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Hydraulic System of JD 955 Combine Harvester as Well as Presented Services based on Statistical Analysis

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ABSTRACT

The JD 955 combine harvester manufactured by ICM. Company has two hydraulic circuits which are the principal circuit (dividing valve circuit) and the steering circuit. Therefore, investigation and inspection of defects of the hydraulic system used in combine, considering its functions in the machine is so significant. In this article the problems of the hydraulic system throughout JD 955 combine harvester and the way services are given for disappearing the problems, have been investigated. For this purpose some 90 combines were selected which had been supplied to the customers over the last one or two years. The 140 defects detected from their hydraulic circuits were analyzed then services supplied to the selected combines and actually after sales services were researched within some categories. Results showed that the hydraulic pump had the most problems and was spent the most expense. In addition, throughout the after sales service categories only charges of the defects had significant difference with each other. Finally some policies suggested in order to decrease and eliminate the defects.

Key words: Frequency, guarantee cost, hydraulic system, kurtosis error, priority valve

INTRODUCTION

Combine harvester is the most significant machine for harvesting agricultural crops, since recent technology has developed such a machine which can harvest a wide variety of crops from wheat and oats to peas and so on, only with some little changes in accessories in different conditions of fields (Rad, 2004). ICM. Co located in Markazi province, produce combine harvester and agricultural machinery which is the leading company in agricultural machinery over Iran and the middle east region. Nine hundred and fifty five combine manufactured by ICM Company is the most common combine in Iran so that more than 90% of combines which have been ranged in light class of combine classification are of this kind.

Nowadays, utilizing hydraulic systems in combine harvesters have extended dramatically, so that flexibility of the intended combine to a large extent depends on the performance of the hydraulic system because while working of the combine in the field it is incessantly required to increase travel speed in sparse fields and reduce it in the dense fields as well as considering the field conditions it is needed to change the platform and reel height continuously. In addition steering of the machine is provided by hydraulic system. Therefore, investigation and inspection of defects of the hydraulic system used in combine, considering its functions in the machine is so significant.

In the current article the problems of the hydraulic system throughout JD 955 combine harvester and the way services are given for disappearing the problems, have been investigated. The investigation was aimed to discover some relations for some parameters and amount of defects in the system. Determining these parameters as well as statistical study of problems of a number of combines in disperse and random statistical population, finally some policies suggested in order to decrease and eliminate the defects. Hydraulic pumps and actuators including motors and cylinders are among the most important components of a hydrostatic system (Riahee and Asnaashari, 2006). Since pumps which are well-known as the heart of a hydraulic system, flow the oil towards the actuators and they turn hydraulic force into rotary or reciprocating force, consequently displacement or rotation of the intended part is provided (Dalayeli and Madineh, 2002). The above-mentioned combine has two hydraulic circuits which are principal circuit (dividing valve circuit) and steering circuit. The principal circuit operates three actuators connecting with height control of both cutting platform and reel, also moves variable sheave in order to vary ground speed and steering circuit steers the machine. The only common point of two circuits is their pump, in which is a priority valve in order to first supply the needed oil of the steering circuit, then it delivers the rest oil to the another circuit. Other component of the circuit are thoroughly separated. Segregation of hydraulic circuits is a acceptable method but in order to achieve significant improvements in system efficiency, using a concentrated circuit is possible (Darling and Tilley, 1999). Berg (1995) elaborated the role of the marginal cost analysis (MCA) method for optimization of maintenance policies and studied the repair and replacement policy whether to repair or replace a failed item based on the repair costs.

