaviti i da će isti naći primenu na farmama.

Dobijeni rezultati istraživanja mogu poslužiti kao osnova za konstrukciju kaveza, projektovanje opreme za prikupljanje jaja, dizajniranje ambalaže za jaja, kao i u procesu selekcije za dobijanje novih genotipova kokoši nosilja sa povećnom otpornošću na razbijanje jaja.

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DIRECT METHODS FOR DETERMINATION OF THE EGG SHELL STRENGTH

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Abstract: During the manipulation of hen eggs from the farm to the consumer due to action of external forces and weak mechanical strength of shell, the eggs break. The goal of egg producers is to reduce losses when breaking eggs during the production and placement, and thus increase revenues. Each egg can be damaged by external forces whose values are greater than maximum strength of the egg shell.

Direct and indirect methods are used to determine the quality of eggs and shell strength. By direct methods, strength of the shell can be determined on the basis of puncture force measurements, impact forces, quasi-static compression forces and free fall forces on a known surface.

In our research, a device was constructed for the realization of experiment and a direct method for determining strength of eggs was applied on the basis of measured breaking force of the shell. The device for measuring strength of eggs by the direct method of puncture eggshell was constructed and applied at the Faculty of Technical Sciences and the Faculty of Agronomy in Čačak.

Class "M" hen eggs produced on the "Grbović" farm in the vicinity of Čačak were used in the research. The laying hens are a 41-week-old Isa Brown hybrid. During the research, physical characteristics of hen eggs were determined: length, width, index of shape and weight of eggs, as well as weight of the shell, share of the shell in the total mass of eggs, thickness and puncture force of the shell.

The results of research show that the length of egg is 57.00 mm, width 44.59 mm with a coefficient of variation from 2.7 to 1.4%. The thickness of egg shell is on average 0.39 mm, in range from 0.377 to 0.416 mm. The share of shell is 10.54% of average weight of eggs (62.43 g). The quality of the tested eggs was quite uniform because the puncture force of egg shell ranged from 20.35 to 23.97 N.

The research results are important for cage construction, design of egg collection equipment, design of egg packaging, and applicable in selection for obtaining new genotypes of laying hens with increased resistance to egg breaking.

Key words: *Eggs strength, methods for determining the quality - egg strength, shell puncture force, physical properties of eggs.*

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A STUDY OF AERODYNAMIC PROPERTIES OF YAM FLOUR

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Abstract. The aerodynamic properties of five varieties of Yam namely: white yam, purple yam, three leaves yam, water yam and yellow yam were investigated under oven drying methods at 33^{o}C. The dried yams were milled to flour and were taken to laboratory to determine their aerodynamic properties with respect to pneumatic conveying of the yam flours. The yam flour varieties recorded terminal velocity range of 1.38 to 1.60 m/s. Drag coefficient of 0.47 and Reynolds number varying from 0.63 to 0.97x10^{-5} kgm^{-2}/s. The analysis of variance conducted on the effect of yam varieties on the aerodynamic properties of yam flour did not show significant difference at both 5% and 1% level of probability. The study will guide engineers in design of yam flour pneumatic conveying equipment.

Key words: *Aerodynamic properties, pneumatic conveying, Yam flour, drag coefficient.*

INTRODUCTION

Aerodynamics is a branch of dynamics that deals with the movement of air and other gaseous fluids as it relates to forces acting on bodies moving through such fluids. It is the study of movement of air and the interaction between the air and solids passing through the air [1] In the course of this research work, focus will be on pneumatic conveying.

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Pneumatic conveying is the movement of flour/powder and other granules using air as a medium.

It is a method of moving material using air as a transporting medium. Pneumatic conveying can be achieved through negative conditions (vacuum) or positive conditions (pressure) [2].

The bulk granules or material are conveyed through an enclosed system (pipeline) by collective force of pressure and air flow used to convey the materials. It has many advantages over mechanical conveyors as follows, (1) Closed system conveying reduces cross contamination (2) Ease of automation, control and routing flexibility. (3) Easy dust control (4) Cost savings in flight rate of bulk materials (5) Lower maintenance, power and labour [3].

Aerodynamic properties are essential parameters in hydraulic conveyance and handling as well as hydraulic categorization of agricultural products.

To generate simple data for the development of machines for sorting, conveying and sizing of agricultural products, some properties like physical characteristics and terminal velocity are required. The two most important aerodynamic properties of a body are its terminal velocity and drag force (drag coefficient too). Relating the terminal velocity of different threshed materials, it is likely to determine and set the highest possible air velocity in which grain materials can be separated without loss of grain or the principle can be adopted to sort grain into different size groups.

More so, agricultural materials and food products are usually conveyed using air. The interaction force between the solid particles and the moving fluids determine the forces applied to the particles. This interaction is influenced by the density, shape, and size of the particle along with the viscosity, density and velocity of the fluid [4].

Terminal velocity and drag coefficient of agricultural materials are important in designing of air/hydro conveying equipment and separation systems. Air is frequently used as a conveyer for conveying or for separating the sough table materials; therefore terminal velocity and drag coefficient are required for air conveying and pneumatic separation of products [5]. In processing of biomaterials, air is usually used as a mover for transport or for sorting out the desirable products from unwanted materials, hence the aerodynamic properties such as terminal velocity and drag coefficient are required for air conveying and pneumatic sorting of biomaterials. When the air velocity is higher than terminal velocity, it lifts the particles; and to allow greater fall of a particle, the air velocity could be adjusted to a level just below the terminal velocity. Terminal velocity is the highest velocity an object can reach as it falls through a fluid (example is air). It arises when the addition of the drag force (F_d) and the buoyancy is equal to the downward force of gravity acting on the object. Subsequently, if the net force on the object is zero, the object has no acceleration. An object is said to move at its terminal velocity in fluid dynamics if its speed is continuous as a result of the restrictive force exerted by the fluid through which it is moving [6]. When the speed of an object increases, the drag force acting on it increases, and it all depends on the substance through which it passes (example is air or water). At some speed, the drag or force of resistance may equal the gravitational pull on the object (buoyancy is considered below). At this point the object stops to accelerate and continues falling at a constant speed called the terminal velocity (it is also known as settling velocity).

An object moving downward faster than the terminal velocity will slow down till it gets to the terminal velocity.

Drag is dependent on the projected area, the object's cross-section in a horizontal plane. An object with a big projected area relative to its mass, such as a parachute, has a lower terminal velocity than one with smaller projected area [7]

Pneumatic conveying is an innovative technology that facilitates the transference of solids in an enclosed system. It enables the solids to be homogenized into a stream of gas and uses pressure and/or vacuum to move the gas stream with the entrained solids [8] The solids to gas relationship, and resultant flow rates and pressures are controlled and observed for efficient conveying of the solids from their primary source to a secondary place. The solids are alienated from the gas stream by a dust collection or filter element, which is classically a major component of this type of equipment. Pneumatic conveying is an innovative, simple solution to numerous outdated conveying difficulties.

It is a reliable substitute to mechanical conveyors that operate with moving parts such as belts, screws, rollers, vibrating plates, elevator buckets, drag chain, cables, discs, etc. [9]. These systems can work efficiently for conveying large objects, although they are limited in the ability to safely and effectively convey small and fine particles such as plastic pellets, soda ash, talc, cement, silica and alumina [10].

Pneumatic conveying is extensively used in industry to handle and move dry and free-flowing powdered and granular material because it is appropriate for diverse processes. Fine particles of less than 1 micron as well as 15mm solids, can be conveyed vertically and horizontally from distances of few meters to a few kilometers at rates of hundreds of tons per hour. Though pneumatic conveying involves a greater power usage and more expertise than mechanical conveying, it has less Initial capital investment; it requires less control and maintenance, takes up little space and pipeline are easier routed. It shields the material from the environs by enclosing it, and it is cleaner and easier to automate. The system is totally enclosed which means that harmful materials can be safely conveyed, and dust is reduced. The objective of this study is to investigate the aerodynamic properties of yam flour which will guide engineers in design of yam flour pneumatic conveying system and equipment.

MATERIALS AND METHODS

Research Materials

The research materials include five varieties of yam flours: White Yam *(Dioscorearutundata),* Purple Yam (*Dioscoreaalata),* Yellow Yam (Dioscoreacayenensis), Three leaves yam (*Dioscoreabulbifera)* and Water yam (*Dioscoreaalatalinn).*

Research apparatus

The following apparatuses/equipment was used for the experiment:

1. Drying equipment: An electric oven dryer of model LOA 1805, Munich Germany; A Solar dryer (solar energy collector) locally fabricated; it was made of metallic box having gross dimensions. The gross dimensions of the absorber plate are 1.0m long, 0.62m wide and 0.55mm thickness with a net surface area of 0.62 m^2.
2. Analytical balance (Model PA 2120; sensitivity 0.001g Ohaus Co, Pine Brook NJ, USA) used for samples weight measurement.

Experimental Procedure

Sample preparation

The yam tubers were washed, hand-peeled and sliced to range of 10 to 15mm thickness. The sliced yam tubers were generally dried to a constant weight and milled accordingly using Laboratory hammer mill. The yam flour was separately kept in moisture resistant/air tight container and was taken to the laboratory for aerodynamic properties tests.

Determination of Aerodynamic Properties of Yam Flour

Measurement of terminal velocity

The terminal velocity of the Yam flour was determined using equation (1) according to [11].

$$Vt = \sqrt{\frac{2mg}{\rho ACd}} \quad (1)$$

Where:
V_t = terminal velocity/s
m = mass of the falling object, g
g = acceleration due to gravity, m/s
Cd = drag coefficient
ρ = density of the fluid through which the object is falling, g/cm^3
A = projected area of the object, cm^2

Evaluation of Reynolds number

The Reynolds numbers of the yam flours were evaluated from the measured terminal velocity and diameter of the samples using the expression as propounded by [12] and adopted by [13].

$$N_R = \frac{VtD}{Nf} \quad (2)$$

here:
N_R = Reynolds Number (dimensionless)
V_t = terminal velocity, m/s
f = air density g/cm^3
D = diameter of flours (m)
N = air/kinematic viscosity, kgm^{-2}/s

The air density is assumed to be 1.15 kg^{-1} and kinematic viscosity 1.88 $x10^{6}$ $kgm^{-2}s$ at constant laboratory temperature and pressure.

Estimation of the effective diameter of the flour

The diameter of the yam flour was measured using the method adopted by [14] as described by [15] in which 20g of flour was poured inside a funnel of orifice diameter of 0.8cm, clamped at height of 10 cm; and the flour samples were allowed to flow freely to a flat platform to an arbitrary height and the diameter (D) of the heap of the flour was measured and recorded.

Determination of drag coefficient

The shape of the yam flour was spherical and the calculated drag coefficient for spherical biomaterials is 0.47 [11]

RESULTS AND DISCUSSION

Table 1. Aerodynamic Characteristic of Yam Flour Varieties

Yam Value	Property	Mean ± SD	Maximum Value	Minimum Value
White Yam	Terminal Velocity m/s	1.37 ± 0.12	1.52	1.22
	Reynolds Number (N_{12} x 10^{-5})	0.68 ± 1.41	1.02	0.34
	Drag Coefficient	0.47	0.47	4.7
Three Leaves Yam	Terminal Velocity m/s	0.97 ± 0.03	1.60	1.31
	Reynolds Number (N_{12} x 10^{-5})	0.93 ± 1.32	1.06	0.44
	Drag Coefficient	0.47	0.47	4.7
Purple Yam	Terminal Velocity m/s	1.38 ± 2.11	1.49	1.26
	Reynolds Number (N_{12} x 10^{-5})	0.68 ± 0.24	1.04	0.31
	Drag Coefficient	0.47	0.47	4.7
White Yam	Terminal Velocity m/s	1.28 ± 5.13	1.38	1.18
	Reynolds Number (N_{12} x 10^{-5})	0.63 ± 1.23	1.01	0.24
	Drag Coefficient	0.47	0.47	4.7
Yellow Yam	Terminal Velocity m/s	0.97 ± 0.03	1.60	1.31
	Reynolds Number (N_{12} x 10^{-5})	0.93 ± 1.32	1.06	0.44
	Drag Coefficient	0.47	0.47	4.7

Table 2. Effect of yam type on the Aerodynamic properties of yam flour

Source of variation	D.F.	Sum of Squares (SS)	Mean square (MD)	F.Cal	F.Tab	
CFM	1	64.21156			5%	1%
Yam varieties	4	2.28484	0.57121	0.073^{NS}	5.19	11.39
Error	5	-39.055	7.811			
Total	9	-39.72066				

Table 1., presents the aerodynamic behaviors of the yam flour varieties. Results revealed that three leaves yam had the highest range of terminal velocity of 1.31 to 1.60m/s, followed by white yam with terminal velocity range of 1.22 to 1.52 m/s, yellow yam (1.24 - 1.50 m/s), purple yam (1.26 - 1.49 m/s) and least was water yam with terminal velocity range of 1.18 -1.38 m/s.

The terminal velocity of the yam flours are within the range of terminal velocity obtained by [13] which indicated that pneumatic conveying of the flour is possible with minimum or no loss of the flour.

Furthermore, yellow yam recorded the highest Reynolds number varying from 0.39 x 10^{-5} to 1.09 x 10^{-5} with mean value of 0.74 x 10^{-5} kgm^{-2}/s, and standard deviation of 0.08 followed by three leaves yam with Reynolds number of 0.44 x 10^{-5} and standard deviation of 1.32. The least Reynolds number was recorded by white yam (0.34 x 10^{-5} to 1.02 x 10^{-5} kgm^{-2}/s, with mean and standard deviation of 0.68±141.

The yam varieties generally had uniform drag coefficients of 0.47 according to the assumption of [11].

Finally, The analysis of variance ANOVA conducted on the effect of yam varieties on the aerodynamic properties of yam flour (Table 2) did not show significant difference at both 5% and 1% level of probability.

CONCLUSIONS

1. Based on the findings from the research work, the following conclusions can be made: The yam flour varieties had terminal velocity range of 0.98 to 1.60 m/s with Drag coefficient of 0.47 .
   Reynolds number varying from 0.63 to 0.97x10^{-5} kgm^{-2}/s hitch is indeed an indication that pneumatic conveyance of the flours are possible.
2. Yam type has no significant effect on the aerodynamic properties of the yam flours
3. The result showed that less energy cost is required in designing a pneumatic conveying system for the studied yam floors.

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ISTRAŽIVANJE AERODINAMIČKIH OSOBINA YAM BRAŠNA

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Sažetak. Aerodinamičke osobine pet sorti Yam zrna za: Beli *(Dioscorearutundata)*, Ljubičasti (*Dioscoreaalata)*, Žuti (*Dioscoreacayenensis*), Trolisni (*Dioscoreabulbifera),* i Vodeni (*Dioscoreaalatalinn)* , istražene su sušenjem u peći na 33°C.

Osušena zrna Yam su samlevena u brašno, da bi se odredile njihove aerodinamičke osobine, zbog kasnije mogućnosti pneumatskog transporta brašna.

Ispitane sorte Yam brašna imaju krajnju brzinu od 1,38 do 1,60 m/s. Koeficijent otpora je 0,47 i Reynolds broj varira od 0,63 do 0,97 $x10^{-5}$ kgm^{-2}/s.

Analiza varijanse sprovedena na efektu uticaja Yam varijeteta na aerodinamičke osobine brašna nije pokazala značajnu razliku na nivou verovatnoće od 5% i 1%.

Studija bolje upućuje inžinjere u dizajniranje opreme za pneumatski transport Yam brašna.

Ključne reči: *Aerodinamičke osobine, pneumatski transport, Yam brašno, koeficijent otpora.*

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REAL TIME IT-MONITORING OF WASTEWATER QUALITY IN THE PREVENTION OF THE COVID-19 PANDEMIC

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Abstract: New measures are being taken in the EU member states for flexible and scalable solutions in monitoring wastewater quality. The latest scientific studies have further confirmed the presence of SARS-CoV2 virus in wastewater. This virus was also detected in stool samples of patients with COVID-19 symptoms, but also in asymptomatic cases of the disease, which confirms the possibility of faecal-oral transmission. The aim of this paper is to introduce automated real-time online monitoring in the wastewater treatment plant "Ekogramont" with the possibility of using this monitoring in the prevention of the COVID-19 pandemic. The plant is located at 1080 m above sea level and was built in the period from 1998 to 1999 for the needs of the company for bottling spring water "Vlasinska ROSA", which is now owned by the company "Coca Cola" HBC. The proposed SCADA system collects the data from the sensors located in the sewage water and delivers the obtained results to the computers in the central station. The suitability of such automated monitoring comes to the fore in extreme weather conditions which prevail in this high mountain area, when for the purposes of standard analysis, wastewater sampling is disabled. The system also contains the so-called “contamination" alarm which is activated by every parameter which exceeds the set critical limit. The standard RT-PCR protocols WHO and FDA are used to detect SARS-CoV2.

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The detection of the viral genome in sewage, prior to the exponential phase of the epidemic, is a valuable indicator of the imminent danger of an outbreak.

In this filed, modification of legal regulations in Serbia would enable the formation of a network for automated real-time monitoring of water quality control, with continuous measurement systems that would deliver the measurement results via SCADA systems to the competent institutions.

***Key words**: real-time monitoring, SCADA, wastewater, COVID-19*

INTRODUCTION

New measures are being taken in the EU member states for flexible and scalable solutions in monitoring wastewater quality. Automated real-time water quality monitoring has proven to be a very reliable solution that allows simultaneous delivery of analysis results to the institutions responsible for water quality as well as for dealing with accidents. Thus, for example, the ISA - UV/Vis Spectrometer System is already used to measure water quality on the Elbe River [1].

The latest scientific studies have further confirmed the presence of SARS-CoV2 virus in wastewater [2]. This virus was also detected in stool samples of patients with COVID-19 symptoms, but also in asymptomatic cases of the disease, which confirms the possibility of faecal-oral transmission [3]. Detection of SARS-CoV2 in a company's wastewater by rapid PCR tests would be a tool for early warning and monitoring of COVID-19 status in the employee population. Efficient delivery of rapid PCR test results to the competent institutions is possible via the SCADA system.

The proposed SCADA system collects the data from the sensors located in the sewage water and delivers the obtained results to the computers in the central station. The SCADA system consists of software and hardware that are designed to provide a flexible set of functions for collecting all parameters of measuring wastewater quality, the treatment thereof, monitoring and response in an adequate manner. The sensors are a part of the proposed automated real-time water quality monitoring system which can control up to seventeen parameters [4]. The system also contains the so-called “contamination" alarm which is activated by every parameter which exceeds the set critical limit. The proposed system is modular and scalable, and there is an application for both smartphones and personal computers. In the hierarchy of supervision, man represents the last link.

The aim of this paper is to introduce automated real-time online monitoring in the wastewater treatment plant "Ekogramont" (Fig. 1) with the possibility of using this monitoring in the prevention of the COVID-19 pandemic. The plant is located at 1080 m above sea level and was built in the period from 1998 to 1999 for the needs of the company for bottling spring water "Vlasinska ROSA", which is now owned by the company "Coca Cola" HBC. So far, wastewater monitoring has included periodic monitoring of common physicochemical and biological markers through standard analytical methods. Owing to IT technology, it is possible to continuously monitor these parameters by using modern sensors, smart modules, intelligent transducers, immersion UV/Vis spectrophotometer (ISA), control systems, online analysers and software.

The suitability of such automated monitoring comes to the fore in extreme weather conditions which prevail in this high mountain area, when for the purposes of standard analysis, wastewater sampling is disabled.

Due to the outbreak of the COVID-19 pandemic, automated monitoring can also be used to send the results obtained by analysing the presence of the viral genome in wastewater through rapid PCR tests.

MATERIAL AND METHODS

The biological wastewater treatment plant "Ekogramont" processes water which is a mixture of faecal, technological, technical and atmospheric water. Technological, technical and faecal water are gravitationally brought to the plant through sewage pipes. Through a network of gravity pipelines which are connected to the sewage system, the atmospheric water is collected from roof, green and asphalt surfaces. The processed water is discharged from the plant into the left headstream of the Vrla River, which belongs to the South Morava basin.

Fig. 1. "Ekogramont" - biological wastewater treatment plant

The plant contains an oil and grease interceptor, primary and secondary tube settler, recirculation unit, bio filter dripper, sludge digester, basin for sanitary hydrophytocultures, waste stabilisation pond and slow sand filter [5]. Biological wastewater treatment is a combination of aerobic, facultative anaerobic and anaerobic processes. This plant is based on a simple, energy-efficient and economically acceptable technological solution for wastewater treatment, which uses both microbiological and macrobiological methods [6]. Since the water from the plant is discharged into a watercourse classified as Category 1, wastewater treatment level and discharge schedule must ensure the category 1 water quality. This is an additional reason for the introduction of automated monitoring of the water discharge regime from the plant in order to prevent any possible accident.

The proposed automated monitoring of wastewater quality is based on the SCADA system (Supervisory Control and Data Acquisition) which collects data from sensors at the plant and delivers them to the central station. The primary purpose of the system is alert to changes in water quality.

The SCADA system consists of hardware and software which are designed to provide a flexible set of functions for collecting wastewater quality measurement parameters, processing thereof, monitoring and adequate response.

The SCADA system consists of functionally connected units, namely: software subsystem, hardware subsystem, communication subsystem and system of measuring sensors at the plant. The SCADA system can use a combination of radio and telephone lines for communication as well as satellite systems. This system consists of one or more MTUs (Master Terminal Units) or workstations where the appropriate software is installed. In many applications, the MTU is required to communicate with other computers in the system [7].

Rapid PCR tests are used to detect the presence of RNA from SARS-CoV2 in wastewater. The standard RT-PCR protocols WHO [8] and FDA [9] are used to detect SARS-CoV2. The samples should be taken before and after the processing in the treatment plant. The samples should be taken early in the morning (it is recommended to do so at 7 o'clock), at least once a week, by pouring 1000 mL of wastewater into sterile HDPE plastic containers. The collected samples should be transported to the laboratory in a refrigerator with ice and a temperature of 4 °C. The samples should be taken only when there is no rain, because mixing water from atmospheric precipitation with sewage water gives false results about the presence and the amount of RNA from SARS-CoV2. In the laboratory, 800 mL of each wastewater sample is first concentrated by precipitation with 20% polyethylene glycol 6000. It is then resuspended in 3 mL of PBS (sodium dihydrogen phosphate), pH 7.4 [10]. Viral RNA extraction is performed from 1mL concentrate and is eluted in 50 μL, according to the commercial instructions of the given manufacturer.

RESULTS AND DISCUSSION

SARS-CoV2 (severe acute respiratory syndrome coronavirus-2) is an infectious virus that causes a disease called COVID-19. SARS-CoV2 is a positive, single-stranded RNA coronavirus containing 29,903 nucleotides and ranging in size from 200 nm. Coronaviruses are pathogenic to humans and animals.

It has been proven that SARS-CoV2, in addition to the respiratory system, can also infect the cells of the gastrointestinal tract, in which case the gastric, duodenal and rectal epithelium releases a huge amount of virus. The amount of RNA copies of the virus then ranges from 10^2 to 10^8 per gram [11]. SARS-CoV2 was detected in stool samples of patients with symptoms of COVID-19, but also in asymptomatic cases of the disease, which confirms the possibility of faecal - oral route of transmission. Prior to the outbreak of the COVID-19 pandemic, wastewater monitoring, in addition to monitoring common physicochemical and biological markers (e.g. enteroviruses), also included monitoring those markers that indicate specific human activities such as use of narcotics, drug use/abuse, the emergence of genes for antimicrobial activity, etc.

In this way, the presence of RNA SARS-CoV2 in the wastewater of Spain had been proven before the local authorities reported the first cases of COVID-19 (the first case was reported in Barcelona on February 25, 2020). This study showed that after primary wastewater treatment, SARS-CoV2 RNA was present in 11% of samples and that after tertiary water treatment, RNA of this virus was not detected in any of the samples [12].

The latest scientific papers have additionally confirmed the presence of SARS-2 in wastewater, so in some European cities, this type of its detection has already begun.

In the Republic of Serbia 3,164,313 persons were tested by the middle of March 2021, out of which the presence of SARS-CoV2 was confirmed in 520,911 cases. Mortality rate was 0.91% [13].

The first attempt to introduce the detection of the presence of SARS-CoV2 from wastewater in Serbia began in Vranje, in mid-August 2020, from the wastewater of the city river. This water flows into the South Morava River without any prior treatment [14], [15], [16].

Early detection of SARS-CoV2 RNA in wastewater is a tool for early warning and monitoring of COVID-19 status in a given human population. Due to the large number of asymptomatic cases, monitoring of SARS-CoV2 RNA, originating from sewage water, gives a reliable picture of the current epidemiological situation. Detection of SARS-CoV2 from wastewater allows early detection of this virus. The detection of the viral genome in sewage, prior to the exponential phase of the epidemic, is a valuable indicator of the imminent danger of an outbreak. In this way, it is possible to monitor the status and trend of COVID-19 infection. This monitoring strategy is a much cheaper alternative to mass population testing (which is the primary choice in the fight against this epidemic). Thus, SARS-CoV2 can be detected several weeks before the confirmation of the first case in each subsequent wave, which gives epidemiologists enough time to implement all measures to slow down the spread of the disease. The presence of RNA SARS-CoV2 had been proven in the wastewater of some cities in Spain before the local authorities reported the first cases of COVID-19. Thus, for example, the examination of archived wastewater samples from 2018 and 2019 confirmed the presence of RNA from SARS-CoV2 in the sample from March 12, 2019, i.e. one year before the pandemic was declared [17].

The suggested system is the system for automated real-time water quality monitoring "GO systemelektronik" GmbH, which in practice has proven to be an efficient and long-term solution for online water quality monitoring. The system consists of multiple sensors, smart modules, smart transducers, immersion UV/Vis spectrophotometers (ISA), control systems, online analysers and software (Fig. 2).

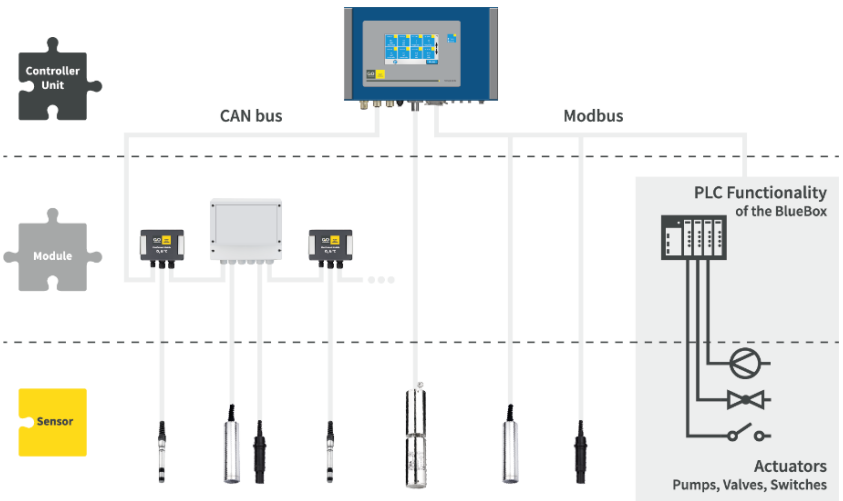

Fig. 2. BlueBox system (GO systemelektronik GmbH)

The system contains an immersion UV/Vis spectrophotometer (ISA) and sensors to control eleven parameters in wastewater, as follows: ammonium, biochemical oxygen demand (BOD), colour, conductivity, chemical oxygen demand (COD), nitrate, pH, dissolved oxygen, temperature, turbidity (FNU), and total suspended solids (TSS).

The software includes a computer operating system, SCADA software, a PLC operating system (*Programmable Logic Controller*), programs for local management using PLCs, communication programs, and network control software. The hardware subsystem consists of computer equipment, PLC, communication hardware, indicators, encoders, modems, cables and other equipment. The communication subsystem consists of hardware and software elements that stand out as a separate subsystem of the SCADA system. The system is modular and scalable, thus there is an application for smartphone, PC and tablet. For example, using the so-called "BlueGate cloud" data service (Fig. 3) one can automatically back up all data and remote access is possible via any web browser [18]. This service also offers real-time data display, visualization and the ability to export all measurement data. All communication over the network is encrypted.

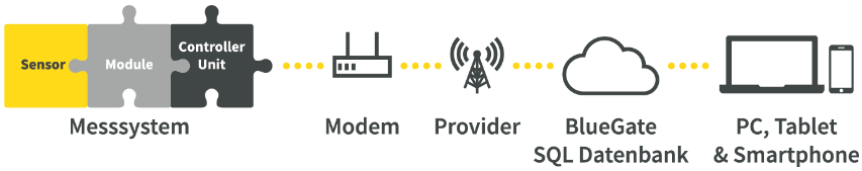

Fig. 3. Cloud data service “BlueGate” (GO Systemelektronik GmbH)

SCADA software performs functions of data management, monitoring and acquisition, but also additional functions (communication, report generation and printing of results). SCADA manages the hardware via a PLC that executes a program written in accordance with the IEC 61131-3 standard. The communication protocol is RS-232, and the PLC and PC exchange messages representing strings of ASCII characters. The functions of the SCADA system are implemented using the Delphi programming language and the components library that are part of the Borland Delphi 6.0 package [19]. The system also allows the setting of alarms, such as notifications of exceeding the limit values (MAC - maximum allowable concentrations), the so-called "Contamination alarm" which is activated when any of the specified parameters reaches and / or exceeds the critical limit. This is especially important because in this way any deviation that would probably go unnoticed by classical periodic laboratory analyses is identified and alarmed [20].

CONCLUSION

The proposed SCADA system collects the data from the sensors located in the sewage water and delivers the obtained results to the computers in the central station. SCADA software performs functions of data management, monitoring and acquisition, but also additional functions (communication, report generation and printing of results).

SCADA manages the hardware via a PLC that executes a program written in accordance with the IEC 61131-3 standard.

The functions of the SCADA system are implemented using the Delphi programming language and the components library that are part of the Borland Delphi 6.0 package. Using the so-called "BlueGate cloud" data service one can automatically back up all data and remote access is possible via any web browser

The suggested system is the system for automated real-time water quality monitoring "GO systemelektronik" GmbH, which in practice has proven to be an efficient and long-term solution for online water quality monitoring. Owing to IT technology, it is possible to continuously monitor these parameters by using modern sensors, smart modules, intelligent transducers, immersion UV/Vis spectrophotometer (ISA), control systems, online analysers and software. In addition to monitoring the quality of physicochemical parameters, the system can also be used to distribute the results of rapid PCR tests in order to detect the presence of SARS CoV2 in wastewater. The standard RT-PCR protocols WHO and FDA are used to detect SARS-CoV2. The system also allows the setting of alarms, such as notifications of exceeding the limit values (MAC - maximum allowable concentrations), the so-called "Contamination alarm" which is activated when any of the specified parameters reaches and / or exceeds the critical limit.

The suitability of such automated monitoring comes to the fore in extreme weather conditions which prevail in this high mountain area, when for the purposes of standard analysis, wastewater sampling is disabled.

In this filed, modification of legal regulations in Serbia would enable the formation of a network for automated real-time monitoring of water quality control, with continuous measurement systems that would deliver the measurement results via SCADA systems to the competent institutions.

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IT-MONITORING KVALITETA OTPADNE VODE U REALNOM VREMENU U PREVENCIJI PANDEMIJE COVID-19

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Sažetak: U državama članicama EU preuzimaju se nove mere za fleksibilna i skalabilna rešenja u praćenju kvaliteta otpadnih voda. Najnoviji naučni radovi potvrdili su prisustvo SARS-CoV2 virusa u otpadnim vodama. Ovaj virus je otkriven i u uzorcima stolice kod pacijenata sa simptomima COVID-19 ali i kod asimptomatskih slučajeva oboljevanja što potvrđuje i mogućnost fekalno-oralnog prenošenja. Cilj rada je uvođenje automatizovanog *on-line* monitoringa u realnom vremenu u postrojenju za prečišćavanje otpadne vode „Ekogramont“ sa mogućnošću korišćenja ovog monitoringa i u prevenciji pandemije COVID-19. Postrojenje se nalazi na 1080 m nadmorske visine i izgrađeno je 1999. godine za potrebe rada preduzeća za flaširanja izvorske vode „Vlasinska ROSA“-Coca cola HBC. Predložen je SCADA sistem koji sakuplja podatke sa senzora smeštenih u kanalizacionoj vodi i dobijene rezultate dostavlja računarima u centralnoj stanici. Pogodnost ovakvog automatizovanog monitoringa dolazi posebno do izražaja u ekstremnim vremenskim uslovima, kakvi vladaju u ovom visokoplaninskom području, kada je za potrebe standardnih analiza onemogućeno uzorkovanje otpadnih voda. Sistem sadrži i tzv. „kontaminacioni alarm” koga aktivira svaki parametar kada se premaši zadata kritična granica. Za detekciju SARS-CoV2 koristi se standardni RT-PCR protokoli WHO i FDA. Otkrivanje virusnog genoma u kanalizacionoj vodi, pre eksponencijalne faze epidemije, predstavlja dragocen indikator o neposrednoj opasnosti od izbijanja epidemije. Izmene zakonske regulative u Republici Srbiji, u ovoj oblasti, omogućile bi formiranje mreže automatizovanog monitoringa kontrole kvaliteta vode u realnom vremenu sa kontinualnim mernim sistemima koji bi rezultate merenja preko SCADA sistema dostavljali nadležnim institucijama.

Ključne reči: *real-time monitoring, SCADA, otpadne vode, COVID-19.*

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DEVELOPMENTS OF ORCHARD TILLERS AND THEIR ASSESSMENT OF INTERCULTURAL WORK QUALITY FOR SUITABLY IN TARAI REGION OF PANTNAGAR

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Abstract: Rotary tillers implements are now projected as important tillage machinery for better seedbed preparation; however the ordinary rotavator being in line with the tractor center line at the rear cannot be used in orchards due to the hindrance posed due to narrow space between the plants. Therefore, the concept of a rotary offset tiller in other words orchard tillers was proposed, which could perform finer intercultural operation between the plants. Since there are some models of Indians and Foreign made rotary offset tiller available and their work quality parameter significantly plays a crucial role in selection of efficient, effective and appropriate machine for orchards. Therefore, present study is carried out with a purpose of selection of suitable and efficient orchard tillers on the basis of intercultural work quality parameters. The various intercultural machines like Rineri offset tiller, Saktiman offset tiller and Side shift tiller selected for this study and finally, orchard tillers were analysed for intercultural work quality for their suitability in Pant Tarai region of Uttarakhand.

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The work quality assessments concluded that side shift tiller was supposed to be best among all other type of intercultural machines because of less fuel consumption 3.5 l/h, less mean weight diameter 42 mm, higher actual field capacity 0.47 and high field performance index 86 %. Therefore, side shift tiller can be recommended to farmers and found to be suitable for intercultural operation in Pant Tarai region.

***Key words**: Tillage, Rotary Offset Tiller, Intercultural Operations*

NEED OF ORCHARD TILLERS

The lighter and finer operations carried out on the soil, between sowing had harvesting are termed as intercultural operations. They include weeding, fertilizer application, mulching, etc. The implements like rotary offset tiller, offset harrow, cultivators used for this purpose are called as intercultural equipment's. The rotavator (derived from rotary cultivator) is a tractor mounted active tillage implement comprising of blades mounted on flanges with affixed to a shaft that is driven by the tractor (PTO). Rotavator performs (one plowing and two harrowing) operation in single pass therefore, rotavator is accepted by the majority of farmers in Indian, as a time-saving equipment under low land and high land conditions. It gave higher quality of work (25–30%) than the cultivator (Sahay et al. 2009). The degree of soil pulverization attained by the rotavator is more as compared to harrow and cultivator. The energy required per unit volume of soil for rotavator is about 39.2 to 47.0 MJ/m^3 while, 70.7 to 116.3 MJ/m^3, 62.2 to 103 MJ/m^3 and 53.3 to 110.2 MJ/m^3 for mould board plough, desi plough and cultivator respectively (Salokhe et al. 2003). Rotary tillage implements are also one of most important versatile tillage machinery for better seedbed preparation but a simple rotavator cannot be used for intercultural operations due to obstruction imposed due to narrow space between the orchards. Therefore, rotary offset tiller came into existence, which performs effectively and finer intercultural operation (Namdev et al. 2017)

DEVELOPMENTS OF ORCHARD TILLERS

Orchard tillers are one of the most useful implement for performing intercultural operation. Initially, some popular foreign developed intercultural machines like Rineri made in Italy, Rotomec and Minos Agri made in USA, Howard made in Australia etc., were imported but after that some of progressive local agriculture firms in India like Shaktiman, FieldKing, etc. also started to manufacture orchard tillers. The orchard tillers like Renieri and Shaktiman were tested for work quality parameter evaluation under DST research project running with collaboration of CSIR, CMERI, COEFM, Ludhiana (Punjab) with various testing center of machinery located in various agricultural universities like PAU, Ludhiana (Punjab), GBPUAT, Pantnagar (Uttarakhand), JNKVV, Jabalpur (Madhya Pradesh) etc. but their work quality is not found satisfactory. Therefore, scientists of Center of Scientific and Industrial Research, Center of Excellence for Farm Machinery, Central Mechanical Engineering Research Institute, Ludhiana (Punjab) designed and developed a new orchard tiller which is also popular as side shift tiller and tested for work quality assessment by

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The views of different orchard tillers are shown in Figure 1, Figure 2 and Figure 3 whereas their technical and brief specifications are tabulated in Table 1, Table 2, Table 3, Table 4 and Table 5.