Smidt-Destombes *et al.* (2009) developed an adjusted marginal analysis and show that it performs considerably good in numerical experiments. Neves *et al.* (2004) proposed a model considering the interaction between maintenance cost and its effect on the reliability index. Wang and Pham (2006) investigated availability, maintenance cost and optimal maintenance policies of the series system with n constituting components under the general assumption that each component is subject to correlated failure and repair, imperfect repair, shut-off rule and arbitrary distributions of times to failure and repair. Marseguerra and Zio (2000) presented an optimization approach based on the combination of a Genetic Algorithms maximization procedure with a Monte Carlo simulation. Lapa *et al.* (2006) presented a novel methodology for preventive maintenance policy evaluation based upon a cost-reliability model and optimized the preventive maintenance policies. Samatliý-Pac and Taner (2009) developed and investigated different repair strategies for one- and two-dimensional warranties with the objective of minimizing manufacturer's expected warranty cost. Kargar and Shakeri (2007) studied the culprits of defects in parts of MF285 tractor and determined the approximate statistics of its problems in Kerman province. Karim and Suzuki (2005) provided a brief survey of the literature directed towards the analysis of warranty claim data. Morris (1988) reported how records from a Norfolk farm were used to derive a repair cost function which related tractor repair cost as a percentage of initial purchase price to cumulative hours of use. Mullen and Williams (2004) exploited survey data that reported annual maintenance/repair expenditures for Canadian manufacturing industries and indicated that the cost of capital, among other variables, has a statistically significant effect on maintenance/repair decisions.

MATERIALS AND METHODS

In order to perceive the problems of the hydraulic system of 955 combine harvester as well as the way which services are presented for repairing the defects or replacement of the required parts, some surveys were performed in the agricultural year of 2009 on a number of 955 combines which were harvesting in fields to achieve the targets of the investigation. While selection combines for performing the study, it was considered to choose ones across the country so that involve all typical climates of the country. For instance from the west- North region, Adebil province which has the lowest temperature, from the south, Khuzestan province with the highest temperature and other provinces such as Khorasan, Tehran, Esfahan and so on throughout the country were selected randomly.

Finally some 90 combines were selected which had been supplied to the customers over the last one or two years. Given the complains of the combine defects from customers in the after sales service department as well as quoted problems by the mobile repairer of the company and calls made to the customers, altogether 140 defects were detected for the whole hydraulic circuits of the 90 combines. The reported complains of defects consisted of approximately all the components of the system such as hydraulic pump, reservoir and the input oil tube from reservoir to the pump which are the common ingredients of the two circuits as well as dividing valve, power steering unit, hydraulic cylinders and so on which are individual parts for each circuit. Detected problems, which were observed on the investigated combines, could be classified into 24 items. On the other hand, different parts of the hydraulic system which are awarded as guarantee for the examined combines could be classified into 14 subjects. In Table 1 classifications for the defects and the awarded guarantee presented so that numbers denotes the defects and letters denote the awarded guarantees.

The column chart shown in Fig. 1 represents frequency of each defect occurred across the studied combines. Defect numbered 1 i.e., malfunction of the hydraulic pump was the most frequent defect discovered which constitutes 67 items and is not shown in the figure. In addition, Fig. 2 presents frequency of the awarded guarantee to the studied combines and more importantly the number of hydraulic pump awarded as guarantee has again the most frequency which makes up 32 items and is not shown in the figure.

Afterwards the way in which services supplied to the selected combines and actually after sales services were researched. For this purpose, five leading categories in the domain of after sales service explored, which includes:

- Duration between delivery of the combine and customer complain
- Duration between delivery of the combine and performing services
- Working hours of the combine at the time of complain
- Working hours of the combine at the time of receiving services
- Cost of the awarded guarantee

Finally, since the gained data did not cover all the four categories for the whole 90 combines i.e., precise information regarding some services were not accessible, the achieved data analyzed.

Table 2 presents the data gained due to the complains of the combine defects from customers as well as quoted problems by the mobile repairer and so on in the domain of after sales service. Then the complained flaws were analyzed in order to identify critical points and provide some appropriate policies to eliminate and control them. So that duration between delivery of the combine and customer complain, duration between delivery of the combine and performing services, working hours of the combine at the time of complain and services and cost of the awarded guarantee were analyzed.