Fig. 1. Rinieri offset tiller

Table 1. Technical specifications of a Rinieri offset tiller (Pal, 2012.)

Model	Offset of the machine (m)	Working width (cm)	Power (hp)	Weight, Kg	Operating Depth, (m)
FS 100	0.40	55-70	20+	230	0.20
FS 130	0.40	55-70	20+	230	0.25
FS 160	0.50	55-70	25+	270	0.20
FS 200	0.50	55-70	30+	350	0.20
FS 220	0.50	70-85	40+	380	0.20

Table 2. Brief specification of a Rinieri offset tiller (Pal, 2012.)

S.L. No.	Specification	Units
1.	Power requirement	30-50 hp
2.	Number of flanges	5
3.	Spacing between flange plates	550 mm
3.	Type of blades	L- Shape
4.	Number of blades	30
5.	Effective Working Width	550-700 mm
6.	Working cut	200 mm
7.	Minimum offset	500 mm

Fig. 2. Shaktiman offset tiller

Table 3. Technical specifications of aS offset tiller (Saktiman Manual, 2013.)

Model	Offset of the machine (m)	Working width (cm)	Power (hp)	Weight, Kg	Operating Depth, (m)
SRT 4	0.9	116	34+	419	0.20
SRT 5	1.2	150	40+	460	0.25
SRT 5.5	1.3	163	50+	470	0.20
SRT 6	1.4	178	55+	479	0.20
VLS 135	1.0	135	40+	500	0.12
VLS 150	1.0	155	45+	530	0.12

Fig. 3. Side shift tiller

Table 4. Brief Specifications of a Shaktiman offset tiller (Saktiman Manual, 2013.)

S.L. No.	Specification	Units
1.	Power requirement	40 hp
2.	Number of flanges	5
3.	Spacing between flange plates	270 mm
4.	Type of blades	C- Shape
5.	Number of blades	30
6.	The overall height of rotary offset tiller	1112 mm
7.	The overall width of rotary offset tiller	1027 mm
8.	The overall length of rotary offset tiller	1730 mm
9.	Effective working width	1350 mm
10.	Maximum working depth	120 mm
11.	Minimum offset	400 mm

BRIEF DESCRIPTION OF MODIFIED SIDE SHIFT TILLER

The rotary offset tiller has rotating tines mounted on a horizontal shaft and can be attached to the three point linkage of 50-65 hp tractors. It is powered by PTO and provided with adjustable mechanical sensing unit which can be adjusted at any position on the frame according to the type of orchard with a side shift of 300 mm. It has seven flanges spaced 220 mm apart and each flange carries in it six blades. It is also provided with an external gear type pump of capacity 15 lit/min driven by PTO of the tractor. The modified side shift tiller is presented in Figure 3.

Table 5. Brief specification of side shift tiller (Namdev, 2015.)

S.L. No.	Specification	Units
1.	Power requirement	50 hp
2.	Number of flanges	7
3.	Type of blades	L- Shape
4.	Number of blades	42
5.	Flange plate diameter	400 mm
6.	Rotor shaft diameter	280 mm
7.	Spacing between flange plates	235 mm
9.	The overall height of offset rotavator	1120 mm
10.	The overall width of offset rotavator	2000 mm
11.	The overall length of offset rotavator	400 mm
12.	Rated width of cut	1800 mm
13.	Hydraulic sift	370 mm
14.	Standard position offset	500 mm
15.	Right side maximum offset	650 mm
16.	Left side minimum offset	300 mm

TECHNICAL MODIFICATIONS OF SIDE SHIFT ROTARY TILLER

On the basis of work quality parameters of various orchard tillers and considering the problems of farmers at ground level as well as problems arising during intercultural operations in different orchards, the following modifications has introduced in side shift tiller designed and developed by Center of Scientific and Industrial Research, Central Mechanical Engineering Research Institute, Center of Excellence for Farm Machinery, Ludhiana (Punjab).

1. The side shift system of the machine can be adjusted and fixed at any position with the help of retaining screw so it can be used both as ordinary rotary tiller as well as side shift tiller.
2. The working width of developed side shift tiller was increased from 0.40 m to 1.8 m hence covers larger area between orchards.

3. The sensing unit was adjustable and can be moved at any position on the frame according to type of orchards. It was also provided with adjusting sensing rod which can be settled at any angle ranges from 5^0 to 7^0 with the help of adjusting slotting plate fixed at any position.

JUSTIFICATION OF MODIFICATIONS OF SIDE SHIFT TILLER

(1.) Farmers can not offered normal rotary tiller and rotary offset tiller separately for different purposes Therefore, side shift system of the machine can be adjusted and fixed at any position with the help of retaining screw hence machine can be used both as ordinary rotary tiller as well as side shift tiller which causes farmers need not to purchase separate machinery for intercultural operation.
(2.) The both rotary offset tillers cover less area between orchards due to smaller effective working width. Therefore, side shift tiller working width is increased from 0.40 m to 1.8 m, in which, it covers larger area between orchards within less time.

(3.) Side shift tiller is provided by adjusting sensing unit, in which, it can adjust at any position on the frame according to type of orchards. It is also provided with adjusting sensing rod which can be adjusted at any angle ranges from 5^0 to 7^0 with the help of adjusting slotting plate fixed at any position. Thus, side shift tiller can performs intercultural operation effectively in narrow space between orchards.

INTERCULTURAL WORK QUALITY PARAMETERS OF DIFFERENT ORCHARD TILLERS

Table 6. Work quality results of different orchard tillers

Parameters	Intercultural Operations		
	Rineri Offset Tiller	Shaktiman Offset Tiller	Side Shift Tiller
Fuel Consumption, l/h	4.2	5.0	3.5
Mean Weight Diameter (MWD), mm	58	45	42
Actual Field Capacity, ha/h	0.35	0.45	0.47
Field Performance Index, %	79	82	86

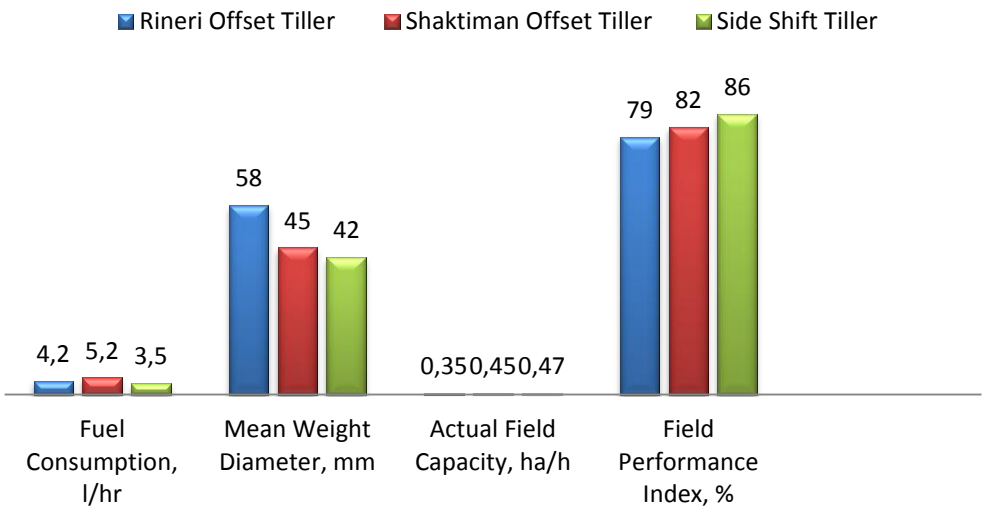

Fig. 4. Intercultural work quality of different orchard tillers

CONCLUSION

The results shows that use of side shift tiller reduced the number of operations thereby increasing the overall field capacity and field performance index along with reducing time required for intercultural operation. The work quality obtained was supposed to be superior as compare to other orchard tillers and it was also possible to incorporate all stubble and residues into soil. Thus, side shift tiller can be recommended for Pantnagar Tarai region farmers for intercultural operation.

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RAZVOJ ROTACIONIH ALATA I PROCENA KVALITETA NJIHOVOG INTERAKTIVNOG RADA POGODNOG ZA VOĆNJAKE TARAI I PANTNAGAR REGION (Indija)

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Sažetak: Oprema (alati) za rotacione freze danas se predviđa kao važna za obradu zemljišta i bolju pripremu međuprostora u voćnjacima. Međutim, obične mašine sa rotacionim alatima koji se nalaze u ravni sa srednjom linijom vuče i sa zadnje strane traktora, ne mogu se uspešno koristiti u voćnjacima zbog smetnji u uskom (ograničenom) prostoru između biljaka.
Zato je predložen u ovom radu, koncept rotacione freze, koji bi mogao da izvrši finiju obradu prostora između redova u voćnjaku.

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Budući da su na raspolaganju neki modeli rotacionih alata (freza) sa proizvodnjom u Indiji i inostranstvu, njihovi parametari kvaliteta rada igraju presudnu ulogu u odabiru efikasne, efikasne i odgovarajuće mašine za voćnjake u Indiji . Zato se ovo istraživanje sprovodi u svrhu izbora pogodnih i efikasnih rotofreza za voćnjake na osnovu parametara kvaliteta interaktivnog rada.
Različite mašine za rad međurednom prostoru u voćnjacima, kao što je Rineri, Saktiman i Side rotofreza su odabrane za ovu studiju, i na kraju, analizirane na kvalitet interaktvnih parametara rada kako bi se primenile u regionu Pant Tarai u Uttarakhandu (Indija).
Procene kvaliteta rada omogućuju zaključak: rotofreza sa bočnim pomeranjem alata treba biti najbolja među svim ostalim vrstama interativnih mašina zbog manje potrošnje goriva 3,5 l/h, manjeg srednjeg prečnika alata od 42 mm, većeg stvarnog učinka od 0,47 ha/h i visokog indeksa performansi mašine u radu od 86% .
Zato se farmerima može preporučiti konstrukcija mašine rotofreze (Side Shift Tiller) sa bočnim pomeranjem alata, koja se može pogodno primeniti za interaktivne operacije u voćnjacima u regionu Pant Tarai (Indija).

Ključne reči: *obrada zemljišta, rotaciona freza, interaktivne operacije*

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ISTRAŽIVANJE UTICAJA KVALITETA REZERVNIH DELOVA NA RAD REMONTOVANOG DIZEL MOTORA

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Sažetak: Pri remontovanju motora sa unutrašnjim sagorevanjem, ugradjivan je komplet rezervnih delova: kolenasto vratilo-zamajac. Posle remontovanja pristupilo se ispitivanju motora na probnom stolu. Posle kratkog vremena rada došlo je do pojave havarije motora. Pristupilo se ponovnom remontovanju, sa drugim kompletom rezervnih delova: kolenasto vratilo - zamajac. Posle kratkog vremena rada došlo je do ponovne pojave oštećenja motora, i to po istom mehanizmu nastanka. Cilj rada je prikaz rezultata analize uzroka nastalih oštećenja ispitivanih dizel motora velikih snaga.

Ključne reči*: motor, održavanje, otkaz.*

UVOD

Pri remontovanju dizel motora neophodno je imati na raspolaganju adekvatne rezervne delove, kako po pitanju njihovih konstruktivnih karakteristika, tako i po pitanju njihovog kvaliteta.

Firma koja se bavi remontovanjem motora, prema zakonskoj proceduri, ipostavila je zahtev za nabavku rezervnih delova dobavljaču i potpisala sa njim ugovor o isporuci

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u kome su precizirani i uslovi koje moraju da zadovolje rezervni delovi (da delovi moraju biti novi i nekorišćeni, da se isporučuju kao gotov proizvod i da u potpunosti odgovaraju fabričkim brojevima, oznakama, i standardima, da budu isporučena u originalnim pakovanjima i u originalnoj ambalaži.

Ugovorom o isporuci rezervnih delova je takodje bilo precizirano da isporučilac, prilikom isporuke rezervnih delova, mora da dostavi tehničku dokumentaciju kojom se dokazuju njihove tehnički deklarisane karakteristike.

Pri dopremanju tri kompleta rezervnih delova (kolenasto vratilo i zamajac), od strane dobavljača, komisija za prijem istih, ustanovila je:

- Da delovi nisu novi i nekorišćeni;
- Da u potpunosti ne odgovaraju fabričkim brojevima, oznakama, i standardima;
- Da, uz dopremljene rezervne delove, nije dostavljena tehnička dokumentacija kojom se dokazuju njihove tehnički deklarisane karakteristike;
- Da postoje odstupanja geometrijskih parametara rezervnih delova od onih koji su propisani tehničkom dokumentacijom proizvodjača.

I pored prethodno navedenog činjeničnog stanja, dopremljeni rezervni delovi su preuzeti jer se dobavljač obavezao da će sve nedostatke otkloniti.

Pristupilo se ugradnji jednog kompleta rezervnih delova (kolenastog vratila broj 90325/76700 i zamajca broj 80254/174684), pri remontovanju predmetnog motora.

Posle ugradnje prethodno navedenih rezervnih delova u predmetni motor, motor je postavljen na probni sto radi provere funkcionalnosti i kvaliteta obavljenog remonta.

Pri proveri funkcionalnosti i kvaliteta obavljenog remonta predmetnog motora na opitnom stolu došlo je do pojave havarije istog, i to posle 4,5 minuta rada pri 800o/min.

Firma koja je vršila remontovanje motora ispostavila je zahtev za rešavanje reklamacije dobavljaču predmetnih rezervnih delova.

Izvršeno je merenje kružne ekscentričnosti, kao i merenje neuravnoteženosti predmetnih rezervnih delova i pri tom ustanovljeno da svi rezervni delovi ne zadovoljavaju uslove standarda ISO 1940 po pitanju kružne ekscentričnosti, kao i po pitanju neuravnoteženosti.

Iako su predmetni rezervni delovi isporučeni kao novi i nekorišćeni, i kao delovi koji zadovoljavaju sve uslove standarda ISO 1940, i tehničke karakteristike, a pošto se ustanovilo da to nije tako, i da je došlo do havarije pri ispitivanju motora na probnom stolu, pristupilo se "dovodjenju nameni" svih predmetnih rezervnih delova.

Pošto je dobavljač rezervnih delova garantovao da su delovi "privedeni nameni", pristupilo se ugradnji drugog kompleta rezervnih delova (kolenasto vratilo broj 11682/17445 i zamajca broj 23645/17817).

Posle ugradnje prethodno navedenih rezervnih delova (drugi komplet) u predmetni motor, motor je postavljen na probni sto radi provere funkcionalnosti i kvaliteta obavljenog remonta.

Pri proveri funkcionalnosti i kvaliteta obavljenog remonta predmetnog motora, sa drugim kompletom rezervnih delova, na opitnom stolu, došlo je do pojave havarije istog, i to posle 4 sata rada bez opterećenja, na isti način, i po istom mehanizmu nastanka havarije predmetnog motora kao i pri remontovanju sa prvim kompoletom rezervnih delova.

Pošto izvršilac radova "dovodjenja nameni" predmetnih rezervnih delova, i dobavljač istih, nisu garantovali ugradnju trećeg kompleta rezervnih delova (kolenasto vratilo broj 26121/176849 i zamajca broj 52714/17495), nije se pristupilo remontovanju predmetnog motora sa ovim kompletom.

U radu je pažnja poklonjena analizi kvaliteta remontovanja dvanaestocilindričnog dizel motora D 12A-525 specifične konstrukcije i namene, sa aspekta ugradjenih rezervnih delova: kolenastih vratila i pripadajućih zamajaca.

Kao rezultat rada autori ovoga rada, na rešavanju kompleksnog zadatka remontovanja dvanaestocilindričnog dizel motora D 12A-525 specifične konstrukcije i namene, i to prvenstveno sa aspekta sa aspekta rezervnih delova, nastali su brojni rezultati istraživanja predmetne problematike. U radu je dat samo jedan deo tih rezultata, a koji se odnosi prvenstveno na istraživanja autora o uticaju kvaliteta rezervnih delova na proces remontovanja dizel motora, kao i rezultati istraživanja uzroka nastalih oštećenja zbog korišćenja neadekvatnih rezervnih delova.

OBJEKAT ISTRAŽIVANJA

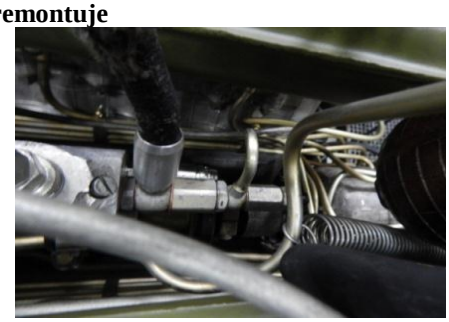
Predmet istraživanja uticaja kvaliteta rezervnih delova pri remontovanju dvanaestocilindričnog dizel motora D 12A-525 specifične konstrukcije i namene (slika 1), su sledeća tri kompleta kolenasto vratilo motora i zamajac:

- Sklop kolenastog vratila broj 90325/76700 (slike 5, 6) i zamajca broj 80254/174684 (slike 7,8). Ovo je sklop sa kojim je pri prvom ispitivanju motora D 12A-525 na probnom stolu došlo do havarije;
- Sklop kolenastog vratila broj 11682/17445 (slike 9,10,16) i zamajca broj 23645/17817 (slike 11,12,13,14,15). Ovo je sklop sa kojim je pri drugom ispitivanju motora D 12A-525 na probnom stolu došlo do havarije;
- Sklop kolenastog vratila broj 26121/176849 (slike 17,18) i zamajca broj 52714/17495 (slike 19,20,21,22) Ovo je sklop sa kojim nije vršeno ispitivanje motora D 12A-525 na probnom stolu.

Dvanaestocilindrični dizel motor D 12A-525 (V12) (slika 1) ima sledeće tehničke karakteristike: zapremina radnog prostora motora 38880cm^3, maksimalna snaga motora 386kW, maksimalni obrtnoi momenta 2150Nm (u opsegu od 1200 do 1400o/min).

Motor koji se remontuje

Slika 1. Pogonski motor D 12A-525 - pogled sa boka
Figure 1. Engine D 12A-525 - side view



Slika 2. Davač pritiska na opitnom stolu i ispitivanom motoru
Figure 2. Pressure sensor on the test bench and engine

Probni sto na kome se ispituje kvalitet remontovanog motora

Slika 3. Opitni sto -pogled sa čela
Figure 3. Experimental table-front view

Slika 4. Opitni sto - pogled odozgo
Figure 4. Experimental table-top wiev

Rezervni delovi (komplet broj 1): kolenasto vratilo 90325/76700 i zamajac 0254/174684

Slika 5. Kolenasto vratilo 90325/76700
-pogled na broj kolenastog vratila
i na klinove
Figure 5. Crankshaft 90325/76700
-view of crankshaft number and pins

Slika 6. Kolenasto vratilo 90325/76700
bez pokretnih masa
Figure 6. Crankshaft 90325/76700
-view of a complete crankshaft without
moving masses

Slika 7. Zamajac 80254/174684
- oznaku zamajca i oštećenja zubaca
Figure 7. Flywheel80254 /174684
- a flywheel marking and tooth damage

Slika 8. Zamajac 23645/17817
-strana koja se spaja sa kolenastim vratilom
Figure 8. Flywheel 23645/17817 -view of the
flywheel from the side that connects
to the crankshaft

Rezervni delovi (komplet broj 2): kol.vratilo 11682/17445 i zamajac 23645/17817

Slika 9. Kolenasto vratilo 11682/17445
- oznaka i broj
Figure 9. Crankshaft 11682/17445
-a mark and crankshaft number

Slika 10. Kolenasto vratilo 11682/17445
Figure 10. Crankshaft 11682/17445

Slika 11. Zamajac 23645/17817
-pogled na oznaku
Figure 11. Flywheel 23645/17817
-view of the mark

Slika 12. Zamajac 23645/17817
-pogled sa strane kojom se spaja sa kolenastim vratilom
Figure 12. Flywheel 23645/17817
-view of the flywheel from the side that connects to the crankshaft

Slika 13. Zamajac 23645/17817
-pogled na broj zamajca
Figure 13. Flywhee 23645/17817
-view of flywheel marking and tooth damage

Slika 14. Zamajac 23645/17817
-pogled na oznaku zamajca
Figure 14. Flywhee 23645/17817
- view of flywheel marking and tooth damage

Slika 15. Zamajac 23645/17817
-pogled na otvore za klinove i zavrtnjeve
Figure 15. Flywheel 23645/17817
-view of the holes for pins and screws

Slika 16. Kolenasto vratilo 11682/17445
-pogled na oznaku - broj kol.vratila
Figure 16. Crankshaft 11682/17445
-view of the mark - crankshaft number

Rezervni delovi (komplet br.3): kolen. vratilo 26121/176849 i zamajac *52714/17495*

Slika 17. Kolenasto vratilo 26121/176849
Figure 17. Crankshaft 26121/176849

Slika 18. Zamajac 52714/17495 i kolenasto vratilo 26121/176849
Figure 18 Flywhel l52714/17495 and Crankshaft 26121/176849

Slika 19. Zamajac 52714/17495
-pogled na oznaku zamajca
Figure 19 Flywhel 52714/17495
- view of the mark

Slika 20. Zamajac 23645/17817
-pogled na zamajac sa strane kojom se spaja sa kolenastim vratilo,
Figure 20. Flywhel 52714/17495
-view of the flywheel from the side that connects to the crankshaft

Slika 21. Zamajac 52714/17495
-pogled na oznaku zamajca i na oštećene zupce zamajca
Figure 21 Flywhel 52714/17495
- view of the mark and tooth damage

Slika 22. Zamajac 52714/17495
-pogled na oznaku zamajca i na oštećene zupce zamajca
Figure 22. Flywhel 52714/17495
- view of the mark and tooth damage

REZULTATI ISTRAŽIVANJA I DISKUSIJA

Ispitivanje remontovanog dizel motor D 12A-527 u koji je bio ugradjen prvi komplet rezervnih delova (kolenasto vratilo 90325/76700 i zamajac 80254/174684)

U ovom delu rada dat je prikaz tehničkog stanja, kolenastog vratila (90325/76700) sa odgovarajućim zamajcem (80254/174684), koji su namenjeni za ugradnju u dvanaestocilindrični dizel motor D 12A-527 specifične konstrukcije i namene (slika 1).

Pri ispitivanju motora D 12A-527 (slike: 1, 2), u koji je bio ugrađen sklop: kolenasto vratilo broj 90325/76700 i zamajac broj 80254/174684, došlo je vrlo brzo, posle 4,5 minuta rada motora na "praznom hodu" i pri broju obrtaja od 800 o/min, do havarije, uz pojavu belog dima.

Posle demontaže motora utvrdjeno je da je došlo do:

- Oštećenja ležaja kolenastog vratila pored zamajca, na mestu gde motor trpi najveće opterećenje (slike 29, 30);
- Topljenja belog metala i zapušivanja otvora za podmazivanje ležaja kolenastog vratila pored zamajca (slika 24);
- Oštećenja povratnika ulja (slika 24);
- Izrazito vidljivih tragova termičkog preopterećenja delova kolenastog vratila (slika 24).

Svi, prethodno navedeni efekti nastale havarije upućuju na zaključak da ugradjeni rezervni delovi nisu bili kvalitetni, da nije postajala uparenost delova kolenasto vratilo-zamajac, da komplet kolenasto vratilo-zamajac nisu uravnoteženi.

Usled postojanja velike neuravnoteženosti sklopa: kolenasto vratilo - zamajac, (što je kasnije potvrdila, u svom zvaničnom izveštaju, i firma zadužena da utvrdi stanje kolenasto vratilo i zamajaca sa aspekta stanja izbalansiranosti istih, došlo je do nastanka teškog oštećenja motora.

Došlo je do skidanja belog metala sa ležajeva i zapušenja otvora za podmazivanje na najopterećenijem rukavcu kolenastog vratila (slike: 23,24); Pojava oštećenja povratnika ulja (slika 23); Došlo je do termičkog naprezanja rukavca i ležajeva (slika 23); Došlo je do oštećenja radioaksijalnog ležaja (slika 23); Došlo je i do pojave belog dima.

U procesu demontaže motora uočeno je "zaribavanje" motora na mestu radijalno-aksijalnog ležaja kolenastog vratila i oštećenje povratnika ulja (slika 23).

Tehničko stanje sklopa kolenasto vratilo-zamajac, a koji je bio ugrađen u motoru koji je ispitivan na probnom stolu, i na kome je došlo do prve havarije pri ispitivanju:

1. Delovi sklopa kolenastog vratila broj 90325/76700 i zamajca broj 80254/174684, nisu novi, nisu nekorišćeni, ne odgovatraju fabričkim brojevima, oznakama i standardima.

O tačnosti prethodne tvrdnje, govori tehničko stanje delova ovih sklopova:

- Pohabani i deformisani zupci na zupcima zamajaca (slike: 8,11,12, 13,1419,20, 21,22);
-Postojanje izražene korozije na površinama rezervnih delova (slike: 5,7,8,9,12,15,1617,20,21,22,32);

2. Postoji neuparenost zamajaca i kolenastog vratila .

O tačnosti prethodne tvrdnje, govori činjenica nepostojanje verodostojne tehničke dokumentacije ("pasoša uparenosti") kojom se dokazuju "uparenost" ovog sklopa.

3. Ne odgovaraju dimenzije otvora na zamajcu i klinova na kolenastim vratilima (slike: 15,1617,20,21,31,32).

4. Postoji nedozvoljeno odstupanje radijalnog "bacanja"- ekscentričnosti kolenastog vratila u odnosu na preporučeno od strane proizvođača (slike: 39, 40,41,42).

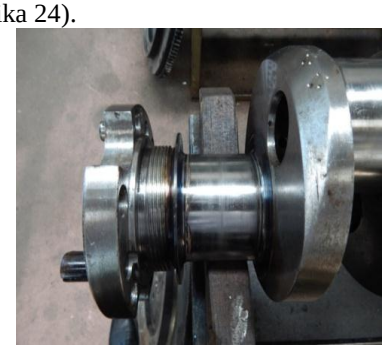
5. Postoji odstupanje u dimenzijama prečnika otvora na zamajcima i rkolenastih vratila.

- Prečnici otvora na zamajcima i klinova na kolenasto vratiloma, u velikoj meri odstupaju od definisanih mera tehničkom dokumentacijom (slike: 15,16,31,32);
- Otvori na zamajcima i prečnici klinova na kolenasto vratiloma, sa kojima čine sklop, nisu u toleranciji H/h (to je i nemoguće kada su prečnici otvora na zamajcima i prečnici klinova na kolenasto vratiloma neodgovarajući).

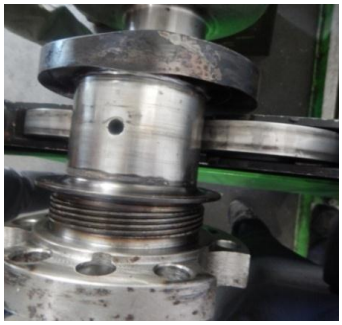
6. Postoji oštećenja rukavca kolenastog vratila (slika 23,24).

7. Postoji oštećenja ležajeva motora (slika 25,26,27,28,29,30).

9. Postoji oštećenja (začepljenje) otvora za podmazivanje na rukavcu kolenastog vratila (slika 24).

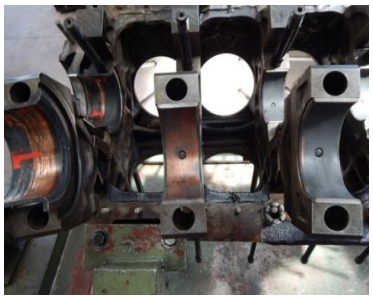


Slika 23. Kolenasto vratilo 90325/76700 -pogled na termički oštećen ležaj pov. ventila i prvog rukavca kolenastog vratila
Figure 23. Crankshaft 90325/76700 -view of thermally damaged non-return valve bearing and first crankshaft sleeve



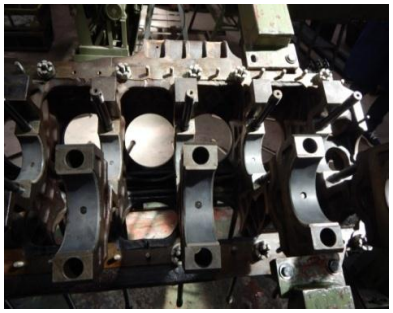
Slika 24. Kolenasto vratilo 90325/76700 -pogled na zapušenom otvoru dovoda maziva prvog rukavca kolenastog vratila
Figure 24. Crankshaft 90325/76700 - view of the clogged lubricant supply port of the first crankshaft sleeve

Slika 25. Pogled na ležajeve kolenastog vratila 90325/76700 motora
Figure 25.View of 90325/76700 engine crankshaft bearings



Slika 26. Pogled na ležajeve kolenastog vratila 90325/76700
Figure 26.View of 90325/76700 engine crankshaft bearings

Slika 27. Pogled na ležajeve kolenastog vratila 90325/76700
Figure 27. View of crankshaft bearings 90325/76700



Slika 28. Pogled na ležajeve kolenastog vratila 90325/76700
Figure 28. View of crankshaft bearings 90325/76700

Slika 29. Pogled na oštećen ležaj kolenastog vratila 90325/76700
Figure 29. View of damaged crankshaft bearing 90325/76700

Slika 30. Pogled na neoštećen ležaj kolenastog vratila 90325/76700
Figure 30.View of undamaged crankshaft bearing 90325/76700

Slika 31. Zamajac 80254/174684
-pogled na otvore za klinove i zavrtnje kolenastog vratila
Figure 31.Flywheel 80254/174684
-view of the openings for the crankshaft pins and screws

Slika 32. Kolenasto vratilo 90325/76700
Figure 32. Crankshaft 90325/76700

Ispitivanje remontovanog dizel motor D 12A-527 u koji je bio ugradjen drugi komplet rezervnih delova (kolenasto vratilo 11682/17445i zamajac 23645/17817)

U ovom delu rada dat je prikaz tehničkog stanja, kolenastog vratila (11682/17445) sa zamajcem (23645/17817), a koji su namenjeni za ugradnju u dvanaestocilindrični dizel motor D 12A-527 specifične konstrukcije i namene (slika 1).

Pre remontovanja predmetnog motora sa drugim kompletom rezervnih delova (kolenastog vratila broj 11682/17445 i zamajca broj 23645/17817, izvršeno je merenje kružne ekscentričnosti i merenje neuravnoteženosti predmetnih sklopova.

Uvidom u rezultate merenja, i upoređivanjem tih rezultata sa standardom ISO 1940, uočeno je da na sva tri ispitivana kompleta: kolenasto vratilo-zamajac, da je granica zaostalog debalansa i kružne ekscentričnost višestruko veća od propisanih vrednosti.

Izvršena je dorade na zamajcima i kolenastim vratilima, sa ciljem dovođenja istih u dozvoljeni zaostali debalans i kružnu ekscentričnost.

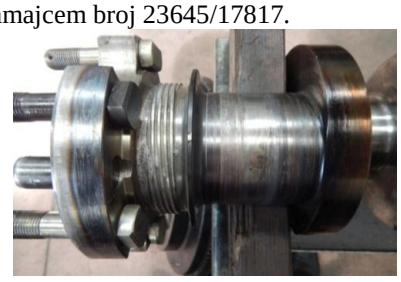
U izveštaju firme koja je izvršila radove navodi se da je uradjeno sledeće: korekcija (proširivanje otvora na zamajcima za dosed klinova usled nekontrolisanog kontakta), navarivanje, mašinska dorada dosednih tolerisanih prečnika na zamajcima motora i ispravljanje kolenastih vratila.

Izvršeno je brušenje i poliranje rukavca zbog postojanja ovalnosti i koničnosti rukavca većih od 0,02mm konstatovanih pri prijemu kolenastih vratila, i zbog postojanja ekscentričnosti veće od 0,06 mm (kako je propisano dokumentacijom proizvođača).

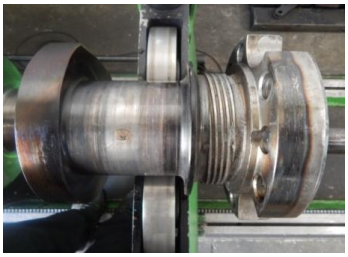
Nakon izvršene mašinske obrade kolenastih vratila, izvršena je kontrola i uočena neusaglašenost po pitanju naleganja kolenastih vratila i zamajaca na dosednim klinovima.

S tim u vezi treba imati u vidu i činjenicu da prilikom balansiranja kolenastih vratila i zamajca, izvršeno je nedopustivo veliko proširivanje rupa na sva tri predmetna zamajca motora za dosed klinova na kolenasto vratiloma. Prečnici otvora na zamajcima su veći od prečnika klinova na kolenasto vratiloma i po 5mm, iako sklop klin na kolenastom vratilu-otvor na zamajcu mora da bude u tolerantnom polju H/h.

Zbog neophodnosti remontovanja motora D12A-525, a prema radnom nalogu, pristupilo se montaži motora D12A-525 sa kolenastim vratilom broj 11682/17445 i zamajcem broj 23645/17817.



Slika 33. Kolenasto vratilo 11682/17445 -pogled na termički oštećen ležaj povratnog ventila i prvi rukavac kolenastog vratila
Figure 33. Crankshaft 11682/17445-view of the thermally damaged non-return valve bearing and the first crankshaft sleeve

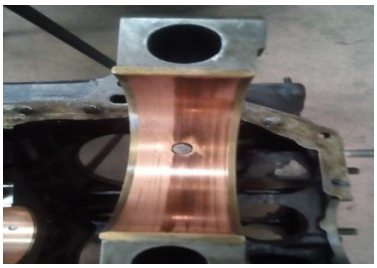


Slika 34. Kolenasto vratilo 11682/17445 - pogled na deo kolenastog vratila sa pokretnim masama
Figure 34. Crankshaft 1682/17445-view of the crankshaft section

Slika 35. Kolenasto vratilo 11682/17445 -pogled na oštećeni prvi rukavac kolenastog vratila i zapušeni otvor za dovod maziva
Figure 35. Crankshaft 11682/17445 -view of the damaged first crankshaft arm and clogged lubricant supply port

Slika 36. Zamajac 23645/17817 -pogled na oznaku-broj zamajca
Figure 36. Flywhel 23645/17817 - view of the mark

Slika 37. Kolenasto vratilo 11682/17445 -pogled na zapušenom otvoru dovoda maziva prvog rukavca kolenastog vratila
Figure 37. Crankshaft 11682/17445 - view of the clogged lubricant supply opening of the first crankshaft arm



Slika 38. Pogled na neoštećeni ležaj kolenastog vratila 11682/17445
Figure 38.View of undamaged crankshaft bearing

Tokom ispitivanja remontovanog motora (sa kolenastim vratilom broj 11682/17445 i zamajcem broj 23645/17817), a tokom povećanja broja obrtaja posle razradnog režima od 4 sata i rashlađivanja u režimu rada bez opterećenja, pri povećanju broja obrtaja došlo je do neuobičajenih vibracija u motoru, pada pritiska ulja, povećanja temperature, pojave gustog belog dima, curenja ulja,...

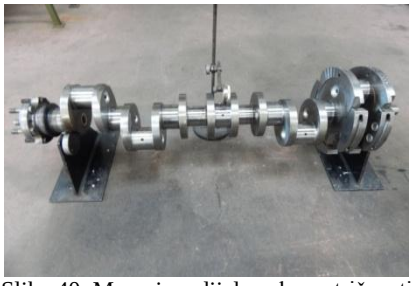
Nakon demontaže predmetnog motora, a posle pojave prethodno opisanog otkaza, utvrđeno je da su nastala identična oštećenja na motoru kao i pri ispitivanju ovog motora sa kolenastim vratilom broj 90325/76700 i zamajac broj 80254/174684.