Table 1: Classifications for the defects and the awarded guarantee with their designated number and letter

Designated No.	Defects	Designated letter	Awarded guarantee
1	Hydraulic pump malfunction	A	Hydraulic pump
2	High-pressure pipe is defective	B	Single-valve reel cylinder
3	Steering cylinder malfunction or leakage	C	Hydraulic hose from pump to dividing valve
4	Pump gets hot	D	Steering cylinder
5	Platform cylinder malfunction	E	Accumulator
6	Reel cylinder malfunction or leakage	F	Double-valve reel cylinder
7	Accumulator	G	Forward travel cylinder
8	Hydraulic belt	H	High- pressure hydraulic pipe
9	End pin of platform cylinder	I	Hydraulic pump tube
10	Platform does not lower	J	Platform cylinder
11	Steering is not carried out	K	Steering cylinder ball joint
12	Dividing valve leakage	L	Hydraulic pump entrance fitting
13	Platform cylinder leakage	M	Repair kit for dividing valve
14	Entrance tube of pump is defective	N	dividing valve
15	Double-valve reel cylinder		
16	Hydraulic leakage		
17	Hydraulic hose defect		
18	Steering pump malfunction		
19	Forward travel cylinder defect		
20	Platform does not go up		
21	High-pressure hose is burst		
22	Warming of dividing valve		
23	dividing valve malfunction		
24	Warming of hydraulic oil		

Table 2: Data obtained in the domain of after sales service

	Cases					
	Included		Excluded		Total	
After sales services categories	N	Percent	N	Percent	N	`Percent
Period between delivery and complain * Defect	115	82.1	25	17.9	140	100.0
Period between delivery and service * Defect	72	51.4	68	48.6	140	100.0
Work time at service*Defect	63	45.0	77	55.0	140	100.0
Work time at complain*Defect	17	12.1	123	87.9	140	100.0
Charge * Defect	69	49.3	71	50.7	140	100.0

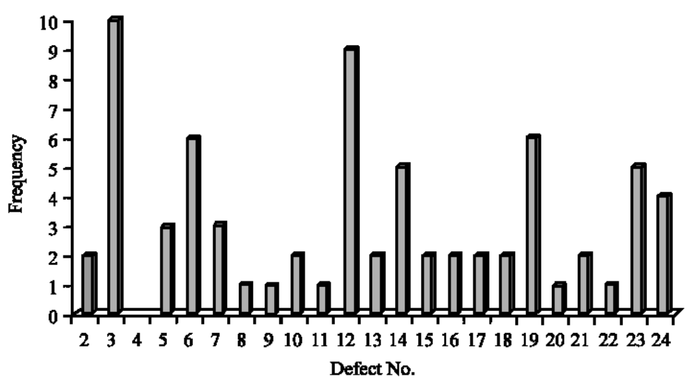

Fig. 1: Frequency of the entire defects occurred over the studied combines

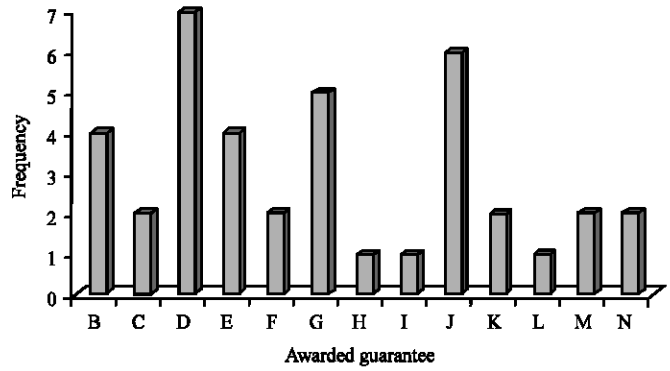

Fig. 2: Frequency of parts awarded as guarantee

RESULTS AND DISCUSSION

The results achieved considering the frequency of the defects across 90 combines showed that the most proportion of problems were associated with three parts of hydraulic pump, dividing valve and cylinder which comprised 65% of the entire flaws. Moreover, among them pump had the most malfunction which constituted 67 items i.e., 47.86% of the whole defects, which were attributed to the two main parameters of firstly, high pressure produced by the pump to overcome resistant forces, secondly, the priority valve at the end section of the pump which has a sensitive and delicate composition. Existence of such a valve is because the hydraulic pump is the common part for the two circuits of the system and steering circuit in addition to high importance in the performance of the combine, is essential in terms of safety.