Uočeni su isti otkazi: Oštećenja motora na mestu radijalno-aksijalnog ležaja kolenastog vratila i oštećenje povratnika ulja; Došlo je do skidanja belog metala sa ležajeva i zapušenja otvora za podmazivanje na najopterećenijem rukavcu kolenastog vratila (slike:33,34);

Došlo je do oštećenja povratnika ulja (slika 33); Došlo je do termičkog naprezanja rukavca i ležajeva (slika 33); Došlo je do oštećenja radioaksijalnog ležaja; Došlo je i do pojave belog dima.

3.2. Merenje ekscentričnosti i odstupanja od dozvoljenog standarda

Slika 39. Merenje radijalne ekscentričnosti
Figure 39. Measurement of radial eccentricity



Slika 40. Merenje radijalne ekscentričnosti
Figure 40. Measurement of radial eccentricity

Slika 41. Merenje radijalne ekscentričnosti
Figure 41. Measurement of radial eccentricity

Slika 42. Merenje radijalne ekscentričnosti
Figure 42. Measurement of radial eccentricity

UZROCI I POSLEDICE NASTALIH OŠTEĆENJA MOTORA PRI ISPITIVANJU SA UGRAĐENIM DELOVIMA

1. Delovi predmetnih sklopova: sklop kolenastog vratila broj 90325/7600 i zamajca broj 80254/174684, sklop kolenastog vratila broj 11682/17445 i zamajca broj 23645/17817, sklop kolenastog vratila broj 26121/176849 i zamajca broj 52714/17495, nisu novi, već korišćeni delovi.

Na zupcima svih predmetnih zamajaca (sa brojevima: 80254/174684, 23645/171817; 52714/174495), vidljivi su tragovi eksploatacije ovih zamajaca, i to sa velikim oštećenjima i deformacijama njegovih zubaca, što jasno upućuje na zaključak da svi predmetni zamajci, ne samo da ne odgovaraju predmetnim kolenasto vratiloma (sa brojevima: 90325/76700, 11682/17445, 26121/176849, respektivno), već su i deformisani i oštećeni, što znači da nisu novi.

2. Delovi predmetnih sklopova (kolenasto vratilo - zamajac) nisu "upareni", i ne odgovaraju jedan drugome. "Pasoši uparenosti kolenastog vratila i zamajca" nisu originalni.

Prema važećim homologacionim propisima, delovi za prvu ugradnju moraju biti homologovani, kao i delovi koji služe u procesu održavanja kao rezervni delovi, a to znači da zadovoljavaju određene tačno definisane homologacijske propise i standarde. Delovi za prvu ugradnju, kao i delovi za održavanje, moraju biti u istom kvalitetu. Nepostojanje originalnih pasoša uparenosti predmetnih sklopova, odnosno njihovih vernih kopija, a što je propust dobavljača i isporučioca predmetnih sklopova, kao i verovanje korisnika da će ovi ključni dokumenti biti naknadno dostavljeni od strane dobavljača, doveli su do dileme pri odlučivanju po pitanju prijema pristiglih sklopova, a potom i do ugradnje sklopova u motor i njihovom ispitivanju, kada je dolazilo do havarije, na isti način, i po istom mehanizmu dva puta.

3. Priložene kopije "Pasoša uparenosti" predmetnih sklopova (kolenasto vratilo i zamajaca) nisu verodostojni i ne odgovaraju stvarnom stanju stvari. Nisu priložene ni overene kopije originala "Pasoša uparenosti", koje bi eventualno mogle biti "zamena" za originalne "Pasoše uparenosti". U praksi, uz ovakve sklopove, obavezno se dostavljaju originalni pasoši uparenosti sklopova: rukavac- zamajci. To je obaveza proizvođača.

4. Na zamajcima jasno se vidi da su vršene korekcije njihovih oznaka (slike: 15,26,28), što je posebno "interesantan" detalj koji mnogo govori o "uparenosti" sklopova: kolenasto vratilo - zamajac. Korekcije oznaka na zamajcima nisu smele da se vrše, i ovaj "detalj" zaslužuje posebnu pažnju.

5. Do havarije, koja je nastala pri ispitivanju motora D12A 525 na probnom stolu, uz poštovanje precizno definisane procedure, kada je u motor ugrađen sklop koji čini kolenasto vratilo broj broj 90325/7600 i zamajca broj 80254/174684 (sa ovim sklopom je došlo do pojave prve havarije motora), došlo je isključivo zbog neuravnoteženosti i nepostojanja određene geometrije i zadovoljenja određenih geometrijskih parametara i rasporeda masa sklopa kolenasto vratilo-zamajac, a što je kasnije i potvrđeno od strane firma koja je preuzela obavezu da to proveri.

6. Do havarije , koja je nastala pri ispitivanju motora D12A 525 na probnom stolu, uz poštovanje precizno definisane procedure, kada je u motor ugrađen sklop kolenastog vratila broj 11682/17445 i zamajca broj 23645/17817 (sa ovim sklopom je došlo do pojave druge havarije motora), došlo je isključivo zbog neuravnoteženosti i nepostojanja

određene geometrije i zadovoljenja određenih geometrijskih parametara i rasporeda masa (neuravnoteženosti) sklopa kolenasto vratilo-zamajac.

Do ove (druge) havarije motora, kada je u njemu bio ugrađen sklop rukavac-zamajac: došlo je iz istih razloga kao i pri pojavi prve havarije, i to po istom mehanizmu, i na isti način kao pri pojavi prve havarije.

Uzrok pojave ove havarije je, kao i pri pojavi prve havarije, neuravnoteženost sklopa rukavac-zamajac.

7. Pri montaži sklopova u motor D12A 525, a koji su predmet analize u ovom radu, ugrađivao pravilno, po precizno definisanoj proceduri, i profesionalno pristupio procesu ispitivanja ovog motora na probnom stolu sa sklopom kolenasto vratilo-rukavac (kolenasto vratilo broj broj 90325/7600 i zamajca broj 80254/174684), a potom i sa sklopom kolenasto vratilo-rukavac (kolenasto vratilo broj 11682/17445 i zamajac broj 23645/17817).

8. Rezervni delovi (kolenasto vratilo i rukavci), nisu zadovoljavali propisane uslove, i po tom osnovu nisu trebali da budu preuzeti od strane korisnika. To je i predložila, sa punim pravom, i to u prvom koraku pri prijemu, i komisija za prijem. Suština je da na osnovu nepostojanja originalnih pasoša uparenosti predmetnih sklopova, odnosno verodostojnih dokumenata koji potvrđuju da priložene kopije pasoša uparenosti su verne originalu, predmetni sklopovi su trebali da budu vraćeni dobavljaču.

9. Merna i kontrolna oprema, koja se koristi u firmi, koja je preuzela obavezu da analizirane rezervne delove privede nameni, nije baždarena i kalibrisana, što je po postojećim propisima obavezno. Korišćenje takve merne i kontrolne oporeme izaziva opravdanu sumnju u njenu tačnost, ali i opravdanost upotrebe. Za svaki kontrolni i merni uređaj mora da postoji važeći dokument (uverenje o ispravnosti i etaloniranju) koji je izdala ovlašćena akreditovana laboratorija.

10. Merna i kontrolna oprema, koja je korišćena u firmi koja je vršila ispitivanje motora sa rezervnim delovima koji su predmet ove analize , je baždarena i kalibrisana, što je po postojećim propisima obavezno.

Korišćenje takve merne i kontrolne oporeme omogućuje tačnost pri merenju i kontrolisanju, ali i opravdanost upotrebe te opreme.

Za svaki kontrolni i merni uređaj postoji važeći dokument (uverenje o ispravnosti i etaloniranju) koji je izdala ovlašćena akreditaciiona laboratorija.

Firma koja je vršila ispitivanje motora poseduje uverenja o ispravnosti i etaloniranju celokupne merne i opitne opreme, koju koristi.

11. Firma koja je preuzela obavezu da sklopove koji su predmet ove analize, "privede nameni", odnosno da ih dovede u takvo tehničko stanje da oni zadovoljavaju potrebne i dovoljne uslove za ugradnju u predmetne motore, to nije uradila.

Nedostaci na sva tri predmetna sklopa: rukavci - zamajac (sklop kolenastog vratila broj 90325/7600 i zamajca broj 80254/174684, sklop kolenastog vratila broj 11682/17445 i zamajca broj 23645/17817 i sklop kolenastog vratila broj 26121/176849 i zamajca broj 52714/17495) nisu otklonjeni u ovoj firmi, posle nastanka prve havarije pri ispitivanju na probnom stolu predmetnog motora D12A 525 sa sklopom kolenastog vratila broj 90325/7600 i zamajca broj 80254/174684.

Merenjem je utvrđeno da escentričnost na četvrtom rukavcu kolenastog vratila broj 11682/17445 ima vrednost 0,16 mm. Dozvoljeno je od strane proizvođača da može biti maksimalno 0,06 mm.

Merenjem je utvrđeno da ne postoji usaglašenost prečnika otvora na zamajcima i prečnika klinova na kolenastim vratilima, i to na svim sklopovima koji su predmet ove analize, a kako je propisao proizvođač.

Posebno treba imati u vidu da je sklop klin na kolenastom vratilu i njemu odgovarajućeg otvora na zamajcu mora biti u tolerantnom polju H/h.

Nedopustiva je tvrdnja, da dimenzije klinova i njihovih dosednih otvora nisu bitne.

Merenjem je utvrđeno da ne postoji usaglašenost geometrijskih parametara rezervnih delova, koji čine predmetne sklopove, sa propisanim od strane proizvođača. Ne postoji usaglašenost stanja uravnoteženosti predmetnih sklopova sa postojećim standardom.

Posebno je pitanje pravilnog uzimanja, i na pravilan način, u obzir pri uravnotežavanju predmetnih sklopova, funkcije i delovanja pokretnih masa - tegova za uravnotežavanje koji su sastavni deo kolenasto vratilo (slike 10, 18).

Tačnost uravnotežavanja ovakvih složenih sistema, i realizovanih postupaka "privođenja nameni" sklopova koji su predmet ove analize, nije obavljen na primeren način, a saglasno predmetnoj problematici i postojećim standardima.

12. Probni sto, na kome su ispitivani predmetni motori D12 sa sklopom kolenastog vratila broj 90325/7600 i zamajca broj 80254/174684, kada je došlo do havarije pri prvom ispitivanju predmetnog motora, i sa sklopom kolenastog vratila broj 11682/17445 i zamajca broj 23645/17817, kada je došlo do havarije pri drugom ispitivanju predmetnog motora, ima ugrađen kalibrisani davač (slika 2), koji osigurava minimalni pritisak od 6 bara tokom ispitivanja motora, što garantuje normalno podmazivanje ispitivanih motora.

Ukoliko bi pritisak u predmetnom motoru, a pri ispitivanju na opitnom stolu, a sa ugađenim sklopovima koji su predmet analize, pao ispod vrednosti od 6 bari, probni sto bi prestao sa funkcionisanjem (to je iz siguronosnih razloga).

13. Proverom celokupne dokumentacije (radni nalozi, trebovanja, prateći listovi, mikrometražni kartoni, lista zamenjenih materijala, defektacione liste, i sagledavanjem kompletne predmetne problematike, moglo se zaključiti da je ispitivanje predmetnog motora, od strane tužioca, obavljeno profesionalno i uz poštovanje svih protokola i preporuka proizvođača.

14. Tokom analize, utvrđeno je da sklop kolenastog vratila broj 26121/176849 i zamajca broj 52714/17495, ne zadovoljavaju potrebne i dovoljne uslove za ugradnju u predmetni motor, te ukoliko bi se ugradili u motor i pristupilo se ispitivanju, došlo bi do pojave havarije, po istom mehanizmu, kao i pri ispitivanju prethodna dva sklopa koja su ranije ugrađivana u ovaj motor pri ispitivanju, kada je došlo do prve, odnosno druge havarije.

15. Greške i nepravilnosti ne treba pripisivati firmi koja je vršila remontovanje predmetnih motora, a koja se držalo svih propisanih procedura ispitivanja, koristila adekvatnu ispitnu, mernu i kontrolnu opremu, i nije imao propusta u radu sa sklopovima koji su predmet ove analize.

Naručilac rezervnih delova (firma koja je remontovala motore), opravdano je od isporučioca tražio: da rezervni delovi moraju biti novi, nekorišćeni, da se isporučuju kao gotovi proizvodi, da u potpunosti odgovaraju fabričkim brojevima, oznakama i standardima iz tehničke specifikacije, da budu isporučena u originalnim pakovanjima i originalnoj ambalaži.

Isporučilac, prilikom isporuke rezervnih delova bio je dužan da dostavi tehničku dokumentaciju kojom se dokazuju tehnički deklarisane karakteristike analiziranih rezervnih delova.

16. Sagledavajući detaljno i temeljno celokupnu predmetnu problematiku, može se zaključiti da su propusti nastali:

- Na strani dobavljača iz sledećih razloga: Nabavka starih korišćenih rezervih delova; Nabavka nekompatibilnih kolenasto vratilo i zamajaca bez obaveznih dokaza o kompatibilnosti istih (bez originalnih "pasoša" uparljivosti);
- Na strani firme koja nije uspela da otkloni neispravnosti (odnosno privede nameni) sklopove koji su predmet ove analize (a za koje je prvo utvrdila da ne odgovaraju nameni), a koje je, u dogovoru sa naručiocem i dobavljačem, prihvatila.

ZAKLJUČAK

Od kvaliteta rezervnih delova u velikoj meri zavisi kvalitet remontovanih dizel motora.

Posle remontovanja dizel motora izrazito velike snage, obrtnog momenta i zapremine motora, došlo je do pojave otkaza delova koji su ugradjeni kao novi, a pri ispitivanju na probnom stolu.

Nakon ponovne ugradnje novih rezervnih delova, došlo je do ponovljene pojave otkaza motora po istom mehanizmu i sa istim posledicama.

U radu su dati rezultati istraživanja kvaliteta delova koji se koriste pri remontovanju dizel motora. Prikazana je analiza uzroka pojave havarija dizel motora, kao i izgled predmetnih rezervnih delova pšre i posle remontovanja motora.

Posle ugradnje rezervnih delova: kolenastog vratila broj 90325/76700 (slike 5, 6) i zamajca broj 80254/174684 (slike 7, 8) u motor D 12A-525 (slika 1), motor je postavljen na probni sto (slika 3 i slika 4) radi provere funkcionalnosti i kvaliteta obavljenog remonta.

Posle vrlo kratkog vremena rada (4,5 minuta), i to bez opterećenja, i pri 800 min^{-1}, došlo je do pojave havarije motora. Pristupilo se demontaži motora i analizi uzroka pojave havarije.

Kompleti kolenasto vratilo-zamajac upućeni su u firmi koja je konstatovala da postoji višestruka neuravnoteženost rezervnih delova: kolenasto vratilo-zamajac, i koja je pristupila "dovodjenju nameni" istih.

Posle dovodjenja sprovedenih postupaka korekcije rezervnih delova ("dovodjenju nameni" istih), pristupilo se remontovanju motora D 12A-525 ugradnjom drugog kompleta rezervnih delova: kolenasto vratilo (slike 9,10,16)-zamajac (slike 11,12,13,14,15), kod koga su sprovedeni korektivni postupci i njihovo uravnotežavanje.

Motor je postavljen na probni sto i pristupilo se, prema precizno definisanoj proceduri, otpočinjanju procesa ispitivanja motora. Na probnom stolu, došlo je do havarije motora posle 4 sata rada bez opterećenja, i to po istom mehanizmu nastanka.

Posle demontaže motora utvrdjena su ista oštećenja kao i pri prvom ispitivanju.

Sa trećim kompletom (slike 17,18) kolenasto vratilo-zamajac (slike 19,20,21,22, 23,24) nije vršen remont motora jer je konstatovano da po kvalitetu ne odgovaraju ugradnji u motor koji je potrebno remontovati.

Može se konačno zaključiti, da odgovornost za nastala oštećenja, do kojih je došlo tokom ispitivanja motora D 12A-525, treba pripisati, dobavljaču rezervnih delova.

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RESEARCH OF THE INFLUENCE OF SPARE PARTS QUALITY ON THE WORK OF A REPAIR DIESEL ENGINE

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Abstract: When repairing the internal combustion Diesel engine, a set of spare parts was installed : crankshaft-flywheel. After the overhauol, the engine was tested on a test bench. After a very short time of operation, an engine failure occurred. Re-overhaul was started, with another set of spare parts: crankshaft-flywheel.

After a short time of operation, there were recurrences of engine failures, according to the same mechanisms of occurrence.

***Key words**: motor, maintenance, failure*

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OPTIMIZATION OF BIO-LUBE PRODUCTION USING THE AUTOMATED FUZZY LOGIC CONTROLLED TEMPERATURE BIOREACTOR AND D-OPTIMAL DESIGN

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Abstract: Optimization of process parameters of many existing biolubricant were carried out based on the factor interactions and yield without putting the physicochemical properties into consideration. The aim of the work is to optimize the reaction temperature and time for the production of high-quality biolubricant using set objectives in relation to the physicochemical properties of the bio-lube produced. The reactor used consists of a reactor tank (2500 cm^3), temperature, time, stirrer (agitation), speed ranged between 0 – 300 ^oC, 0 – 120 minutes and 80 – 500 rpm respectively. The optimum temperature and time design matrix using Response Surface Methodology (D-optimal design) in Design Expert 11.0 software package. The results of the optimized yield of the castor seed oil biolubricant produced were compared with international standards for lubricant. The result shows better yield in the operational process of the fuzzy logic-controlled reactor. The yield of biolubricant for the experimental design matrix produced using the fuzzy logic reactor ranged between 79 – 96 %. Higher values were obtained from the study, except for the pour point values that were lower. The higher yield and the physical and thermal properties in castor oil biolubricant from the fuzzy logic temperature-controlled reactor could be as result of the uniform temperature and reaction time during the production process. The optimum condition for the bio-lube produced considering the optimum set goals for best quality biolubricant produced considering the set goal objective to comprise all the physico-thermal properties obtained in the study.

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The optimum condition was obtained at ninety-nine (99.5) minutes reaction time and 250 ^{o}C reaction temperature with desirability value of 0.76. with the physico-thermal properties of 96.48 %, 33.7 mPa.s (33.7 cP), 15.5 mPa.s (15.5 cP), 179.9 ^{0}C, 291 ^{0}C, 15.9 ^{0}C, for viscosity at 40 ^{o}C, viscosity at 100 ^{o}C, viscosity Index, Flash point, pour point. The physicochemical properties of biolubricant produced at optimum condition are within the recommended international standard. It can be concluded that the fuzzy logic-controlled reactor product is better biolubricant considering the number of parameters set goal to determine the optimum condition for production.