Therefore, priority valve is used to provide needed oil of the steering circuit and then supplies oil to the dividing valve circuit. Achieved results demonstrated that after the pump, dividing valve used in the system has the most problems in the system, which is a stack of valves consisting of three directional control valves, one relief valve and two fixed flow-control valves (orifice). Defects of the dividing valve are mostly ascribed to usage of the sensitive springs and needle type valves inside it, which are plastic and easily broken. In addition, integrity of the above-mentioned valves causes more problems.

Other defects for the hydraulic system were detected as follows:

- Malfunction of the hydraulic cylinders of steering cylinder, cylinders used for changing platform height and cylinders used for changing reel height
- Accumulator of the platform
- Defects of steering power unit
- Burst of high-pressure oil hose located between pump and dividing valve
- Leakage of the system that is mainly due to warming of the system.

In addition to defects of the components, there are other parameters which cause problems in the system that are not actually fault of a part such as getting out of adjustment of a section, being careless over accurate service and maintenance, mistakes induced from operator or faults in the initial design of the system which causes problems such as fluctuation of the system pressure, problems associated with flow, leakage through the pipelines, cylinders and valves. Table 3

Table 3: Some statistical parameters of the most frequent defects regarding studied categories

Defect	Resources	Period of delivery and complain	Period of delivery and service	Work time at service	Work time at complain	Charge
1	Mean	160.559	193.143	15716.8	392.5	183940
	N	59	35	28	8	31
	SD	98.4634	103.315	79478.7	372.932	156928
	Minimum	9	3	10	80	120000
	Maximum	366	356	421254	1200	600000
	SE of Kurtosis	0.613	0.778	0.858	1.481	0.821
3	Mean	160.4	143.5	375		50086
	N	10	4	3		7
	SD	129.869	131.467	442.471		2872.53
	Minimum	5	17	34		49000
	Maximum	366	321	875		56600
	SE of Kurtosis	1.334	2.619	.		1.587
7	Mean	140.25	119.5	321	450	40000
	N	4	2	3	2	4
	SD	64.4535	26.163	100.165	494.975	0
	Minimum	58	101	233	100	40000
	Maximum	205	138	430	800	40000
	SE of Kurtosis	2.619	.	.	.	.
13	Mean	135	159	456.5	800	5000
	N	5	2	2	2	2
	SD	78.8955	97.5807	48.7904	565.685	.
	Minimum	2	90	422	400	5000
	Maximum	192	228	491	1200	5000
	SE of Kurtosis	2	.	.	.	.
15	Mean	239.2	201	183		2600
	N	5	3	2		2
	SD	84.9865	26.1534	100.409		0
	Minimum	178	183	112		2600
	Maximum	364	231	254		2600
	SE of Kurtosis	2	.	.		.
20	Mean	177.167	196.5	397	100	34000
	N	6	4	4	1	5
	SD	75.0904	87.4548	122.76	.	0
	Minimum	66	101	233	100	34000
	Maximum	295	313	530	100	34000
	SE of Kurtosis	1.741	2.619	2.619	.	.
24	Mean	199.2	181	776	438.333	600000
	N	5	3	3	3	2
	SD	90.9077	89.8387	165.879	329.558	.
	Minimum	59	87	660	155	600000
	Maximum	295	266	966	800	600000
	SE of Kurtosis	2	.	.	.	.
Total	Mean	165.617	185.34	9941.18	440.938	143350
	N	94	53	45	16	53
	SD	97.5045	96.6662	62709.5	378.489	166880
	Minimum	2	3	10	80	2600
	Maximum	366	356	421254	1200	600000
	SE of Kurtosis	0.493	0.644	0.695	1.091	0.644

Table 4: One- way variance analysis for after sales services categories with respect to defects