***Key words**: Bio-lube, D-optimal, Numerical, Physico-thermal, Point-prediction*

INTRODUCTION

Engine oil is prominent amongst the most widely recognized lubricants and well utilized in engineering concepts. Conventional lubricants produce a non-clean, highly toxic working environment due to the burning of lubricant as fuel to generate power. Basic disposal strategies which incorporate recycling, copying, landfill and release into water, is one of the major constraints in developing countries [1], [2].

Research has been conducted to have environmentally friendly lubricants that can be used in place of the conventional lubricants which are called biolubricant [3]. The best application for biolubricant is in machinery that loses oil directly into the environment during use, Total Loss Lubricants (TLLs), and in machinery used in any sensitive areas, such as in or near water. Applications for TLLs include two-stroke engines, chain saw bars and chains, railroad flanges, cables, dust suppressants, and marine lubricants [4], [5].

MATERIAL AND METHODS

The experimental design used for the synthesis of castor oil bio lubricant was optimized with the aid of response surface methodology (RSM) using D-optimal design approach. This methodology is used to scrutinize the relationship between the response variable and a set of experimental factors. A polynomial equation was used to predict the response as a function of independent variables and their interactions. In this work, the number of independent variables was two and therefore the response for the quadratic, cubic polynomials become $Y = ß0 + \Sigma ßi\ xi + \Sigma ßii xi^2 + \Sigma\Sigma ßij\ xi\ xj$ (1). Where *ß0*; *ßi*; *ßii* and *ßij* are constant, linear, square and interaction regression coefficient terms, respectively, and xi and xj are independent variables Table 1. The design expert software version 11 was used for multiple regression analysis, analysis of variance (ANOVA), optimization analysis set goals data and the response surface regression procedure. The lack of fit of the model was evaluated by the coefficient of determination R^2, adjustable $R^2$and its statistical significance that was checked by the P-value and *F*-test. Automated Fuzzy Logic Controlled Temperature Bioreactor was used for all the reactions [6].

Table 1. Independent Variables and Their Levels for Response Surface Methodology, D-Optimal Design Response Surface methodology for the Transesterification Reaction of castor oil ester

Independent variables	Variable Levels		
		-1	+1
Time	X_1	30	120
Temperature	X_2	100	250

The experimental factors for this experiment are temperature and time. The two (2) experimental factors were used to establish the number of experimental runs which was given as 13 runs. The details of the factor – levels and values obtain using RSM are as presented in the design matrix Table 2.

Table 2. Experimental matrix design for the optimization of the Transesterification reaction process for biolubricant production

Coded factor			Actual factor	
Run	X_1: Time	X_2: Temperature	X_1: Time	X_2: Temperature
1	-1.00	-1.00	30	100
2	-0.11	-0.15	70	164
3	1.00	0.33	120	200
4	0.00	-1.00	75	100
5	0.47	1.00	96	250
6	0.62	-0.25	103	156
7	-0.25	0.57	64	218
8	-1.00	0.00	30	175
9	-0.61	-0.50	48	138
10	-1.00	-1.00	30	100
11	-1.00	1.00	30	250
12	1.00	-1.00	120	100
13	-1.00	1.00	30	250

Characterization of castor oil biolubricant

Physicochemical properties of castor oil biolubricant were carried out using the American Standard Testing Methods [8]. The main properties of lubricant oil required for good performance were carried out.

These properties are:

1. Determination of Acid Value and Free Fatty Acid

One gram (1g) of oil was placed inside 100ml beaker, 25ml of petroleum ether with 25ml of alcohol (methanol) was added, 4 drops of phenolphthalein was added as an

indicator and mixed thoroughly, after that, the solution was titrated against 0.1M KOH until the end point was reached that is there was colour change which turn to pink. [6].

The Acid Value and Free Fatty Acid (mgKOH/g) was calculated as:

$$Acid\ Value = \frac{Titre\ (ml)\ x\ 0.1\ x\ 56.10}{Weight\ of\ Sample\ (1g)}$$

$$Free\ Fatty\ Acid = \frac{Acid\ Value}{2}$$

2. Determination of viscosity and Viscosity Index (VI)

Viscosity of the oleo-chemicals was determined using a viscometer. Two hundred millilitres (200ml) of the sample was poured into a beaker and heated to 40 ^{0}C and 100 ^{0}C respectively. A desired rotor number of the viscometer was attached to the upper coupling between the thumb and forefinger while cautiously rotating the rotor in anticlockwise direction. The rotor was immersed in the middle of the sample up to the indentation level on the shaft.

The viscometer was then switched and let to run at 60 rpm. The result was obtained and recorded as the viscosity of the sample in mPa s (cP) [9].
The result at 40 ^{0}C and 100 ^{0}C was used to calculate the Viscosity Index

$$Viscosity\ Index\ (VI) = \frac{L - U}{L - H} x\ 100$$

3. Determination of Pour Point

This was measured according to ASTM D97. A medium sized test tube was filled with the oil sample and (the test tube with its content) then be placed in a test tube holder. The set up was then placed in a refrigerator and allowed to solidify. After it solidified, the test tube was removed and a thermometer was used to read the temperature of the solidified sample.

4. Flash Point Determination

heat was supplied to a 10ml of the sample in crucible to raise the temperature of the sample. A thermometer probe was suspended in the sample with a retort stand. The flash point obtained was the minimum temperature at which the vapour of the sample ignited when a flame was brought near [10].

RESULTS AND DISCUSSION

Castor oil methyl ester (biodiesel) feed stock was used in production biolubricant using response surface methodology, D-optimal experimental design.

The response of the experiment as presented in Table 3 shows the different actual factor-levels and their corresponding actual yield in percentage and the physico-thermal properties. [8].

Table 3. Response analysis of biolubricant Yield and physicothermal properties

	Factor 1	Factor 2	Response 1	Response 2	Response 3	Response 4	Response 5	Response 6
Run	A: Time	B: Temperature	Biolubricant Yield	Viscosity @40	Viscosity @100	Viscosity index	Flash Point	Pour point
1	30	100	79	31	7.5	166.282	275	-18
2	70	164	84.5	35	10	173.839	269	-15
3	120	200	91	37	12	175.612	281	-16
4	75	100	84	32	9	174.904	269	-19
5	96	250	96	34	18	176.365	294	-15
6	103	156	86.5	30	11	182.823	288	-15
7	64	218	88	32.5	14	180.643	290	-16
8	30	175	83	35	10	173.839	285	-14
9	48	138	81	37	12	175.612	277	-17
10	30	100	79	32	8.5	172.152	263	-19
11	30	250	94	37.5	15	176.43	285	-14
12	120	100	83	34	9	171.073	260	-18
13	30	250	93	33	13	180.163	291	-15

A numerical, graphical and privative optimization method was used to analyze the data collected from two process parameters (Time and Temperature) to generate the best operational conditions that will convene all goals set (Table 4). To obtain the desirability index for biolubricant produce with relation to the investigated physicochemical properties qualities. Goals were set for each condition and properties at maximum, minimum and in-range for castor oil biolubricant produced.

Table 4. Numerical Optimization Constraints for Biolubricant Produced

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
A:Time	is in range	30	120	1	1	3
B:Temperature	is in range	100	250	1	1	3
Biolubricant Yield	maximize	79	96	1	1	3
Viscosity @40	minimize	30	37.5	1	1	3
Viscosity @100	maximize	7.5	18	1	1	3
Viscosity index	maximize	166.282	182.823	1	1	3
Flash Point	maximize	260	294	1	1	3
Pour point	minimize	-19	-14	1	1	3

The predicted result shows that operational condition that gave fourteen desirability solution the best confidence interval in terms of physico-thermal properties and biolubricant yield are 96.48 %, 33.7 mPa.s (33.7 cP), 15.5 mPa.s (15.5 cP), 179.9 ^{0}C, 291 ^{0}C, -15.9 ^{0}C, respectively for biolubricant yield, viscosity at 40 ^{0}C, Viscosity at 100 ^{0}C, viscosity index, flash point and pour point (Table 5). The desirability with functional object which vary between 0 and 1 with relation to all parameter goals set on the numerical optimization, the selected desirability condition value of the two available solution for the castor oil biolubricant yield and physicochemical properties was 0.76 was the highest desirability value with time and temperature condition of 99.5 minutes and 250 ^{0}C respectively.

Table 5. Numerical Optimization desirability Solutions of the produced Biolubricant

Num	Time	Temp.	Biolub. Yield	Viscosity @40	Viscosity @100*	Viscosity index	Flash Point	Pour point	Desirability
1	99.54	250.00	96.48	33.70	15.50	179.90	291.00	-15.8	0.76
2	99.86	250.00	96.49	33.71	15.56	179.91	291.00	-15.8	0.76
3	99.31	250.00	96.47	33.70	15.49	179.89	291.01	-15.8	0.76
4	100.79	250.00	96.53	33.73	15.51	179.93	290.99	-15.8	0.76
5	98.32	250.00	96.43	33.67	15.48	179.87	291.02	-15.8	0.76
6	97.78	250.00	96.41	33.66	15.47	179.85	291.03	-15.8	0.76
7	102.01	250.00	96.58	33.76	15.53	179.97	290.97	-15.8	0.76
8	104.36	250.00	96.67	33.83	15.57	180.03	290.94	-15.9	0.75
9	93.12	250.00	96.22	33.58	15.41	179.72	291.08	-15.8	0.75
10	91.41	250.00	96.15	33.55	15.38	179.68	291.10	-15.8	0.74
11	108.74	250.00	96.83	33.98	15.63	180.15	290.89	-15.9	0.73
12	88.76	250.00	96.04	33.52	15.35	179.60	291.14	-15.7	0.72
13	110.70	250.00	96.90	34.05	15.69	180.20	290.87	-15.9	0.71
14	85.93	250.00	95.92	33.50	15.31	179.53	291.17	-15.7	0.69

*Intervals adjusted for variation in the factors (POE).

The solutions within one and eight can be considered usable all depending on the properties rely on biolubricant grade. The responses optimisation is comparable to research work by [11], that the Jatropha bio-lubricant yield increased with increase in temperature over time variation.

Graphical optimisation Overlay plot in Figure 1 shows the coefficient magnitudes and significance for all analysed responses in the numerical optimisation solution of the experimental factors that makes it easy to see what terms are common to all the response models, displays the area of feasible response values in the factor space.

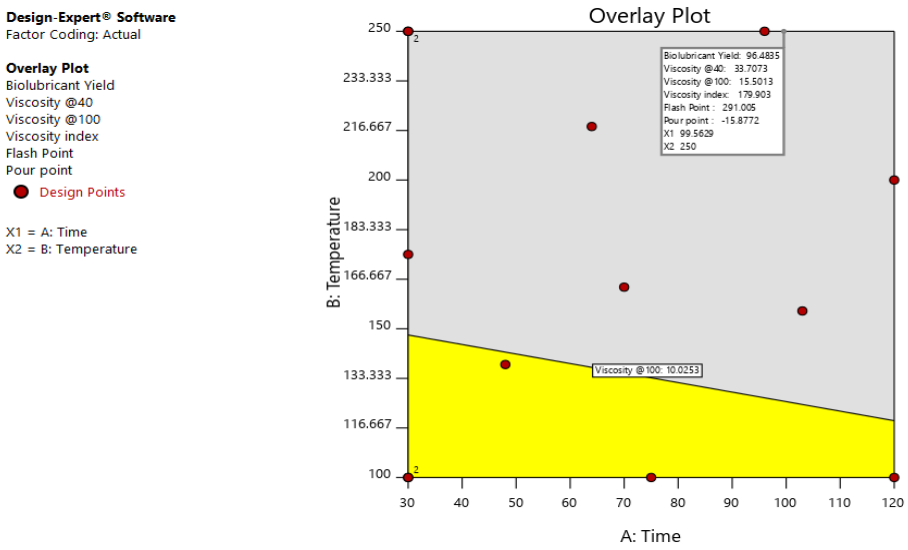

Figure 1. Optimisation Overlay plot of biolubricant in relation to Temperature and Time

On the plot, the bright yellow points range between temperature of 100 – 148 ^{0}C with time of 30 to 120 minutes shows where the entire range of all intervals of the produced biolubricant meet the specified standards that best conciliation can be picked (the sweet spot). The dray colour corresponds to where the point estimate meets the criteria requirements, but part of an interval estimate does not. The standard best conciliation shows that the reaction of the biolubricant will be best done at the sweet spot zone considering only the experimental factors, while the dray shot in consideration of all the tested parameters of the produced castor oil biolubricant. The point prediction of produced biolubricant (Table 6) shows the two-sided points (low and high) of the experimental responses to assist in the uses of prediction and interval estimates at a confidence interval of ninety five percent. The predicted mean, median, standard deviation of all the responses was within standard biolubricant.

Table 6. Point Prediction of produced castors oil biolubricant properties

Response	Predicted Mean	Predicted Median	Std. Dev	SE Mean	95% CI low for Mean	95% CI high for Mean	95% TI low for 99% Pop	95% TI high for 99% Pop
Biolubricant Yield	97.2138	97.2138	1.325	1.59	93.43	100.98	87.75	106.67
Viscosity @40	34.4622	34.4622	2.686	3.23	26.81	42.11	15.28	53.64
Viscosity @100	15.7904	15.7904	1.430	0.95	13.65	17.92	8.183	23.39
Viscosity index	180.462	180.462	3.618	2.42	175.0	185.86	161.22	199.70
Flash Point	290.756	290.756	6.699	4.48	280.7	300.74	255.13	326.37
Pour point	-15.946	-15.946	0.907	1.09	-18.5	-13.36	-22.42	-9.470

Two-sided Confidence = 95% Population = 99%

CONCLUSIONS

The research statistical data analysis clearly shows that the responses parameters as significant effect on the optimization process of castor oil biolubricant as the overlay point shows the sweet spots range of 100-148 ^{0}C temperature with time of 30 to 120 minutes with prediction mean biolubricant yield of 97.21 % and the optimization process desirability function of both the factors and the responses have biolubricant yield of 96.4 % at desirability of 0.76 at 250 ^{0}C temperature with time of 99.5 minutes. But the desirability optimisation gives the optimisation in terms of best quality of biolubricant.

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OPTIMIZACIJA PROIZVODNJE BIOMAZIVA KORIŠĆENJEM AUTOMATIZOVANE FUZZY LOGIČKE KONTROLE TEMPERATURNOG BIOREAKTORA SA D-OPTIMALNIM DIZAJNOM

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Sažetak: Optimizacija procesnih parametara mnogih postojećih biomaziva izvršena je na osnovu interakcije faktora i prinosa bez uzimanja u obzir fizičkohemijskih osobina biomaziva. Cilj rada je optimizacija temperature, reakcije i vremena za proizvodnju visokokvalitetnog biomaziva pomoću postavljenih ciljeva u odnosu na fizičkohemijske osobine proizvedenog biomaziva.

Reaktor ima parametre: rezervoar od 2500 cm^3, temperature od 0 do 300^oC, vreme reakcije od 0 do 120 minuta, i brzinu mešanja koja se kretala 80 - 500 rpm .
Matrica optimalnog dizajna temperature i vremena, kontroliše se primenom metodologije optimalne površine (D-optimalni dizajn) sa softverskim paketom Design Ekpert 11.0.
Rezultati optimizovanog prinosa proizvedenog biomaziva od ricinusovog ulja upoređivani su sa međunarodnim standardima za maziva.
Rezultat pokazuje bolji prinos u operativnom procesu logički kontrolisanog reaktora.
Prinos biomaziva dobijen sa dizajnom eksperimentalne matrice, proizvedenog pomoću fuzzy reaktora, kretao se između 79 - 96%. Dobijene su veće vrednosti iz studije, osim vrednosti tačke prelivanja, koje su bile niže. Veći prinos, fizička i termička svojstva u biomazivu od ricinusovog ulja iz reaktora sa fuzzy (nepreciznom) kontrolom, mogu biti rezultat ujednačene temperature i vremena reakcije tokom proizvodnog procesa. Iz studije su dobijene veće vrednosti, osim vrednosti za tačke prelivanja koje su bile niže.
Veći prinos i fizičko- termičke osobine za biomazivo ricinusovog ulja iz reaktora sa fuzy kontrolom temperature mogu biti rezultat ujednačene temperature i vremena reakcije tokom proizvodnog procesa.
Optimalni uslov za proizvedeno biomazivo uzimajući u obzir optimalno postavljene ciljeve za najkvalitetnije proizvedeno biomazivo, uzimajući u obzir postavljeni cilj koji treba da obuhvati sve fizičko-termičke osobine koje su dobijene u studiji.
Optimalni uslovi su dobijeni u toku 99,5 minuta vremena reakcije i temperature u reaktoru od 250^oC, sa poželjnim vrednostima od 0,76., i fizičko-termičkim osobinama od: 96,48%, 33,7 mPa.s (33.7 cP), 15,5 mPa.s (15.5 cP), 179,9^0C, 291^0C, -15,9^0C, za viskozitet biomaziva na 40^oC, za viskozitet na100^oC, indeks viskoznosti, tačku paljenja, tačku tečenja biomaziva.
Fizičko-hemijske osobine biomaziva proizvedenog u optimalnim uslovima su u okviru preporučenih međunarodnih standarda.
Može se zaključiti da je produkt sa fuzzy logikom (neprecizna logika) kontrolisane proizvodnje reaktora, bolje biomazivo, obzirom na broj postavljenih kontrolisanih parametara za određivanje optimalnih uslova proizvodnje.

Ključne reči: *Biomaziva, D-optimalni dizajn, Numeričko, Fizičko-termičke osobine, tačkasto predviđanje*

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DEVELOPMENT OF AN ALGORITHM FOR PRODUCTIVE USE OF THE IRRIGATED LAND

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Abstract: The studies have established that the yield of winter wheat variety «Chillyaki» on an area of 5 hectares averaged 5.5 t/ha, corn – 2.89 t/ha, mung – 2.08 t/ha, potatoes – 0.59 t/ha, melon – 9.74 t/ha, rice – 4.36 t/ha, marks – 14.64 t/ha. The total profit from the sale of wheat is 423.750,00 UZS, and the net profit is 254.250,00 UZS, 129.000,00 UZS were spent per hectare of re-crops cultivation. The largest net profit comes from rice cultivation after wheat harvest, followed by corn and mung bean, and melon comes the third one, raw cotton is in the last place.

Keywords: *level groundwater, mineralization, irrigation, variety, yield.*

INTRODUCTION

Today, about 12.3% of the main cultivated areas in the world are irrigated, basically all the food products for the needs of the mankind are cultivated in these areas. The protection of these areas from erosion for many countries of the world located in the regions with a dry climate is an urgent problem. Today 1.094 million hectares or 56% of the area in the world are subject to irrigation erosion.

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The main area subject to degradation is located in the countries of Asia, Africa, South America. The damage caused by the irrigation erosion is up to 12-42 billion per year in the United States, and worldwide it's up to 400 billion.

In the world practice of agriculture on lands confirmed by erosion, special interest is paid to conducting research on sowing winter wheat with various methods of soil cultivation and improving the agricultural technology of its cultivation, effective use of the mineral fertilizers and obtaining high yields, in this way, reducing the washout of soil aggregates and improving soil agroecology.

The studies carried out to improve the ecological state of soils, preserve their fertility, increase the grain yield of winter wheat, which are relevant and serve to provide the population with food, are of particular interest.

In the recent years, the structure of crops in Uzbekistan has dramatically changed, i.e. almost 50% of the irrigated area is occupied by grain crops. After harvesting grain crops (depending on the availability per year), part of the vacated area is used for double crops. However, it has not yet been precisely established which of the crops are more economical when sowing. To solve this issue, we carried out some experiments on the territory of the Dustlik farm in the Besharyk district of the Fergana region.

LITERATURE REVIEW

Science and practice of the advanced farms have proven that the rational use of the irrigated land, obtaining the largest amount of products per unit area while saving labor and means of production and improving soil fertility is achieved on the basis of correct crop rotations, sowing repeated crops with progressive agricultural techniques and extensive mechanization of the agricultural work. In the cotton crop rotations the main components are alfalfa, corn, sorghum, winter crops and intermediate and secondary crops (rapeseed, rye, early maturing corn, mung bean, rice, carrots, melon and other legumes).

In the conditions of the irrigated typical sierozem of the Tashkent region, the option with sowing corn for silage and re-sowing corn together with alfalfa turned out to be the most highly productive one. For both options, 81.6 t/ha of silage mass (22357 fodder units) or 5 times (512%) more in comparison with pure sowing of alfalfa were obtained [1, 2].

In the conditions of the irrigated typical sierozem and meadow soils of the Khatyrchinskaya group of areas of the foothill plains, an increase in the yield of fodder per unit area can be achieved by obtaining two yields of corn together with peas for silage and stubble peas for green mass. According to the data, on the irrigated lands of the Zarafshan Valley, corn together with peas of early spring sowing provides 78.29 t/ha, and double peas 54.53 t/ha of green mass (21266 fodder units) or 25-30 times more compared to the pure sowing of alfalfa [10, 11].

Among sorghum-sowing countries, the United States occupies a leading position both in terms of the area under crops of about 6 million hectares and almost in yield. In the warm climate of the irrigated agriculture in the Central Asia, corn and sorghum are a powerful reserve for increasing production of the concentrated and succulent fodder.

It is difficult to overestimate the role of leguminous crops in the system of cotton-row crop rotation as a protein component and source for increasing soil fertility.

It is recommended (for non-alfalfa crop rotations) to sow forage crops in such combinations as peas for grain + corn for silage during the first year and corn for grain with peas during the second year. Such combinations provide 23 thousand of fodder units and 1440 kg of protein totally within two years [3, 4, 16].

In the conditions of the irrigated light sierozem of the Zarafshan Valley, peas for grain and stubble corn for grain yield 34.2 thousand fodder units and 3152 proteins [12, 17].

Increasing protein production is impossible without expanding soybean crops. Soybean grain contains 30-40% of protein, amino acids, which are absorbed by 90%, 17-27% of fat, 25-27% of carbohydrates, vitamins and phosphates. In Uzbekistan soybeans can be sown as a double crop.

In cotton-growing fogs after harvesting a number of major crops before the first frost, usually occurring in the last decade of October, frost-free days with an average air temperature of 20-24º are enough for growing soybeans for grain and green fodder. This is confirmed by the experiments conducted on the cultivation of soybeans in the conditions of Turkmenistan, in the conditions of Samarkand, Kashkadarya and Jizzakh regions of Uzbekistan, on meadow soils, on the newly developed lands of the Kyzylkum massif, on newly developed desert-sandy soils [8, 9, 13, 15, 20].

In the conditions of the irrigated typical sierozem of the Tashkent region it was revealed that from winter rye sown in the first half of October after two machine harvests and the selection of raw cotton after loosening between the beds, 26.8-33.6 t/ha of green mass were obtained. After plowing the rye, corn was sown. On average, for two years, the corn grain yield in the control plot was 6.98, against the background of rye 8.04 t/ha, silage mass 53.15 and 61.00 t/ha. The possibility of cultivating intermediate double crops (rye, rapeseed, oil radish) in the crop rotation system in various cotton growing zones has been widely and comprehensively studied in the former All-Union of SRICG (All-Union scientific and research institute of cotton growing), TIIAME (Tashkent Institute of Irrigation and Agricultural Mechanization Engineers) and other scientific and research institutes [5, 6, 18, 19, 22].

As you know, crop rotations should first of all contribute to a progressive improvement in soil fertility and an increase in the yield of the main crop of cotton, and now of grain crops.

Organic debris left by plants in the soil, being the main energetic material for microbiological activity, has a noticeable effect on the physical, agrochemical and biological properties of soil.

The main source of the organic matter in the soil is root system and crop residues. Both annual and perennial crops are capable to accumulate organic matter in the soil. The material factor gives stable strength to the soil structure.

Mould is a source of food for plants. Humic substances (mould) are actively involved in the initial stages of soil formation, contributing to the biological weathering of minerals and rock destruction. The elements necessary for the nutrition of microorganisms and higher plants are extracted from the minerals. The strongest destructive effect is exerted by sulfonic acids and some low-molecular decomposition products of organic residues - organic acids, amino acids, etc., aqueous solutions that have a strongly acidic reaction [23].

The removal of elements, necessary for plant nutrition and soil structuring, from the soil profile depends on the content and composition of humus.

Humic substances are the main accumulator of soil nitrogen - the most important element of plant nutrition.

In addition to nitrogen, humus accumulates a number of ash elements used for plant nutrition: phosphorus, potassium, iron, calcium, and other macro and microelements, which are released during the decomposition of humus.

The scientists have found that some preparations of humic acids contain tens of times more cobalt and copper, 3-5 times more manganese and 20 times more zinc than the original soils from which these preparations were obtained.

When humus decomposes under the conditions of good aeration and sufficient humidity, large amounts of carbon dioxide enter the presoil layers of the atmosphere, which plays an important role in enhancing photosynthesis of the organic substances (vitamins, antibiotics, enzymes) directly stimulating plant growth and development.

Having studied the yield of cotton varieties: «Namangan-77», «Yulduz», «Gulsara», «Termiz-31» under the conditions of the desert zone of the Kashkadarya region of the Kasan region and the Surkhandarya region of the Dzharkurgan region as the main and secondary crop [21], the following recommendations were given for the production:

5-7 irrigations, depending on the year, should be carried out according to the scheme 1-3-1, 1-2-2, with the mode 70-70-60% and 2-4- 1, 2-3-2 at a soil moisture regime of 75-75-60% for the varieties «Namangan-77» and «Termiz-31». The irrigation rates at 70-70-60% moisture content are 930-1370 m^3/ha, irrigation rates are 5470-6150 and 6190-6370 m^3/ha, respectively.

Thus, the scientists have performed certain works for the effective use of the irrigated lands, but the issues have been studied separately: agricultural techniques of the first and double crops separately. On the experimental field with an area of 5 hectares, wheat variety «Chillaki» was sown; after harvesting the wheat, double crops were cultivated according to the following scheme: 4 cotton varieties («Tashkent-6», «Omad», «S-4727», «Andijan-34») , rice (arpasholi), mung bean, corn variety «Uzbekistan-306», potatoes and melon (variety «Kirkma»).

MATERIALS AND METHODS

The influence of this method on the dynamics of the growth of the varieties «Tashkent-6», «Omad», «S-4727», «Andijan-34», rice (Arpasholi), mung bean, corn variety «Uzbekistan-306», potatoes and melon (variety «Kirkma») for a high yield was observed in the soils with a groundwater level of 1-3 m and a mineralization of 1-3 g/l. The field experiments were carried out in accordance with the methods «Methodology of State Variety Testing of Agricultural Crops», «Methods of Agrochemical, Agrophysical and Microbiological Research in the Irrigated Cotton Regions», «Methodology of Field Experiments with Cotton», Statistical processing of experimental data was carried out according to the method of B.D. Dospekhova using the Microsoft Excel program.

RESULTS AND DISCUSSION

The meteorological conditions are the following: the atmospheric temperature should be favorable to seedlings, further growth and development of wheat.
The effective temperature in the reporting year was higher than the multiyear one. The double crop was sown at the end of June, and the average effective temperature from July to October was 34.8 °C. However, it should be noted that the average effective temperature for wheat growth, from July to October, was not sufficient for opening the boll of the above-mentioned early ripening varieties of cotton.

The soil texture of the experimental plot is light loamy on top, medium loamy on the bottom. The bulk density of the soil of the experimental plot is not entirely favorable for the normal growth and development of plants, but the presence of aryl and shook in the horizons led to an increase in the weight by volume. The layering of the soil-ground part also led to a change in HB (the lowest moisture capacity) - from top to bottom, the moisture content gradually increases (Table 1).

Table 1. Volume weight and the lowest moisture content of the soil of the experimental plot

Depth, cm	Volume weight, g/cm^3	HB, %
0-10	1.36	16.3
10-20	1.38	17.1
20-30	1.39	18.7
30-40	1.41	19.8
40-50	1.43	22.3
50-60	1.44	23.5
60-70	1.46	25.2
70-80	1.47	25.9
80-90	1.47	26.3
90-100	1.48	27.2
		HB_{cp}.= 22.2%

Water permeability during first hour is strong, but then it decreases sharply (Table 2).

Table 2. Water permeability of soil of the experimental plot

Hours	mm/min	m^3/ha
1	143.7	1437
2	39.8	398
3	32.4	324
4	25.3	253
5	18.2	182
6	14.9	149
Total during 6 hours	274.3	2743

The soils of the experimental plot are very poor in nitrogen, phosphorus and potassium. To obtain high yields with good quality high fertilization rates are required (Table 3).

Table 3. Mobile forms of nutrients

Horizons, cm	$N\text{-}NO_3$	P_2O_5	K_2O
Wheat variety «Chillyaki»			
0-30	18.9	21.4	160
30-50	15.6	12.0	100

Analysis of the water extract shows that the soils of the experimental plot belong to the categories of low salinity (Table 4).

Table 4. The content of the water extract, (%)

Horizons, cm	HCO_3	CI	Sa_4	Ca	Mg	Na	K	Saline amount	Solid
0-30	0.027	0.017	0.123	0.035	0.021	0.005	0.002	0.230	0.262
30-50	0.027	0.014	0.079	0.030	0.012	0.005	0.002	0.169	0.187

Watering was carried out with the determination of cell sap using a hand-operated refractometer OC-101, when at 12 o'clock the concentration of cell sap reached 8.3-9.2%.

The phenological observations show (Table 5) that at the beginning of the 3rd decade of April, the height of wheat reached 45 cm, tilling capacity was 4.6% per 1 m^2.

Table 5. Growth and development of the winter wheat

Variety	Height, cm	Tilling capacity, units.	Density of planting , $1m^2$ units.
Chillyaki	45.2	4.6	78.3

Wheat indicators are given in Table. 6. The yield of wheat variety "Chillyaki" on the area of 5 hectares averaged 5.50 t/ha.

Table 6. Wheat indicators

Wheat variety	Quantity of plants for $1m^2$, units.	Height, cm	Number of grain in the spike	Weight 1000 of grain, g	Weight of grain for $1m^2$, g	Yield, t/ha	
						Grain	Chaff
Chillyaki	127.3	72.4	35.8	39.4	667.1	5.50	7.75

The growth and development of cotton are given in Table 7, 8. The recording carried out on October 25 shows that among the tested varieties of cotton, Tashkent-6 turned out to be more productive, but it should be noted that there were no open bolls on the date indicated above. The conclusion is that the cotton variety "Tashkent-6" should be sown earlier.

Table 7. Growth and development of cotton for 1 of August

Cotton variety	1-replication		3-replication	
	Height, cm	Amount of leaflets, units.	Height, cm	Amount of leaflets, units.
Tashkent-6	12.5	5.5	11.5	4.2
Omad	15.4	6.3	12.1	5.4
C-4727	15.1	5.8	11.3	4.4
Andizhan-34	13.8	4.9	8.7	3.9

Table 8. Growth and development of cotton for 1 of September

Cotton variety	1-replication					3-replication				
	Height, cm	Fruit spurs, units.	Flower bud, units.	Flower, units	Sets, units.	Height, cm	Fruit spurs, units.	Flower bud, units.	Flower, units	Sets, units.
Tashkent-6	56.2	9.1	8.8	1.2	0.5	61.2	8.9	10.1	1.1	0.8
Omad	72.7	11.4	14.5	1.9	2.0	75.6	12.9	16.1	1.5	2.1
C-4727	71.0	10.2	12.7	0.95	0.5	70.3	9.9	11.1	1.2	-
Andizhan-34	76.0	13.4	11.3	0.1	-	77.1	13.3	12.1	0.31	-

The yield of the double crops is given in Table 9, from which it can be seen that there were no open bolls, so it was impossible to harvest the cotton. Among the crops tested, maize, mung bean, rice, carrots and melon yielded satisfactory results.

Table 9. Double crops yield, t/ha

№	Name of the crop	Replication			Average
		I	II	III	
1	Tashkent-6	The bolls didn't open			
2	Omad	The bolls didn't open			
3	C-4727	The bolls didn't open			
4	Andizhan-34	The bolls didn't open			
5	Corn	2.93	2.87	2.89	2.89
6	Mung	2.12	2.07	2.04	2.08
7	Potatoes	0.55	0.61	0.62	0.59
8	Melon	9.78	9.81	9.63	9.74
9	Rice	4.41	4.35	4.32	4.36
10	Carrots	14.26	14.20	14.26	14.64

The total profit from the sale of wheat is 423,750.0 UZS, and the net profit is 254.250,00 UZS, 129.000,00 UZS were spent of double crop cultivation per hectare. The largest net profit was obtained from rice cultivation after harvesting wheat, then from corn and mung bean, the third place is taken by melon, raw cotton is in the last place.

CONCLUSIONS

On the basis of the field and production experiments, it can be concluded that under the conditions of the Fergana Valley, it is quite possible to grow two crops during one growing season, and this is very important for the valley region. After sowing double crops, where mung bean, melon and carrots were grown, the yield was 2.99, 3.02, 3.17 t/ha, respectively, and a large volume of raw cotton was obtained.

This work was carried out in accordance with the priority directions of the development of science and technology (agriculture, biotechnology, ecology and environmental protection) of the Republic of Uzbekistan.

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RAZVOJ ALGORITMA ZA PRODUKTINO KORIŠĆENJE NAVODNJAVNOG ZEMLJIŠTA

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Sažetak: Istraživanjima je utvrđeno da je prinos sorte ozime pšenice *«Chilliaki»* na površini od 5 ha u proseku iznosio 5,50 t/ha; kukuruza 2,89 t/ha; boba 2,08 t/ha; krompira 0,59 t/ha, dinje 9,74 t/ ha, pirinača 4,36 t/ha, šargarepe 14,64 t/ ha.
Ukupna dobit (Uzbekistan valuta – UZS) kod prodaje pšenice je 423.750,00 UZS, a neto dobit 254.250,00 UZS, potrošeno je 129.000,00 UZS/ha kod obrade zemljišta za nove useve. Najveća neto dobit je redosledom kod: proizvodnje pirinča, žetve pšenice, kukuruza i boba mung. Manja dobit je kod proizvodnje dinja, dok je dobit kod proizvodnje sirovog pamuka, najmanja, i na poslednjem mestu.

Ključne reči: *nivo podzemne vode, mineralizacija, navodnjavanje, sorta, prinos.*

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SIMBOLIČKO PREDSTAVLJANJE HIDRAULIČKIH AGREGATA I SISTEMA

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Sažetak: Efikasan prenos energije od proizvoljnih tipova primarnih izvora i/ili energetskih pretvarača do odgovarajućih upravljačkih jedinica i/ili potrošača može predstavljati manje ili više kompleksan proces. Analogno ostalim granama savremene tehnike, prenos energije u poljoprivrednoj mehanizaciji potrebno je veoma pažljivo sprovoditi, primenjujući optimizirana tehnička rešenja u svakom pojedinačnom slučaju. To (između ostalog) podrazumeva prenos energije koji je tehnički, tehnološki, ekonomski i ekološki usklađen sa često teško predvidivim dinamičkim potrebama komponenata sistema i krajnjeg potrošača, uz prihvatljive gubitke - najmanje moguće u širokoj lepezi mogućih okruženja definisanih najrazličitijim mogućim uslovima.

Ovaj rad predstavlja nadgradnju serije posvećene simboličkom grafičkom predstavljanju komponenata hidrauličkih sistema prema važećim tehničkim standardima.

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Rad je deo aktivnosti projekta *"Unapređenje biotehnoloških postupaka u funkciji racionalnog korišćenja energije, povećanja produktivnosti i kvaliteta poljoprivrednih proizvoda"*, broj TR 31051, Ministarstvo prosvete, nauke i tehnološkog razvoja Republike Srbije. Ugovor o realizaciji i finansiranju naučno-istraživačkog rada u 2021 između Poljoprivrednog fakulteta u Beogradu i Ministarstva prosvete, nauke i tehnološkog razvoja Republike Srbije, evidencioni broj 451-03-9/2021-14/200116.

U tom smislu, u tekstu su prikazani i funkcionalno opisani samo neki od mnogo većeg skupa tipičnih primera hidrauličkog prenosa energije i pripadajućih upravljačkih funkcija u savremenoj poljoprivrednoj tehnici.

***Ključne reči**: hidraulika, poljoprivredna tehnika, simbol, sistem, agregat, šema*

UVOD

Hidraulički sistemi [10, 11, 12,] široko se primenjuju u industrijskoj proizvodnji, kod građevinskih (buldozeri, kranovi, kopači, utovarači), rudarskih i poljoprivrednih mašina (traktori, kombajni, sejalice, kosačice, drvosekači), šinskih, putnih i vanputnih vozila, kod prenosnika snage, kočionih sistema, upravljačkih i drugih pratećih sistema, kao i sistema oslanjanja na podlogu). Imaju primenu i kod vozila posebne namene (viljuškari, mikseri za beton, kamioni za komunalni otpad, razne platforme za prevoz vozila), letelica, u brodogradnji, najrazličitijim nehumanih oružanih sistema, energetici, pa sve do mašina za obradu metala i plastike (mašine alatke, mašine za valjanje limova, izvlačenje limova, ekstruduranje proizvoda od plastike, u čeličanama, livnicama) itd.

Svaki od ovih sistema čine razne hidrauličke komponente, namenjene za regulaciju, kontrolu, prenos energije, merenja i obavljanje raznih izvršnih funkcija. Povezuju se u najrazličitije funkcionalno povezane i usklađene celine radi izvršavanja jednog ili vise predviđenih radnih zadataka. Navedene komponente se proizvode kao pojedinačni elementi, ili već grupisane komponente u manju ili veću funkcionalnu grupu (celinu).

Složenost detaljnog prikazivanja hidrauličkih sistema u formi klasičnih tehničkih crteža može predstavljati ozbiljan problem. Zato se pojedinačne hidrauličke komponente obavezno grafički prikazuju u formi simbola definisanih određenim tehničkim standardima. Time se olakšava analiza sistema, razumevanje funkcionalnih veza između njihovih komponenata, redovno održavanje i eventualne popravke kvarova u sistemu. Simboli komponenti, koje se najčešće koriste u tehničkoj praksi, prikazani su u literaturi i nekim radovima [1-5, 7, 11, 13, 14, 15].

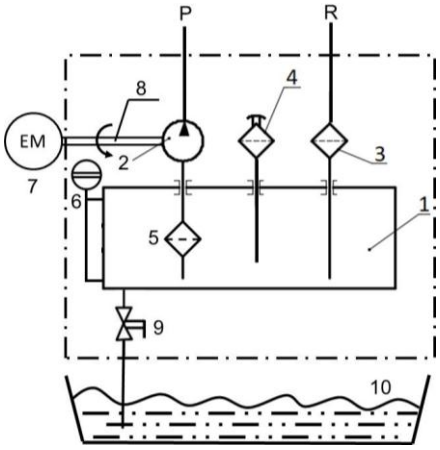
OSNOVE ULJNIH HIDRAULIČKIH AGREGATA

Prema većini priznatih definicija, hidraulički agregati se mogu predstaviti kao manje ili više jednostavni fabrički sklopovi osnovnih hidrauličkih komponenti, sastavljeni u funkcionalnu celinu sa zajedničkim zadatkom da olakšaju i ubrzaju montažu, funkcionalnu nadogradnju i održavanje celokupnog pripadajućeg hidrauličkog sistema. Mada navedeni agregati mogu biti veoma jednostavni, ne predstavljaju previše redak izuzetak ili hidraulički agregat složene konstrukcije, kako po ugrađenim hidrauličkim komponentama, tako i po složenosti operativnih zadataka koje obavljaju.

Agregat prikazan simbolički (slika 1), modifikovan je prema literaturi [6]. Uključuje u svoj sastav niz različitih hidrauličkih komponenata: rezervoar (1), po pravilu manjeg kapaciteta, glavne pumpe (2), filtera povratnog voda (3), grubog prečistača i otvora za dolivanje ulja sa oznakom i zatvaračem (4), finog usisnog filtera pumpe (5), i indikatora nivoa ulja u rezerzervoaru (6).

Glavna potisna pumpa (2) je krutom mehaničkom vezom (8) povezana sa pogonskim elektromotorom (EM) ili motorom sa unutrašnjim sagorevanjem (SUS), i potiskuje radnu tečnost prema ostatku pripadajućeg hidrauličkog sistema i jednom ili više potrošača (potisni cevovod P). Povratni cevovod hidrauličkog ulja prema rezervoaru obeležen je sa oznakom R (*engl. return flow*).

Pražnjenje i ispiranje glavnog hidrauličkog rezervoara se ostvaruje pomoću hidrauličkog ventila (9) sa sedištem, koji iskorišćeno ulje prosleđuje (ispušta) u mobilno korito (10) odakle se šalje na obnavljanje (prečišćavanjne), odnosno reciklažu.



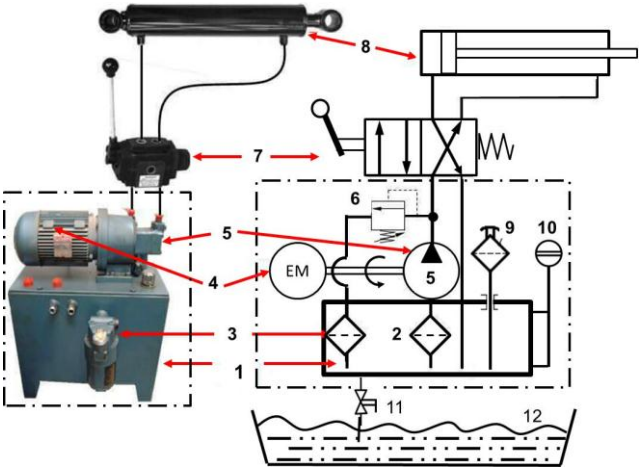
Slika 1. Hidraulička šema jednostavnog agregata, adaptirana prema literaturi [6]:
1-rezervoar,2-pumpa, 3- filter povratnog toka R, 4-otvor za dolivanje ulja u rezervoar sa zatvaračem i grubim filterom, 5-uljni fini filter usisnog voda glavne pumpe, 6-indikator nivoa ulja u rezervoaru, 7-pogonski elektromotor pumpe, 8- mehanička veza pumpe i elektro-motora,
P-potisni vod pumpe prema ostatku sistema i potrošačima i R-povratni cevovod ulja iz sistema u rezervoar.

Figure 1. Symbolic hydraulic schema of a simple aggregate, adapted from the reference [6]:
1-reservoir, 2-pump, 3-filter of the return oil flow – pipe R, 4-top-up filling opening of the reservoir with raw oil filter and cover, 5- fine oil filter of the pump suction line, 6-oil level indicator, 7-power engine of the hydraulic pump, 8-mechanical connection between the hydraulic pump and elekromotor, P–high-pressure pipe line from the pump toward the rest of hydraulic system and consumers, and R-pipeline returning the low pressure oil from the system to reservoir.

Na slici 2 uporedno su prikazani fotografija i pripadajuća hidraulička simbolička šema agregata relativno slične namene. Agregat (slika 2), slične je konstrukcije, koja odogvara simboličkoj šemi, a ugrađen je u hidraulički sistem za upravljanje kretanjem klipa i klipnjače hidrauličkog radnog cilindra dvostranog dejstva (8). Ovaj hidraulički agregat u svom sastavu, uokviren je standardizovanom pravougaonom iscrtanom linijom tipa crta-tačka-crta, sadrži: rezervoar (1) radne tečnosti (hidrauličkog atestiranog ulja), usisni fini uljni predfilter pumpe (2), glavnu pumpu zapreminskog tipa (5), uljni filter povratnog toka (3), kao i pogonski elektromotor (4), ventil za ograničenje pritiska (6), filter sa poklopcem za dopunu rezervoara (9).

Hidraulički razvodnik sa četiri priključka, dva radna položaja i upravljanjem sa ručicom i oprugom za vraćanje u normalni položaj upravlja radom cilindra (7).

Po dostizanju krajnjeg (levog ili desnog) položaja klipa radnog cilindra, pritisak u sistemu raste dok ne dostigne granični pritisak pri kome se otvara ventil za regulaciju pritiska i višak tečnosti sprovodi od pumpe direktno nazad u rezervoar. Time se klip održava u željenom položaju, a sistem istovremeno štiti od preopterećenja.



Slika 2. Agregat u sistemu za upravljanje hidrauličkim radnim cilindrom dvostranog dejstva – modifikovano prema [7]: 1-rezervoar, 2-uljni predfilter pumpe, 3-povratni filter, 4-elektro-motor, 5-hidraulička pumpa, 6-prelivni ventil, 7-hidraulički razvodnik sa dva radna položaja i ručnim upravljanjem, 8-radni cilindar sa klipom dvostranog dejstva, 9-filter sa poklopcem za sipanje i dolivanje ulja, 10-indikator nivoa ulja u rezervoaru, 11-ventil sa sedištem za ispiranje rezervoara i 12-korito za upotrebljenu hiddrauličku tečnost za recikliranje

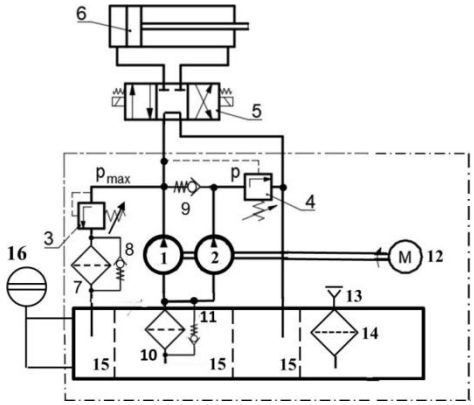
Figure 2. Aggregate in a control system of hydraulic cylinder- modified [7]:
1-reservoir, 2-oil filter, 3-return flow filter, 4-elektromotor, 5-hudraulic pump, 6-relief valve, 7-directional control valve, 8-hydraulic cylinderwith piston, 9 oil filter with inlet top cover, 10-indicator of oil level in the reservoir, 11-poppet valve and 12- waste oil recirculation tank.

Agregati ove vrste spadaju u grupu jednostavnih hidrauliličikih sklopova, a uglavnom se primenjuju za podršku i nalaze se u sastavu hidrauličkih sistema koji sadrže manje količine hiradruuljičkog ulja i ne zahtevaju posebno i precizno održavanje temperature i čistoća ulja. Najčešće se primenjuju za pogon pomoćnih dizalica ili za hidrauliku kočionog sitema automobila i drugih manjih drumskih vozila [6]. Radi lakše uočljivosti, kao što je i slučaj predstavljen na slikama 1 i 2, agregati se (po uobičajenom pravilu) na hidrauličkim šemama po pravilu uokviruju pravougaonicima iscrtanim linijama tipa crta-tačka-crta.

Ilustracije radi, (slika 2) uporedno su prikazani fotografija i kompletna hidraulička simbolička šema primene agregata relativno slične namene kao na slici 1. Agregat (slika 2) je složenije konstrukcije, i ugrađen je u sistem za upravljanje kretanjem klipa i klipnjače hidrauličkog radnog cilindra dvostranog dejstva (8).

Agregat sadrži rezervoar (1) radne tečnosti (hidrauličkog ulja), fini usisni uljni filter ispred pumpe (2), uljni filter povratnog toka (3), pumpu stalnog protoka (5), sa pogonskim elektromotorom (4), ventil za ograničenje pritiska (6), filter sa poklopcem za sipanje i dolivanje ulja (9) i indikator nivoa ulja u rezervoaru (10).

Hidraulički razvodnik (7) sa četiri priključka, dva radna položaja i ručnim upravljanjem sa ručicom i fleksibilnom oprugom za vraćanje u normalni položaj (6) upravlja, radom cilindra (8). Po dostizanju krajnjeg (levog ili desnog) položaja klipa radnog cilindra, pritisak u sistemu raste dok ne dostigne granični pritisak pri kome se otvara ventil za regulaciju pritiska i višak tečnosti sprovodi od pumpe direktno nazad u rezervoar. Tako se klip održava u željenom položaju a sistem istovremeno štiti od preopterećenja.



Slika 3. Simbolička šema hidrauličkog agregata i sistema za promenu brzine kretanja klipa radnog hidrauličkog cilindra dvostranog dejstva [6,8]: pumpa 1-visokog i 2-niskog pritiska, 3-prelivni ventil, 4-redosledni ventil, 5-tropozicioni diferencioni razvodnik, 6-radni cilindar dvostranog dejstva sa elektromagnetnim dvostranim upravljanjem, 7- fini filter ulja povratnog voda, 8-9-11 nepovratni ventili, 10-zajednički usisni predfilter ulja pumpi-1, visokog i niskog-2 pritiska, 12-pogonski EM ili SUS motor hidrauličkog sistema, 13-otvor sa poklopcem za sipanje i dolivanje radnog hidrauličkog ulja, sa 14-pratećim grubim filterom, 15-sabilizaciona mrežica - pregrada, 16-pokazivač nivoa ulja u glavnom rezervoaru.

Figure 3. Symbolic scheme of the hydraulic aggregate and the system for speed variation of double action piston of the working hydraulic cylinder [6,8]: 1-high and 2-low pressure pump, 3-way relief valve, 4-sequential order valve, 5-three position directional valve, 6-double side acting cylinder with solenoid two-way control, 7-fine oil filter in the retutn line oil flow line,
8-9-11 non-return valves, 10-joint suction pre-filter of the 1-high and low-2 pressure pump,
12-power drive EM or SUS engine of the hydraulic system, 13-hole with cover for filling and topping up the working hydraulic oil, with 14-accompanying coarse filter,
15-sabilizinig reservoir nets, 16-oil level indicator in the main tank.

Za prilagođavanje brzine kretanja klipa hidrauličkog radnog cilindra dvostranog dejstva može se upotrebiti agregat (slika 3.) Pored toga, litertura [6], [8], koji sadrže dve (ili više) paralelno vezanih hidrauličnih pumpi pokretanih zajedničkim ili nizom pogonskih elektro-motora nalaze primenu u operativnoj upotrebi.
Namena agregata ovoga tipa je promena brzine klipa hidrauličkog radnog cilindra (6), kao izvršnog organa.

To se ostvaruje pravovremenoim hidrauličkim isključivanjem i/ili uključivanjem pojedinih pumpi agregata i pripadajućih sistema. Navedeni zadatak ostvaruju hidraulički razvodni i redosledni ventili, što za neposrednu posledicu ima promenu ukupnog protoka hidrauličke radne tečnosti u cilindar. Navedeni tehnički zadatak, usmeren na ostvarivanje promenljive brzine kretanja klipa hidrauličnog cilindra, može se rešiti i na drugi način.

To podrazumeva ugradnju skuplje pumpe promenljivog kapaciteta, čemu se pribegava uglavnom samo kod naprednijih i/ili kompleksnijih hidrauličkih sistema.

U agregat (slika 3) su u tu svrhu ugrađene dve pumpe stalnog protoka, čime je omogućeno ostvarivanje tri različita protoka prema potrebama radnog cilindra kao krajnjeg potrošača. Glavna pumpa (1) ostvaruje visoki pritisak ulja, a druga pumpa (2) pritisak manjih vrednosti, čime je omogućeno podešavanje brzine kretanja klipa u skladu sa spoljašnjim mehaničkim opterećenjem klipnjače: veća brzina odgovara manjem spoljašnjem mehaničkom opterećenju, a manja brzina većem opterećenju .

Kada je klip hidro-cilindra pod većim opterećenjem, samo glavna pumpa visokog pritiska (1) šalje ulje ka cilindru, dok druga pumpa (2) vraća ulje u rezervoar. Uključivanje pumpe visokog pritiska (1) obavlja razvodni ventil sa elektromagnetnim upravljanjem (5) u krajnjem desnom položaju, a isključivanje pumpe (2) obavlja redosledni ventil (4). Kada cilindar počinje da se puni uljem obe pumpe potiskuju ulje ka cilindru, sve dok pritisak ne dostigne određenu vrednost *(p)* pri kome se redosledni ventil (4) otvara da usmeri strujanje iz pumpe (2) prema rezervoaru. Od tog trenutka, pumpa (1) samostalno nastavlja da potiskuje ulje dok klip ne dođe do krajnjeg položaja. Ceo sistem, uključujući i agregat, od prekoračenja pritiska štiti sigurnosni prelivni ventil (3) koji se otvara ako pritisak u sistemu prekorači maksimalnu dozvoljenu vrednost, i propušta radno ulje kroz filter povratnog voda nazad u rezervoar.

Uključenjem elektro sklopke elektromagnetnog ventila dolazi do pomeranja razvodnika u levo, u centralnu poziciju, koja odgovara mirovanju klipa. Tada su obe pumpe rasterećene, jer je napojni vod kratko spojen na rezervoar. Ponovnim aktiviranjem upravljačkog elektromagneta razvodnog ventila, taj ventil se dovodi u krajnju levi položaj i time obezbeđuje povratni hod klipa. Pri povratnom kretanju klipa, pritisak radnog ulja opada, tako da redosledni ventil šalje ulje prema cilindru.

Savremena poljoprivredna, građevinska i rudarska mehanizacija i tehnika je danas nezamisliva bez široke primene elektronski kontrolisanih hidrauličkih sistema spregnutih sa mehaničkim elementima prenosa snage i upravljanja [2, 9, 10, 11, 12-16].

ZAKLJUČAK

Primenom hidrauličnih sistema, globalno se podiže stabilnost i pouzdanost u radu konstrukcionih rešenja poljoprivrednih, građevinskih i rudarskih mašina.

Razvoj novih standardizovanih komponenti od pumpi, preko razvodnika, ventila, do radnih cilindara i ostalih hidrrauličkih komponeneti, praktično omogućava primenu hidraulike i kod konstrukcija gde nije do sada očekivano, kao na primer prema literatururi [9-16] gde se redovno nalaze hidrostatička transmisija, prenosnici snage, kočioni sistemi, itd.

Ovaj rad predstavlja nastavak serije radova o "Hidrauličkim simbolima" u više delova [1-5], pod različitim nazivima.

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SYMBOLIC REPRESENTATION OF HYDRAULIC AGGREGATES AND SYSTEMS

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Summary: Efficient transmission of energy from arbitrary types of primary sources and/or energy converters towaward appropriate control units and/or consumers can be a more or less complex process.

In analogue to other existing branches of modern technology, energy transfer in agricultural machinery needs to be carried out very carefully, applying optimized technical solutions in each specified case. This factcts, (among many other problems) implies energy transmission that is technically, technologically, economically and environmentally aligned with the often difficult to predict dynamic needs of system components and the end user, with acceptable losses - at least in a wide range of possible environments defined by various possible conditions. This paper is the first upgrade of the series dedicated to the symbolic graphic representation of hydraulic system components according to valid technical standards. In this sense, the text presents and functionally describes only some of the much larger set of typical examples of hydraulic energy transmission and associated control functions in modern agricultural technology.

Key words: *hydraulics, agricultural engineering, symbol, system, aggregate, schema*

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