Services categories	Resources	Sum of squares	df	Mean square	F	Sig.
Period between delivery	Between Groups (Combined)	42554.087	6	7092.348	0.733	0.624
And complain * Defect	Within Groups	841608.126	87	9673.657		
	Total	884162.213	93			
Period between delivery	Between Groups (Combined)	20481.101	6	3413.517	0.337	0.914
And service * Defect	Within Groups	465424.786	46	10117.93		
	Total	485905.887	52			
Work time at	Between Groups (Combined)	2473000000	6	412200000	0.092	0.997
service * Defect	Within Groups	1.706E+11	38	4488000000		
	Total	1.73E+11	44			
Work time at	Between Groups (Combined)	393044.271	4	98261.068	0.616	0.66
complain * Defect	Within Groups	1755766.667	11	159615.152		
	Total	2148810.938	15			
Charge * Defect	Between Groups (Combined)	4.094E+11	6	1.182E+11	7.361	0
	Within Groups	7.388E+11	46	1606E+7		
	Total	1.448E+12	52			

*Denotes the first parameter is investigated against the second one

represents a brief on services made by ICM. Company with respect to some of more frequent defects so that numbers in the first column denote the type of defect and for every defect their frequency, mean, standard deviation, maximum, minimum and standard error of kurtosis for the five categories evaluated at the domain of after sales service.

As Table 4 indicates the most expense of guarantee which made up 183940 Tomans (Iranian currency) on average allotted for the hydraulic pump as well as the most expensive price was with respect to the dividing valve and some kind of hydraulic pump which made up 600000 per one. In addition, as it is demonstrated in the Fig. 2, after the pump with the most frequency of awarded guarantee, the steering cylinder had the highest number.

Afterwards the five scrutinized categories of the after sales service using the software of SPSS through two different model of variance analysis of between (combined) groups and within groups were analyzed.

Sum of squares, average of squares, degree of freedom, statistical amount of F and finally significance level of the experiment (sig) was gained. As Table 4 represents, significance level for the first four categories is more than standard level of $\propto = 0.05$. Therefore, none of them regarding services to the customers is significant. since the five categories studied within the domain of after sales service were considered as dependent variables and diverse defects were considered as independent variables thus insignificance of the investigated subjects demonstrates that assumed variables as dependent do not depend on the different levels of independent variables i.e. defects. Only the category of charge of the awarded guarantee fall into significant subset. That means there is at least two defects which have significant difference with each other. In order to discover the significant ones, Duncan multiple range test were carried out. As Table 5 shows defect numbered 24 i.e., dividing valve has significant difference with all other defects analyzed due to its price that was substantially more than other ones.

Figure 3 shows the amount of Eta as well as square of Eta as variance percent of independent variable, which has been stated by the variations of within groups. The relative high amount of the variable of charge proved that prediction of costs of the awarded guarantee to the customers considering available data associated with analyzed defects is more than other studied categories.

Table 5: Duncan' test performed for the category of charge in respect to defects

		Subset for alpha = 0.05	
Defect	N	1	2
15	2	2600	
13	2	5000	
20	5	34000	
7	4	40000	
3	7	50086	
1	31	183940	
24	2		600000
Sig.		0.114	1

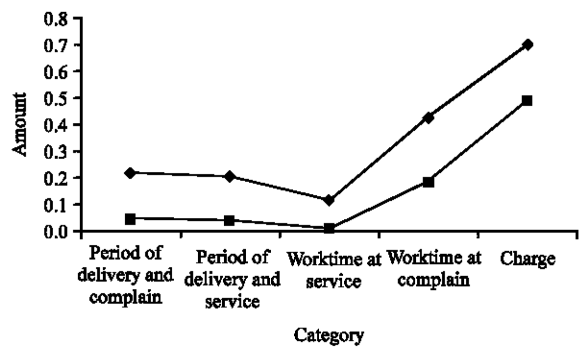

Fig. 3: Amount of Eta as well as square of Eta for the after sales services categories

CONCLUSIONS

Currently the enough available knowledge and expertise are not employed in order to operate and maintain machines. In addition, the majority of the users are not conscious of the hydrostatic system and defective effects of using improper hydraulic oil, filter and cleaner. In case services and maintenance are done either improperly or based on try-out, it would lead to increases in interruptions due to repair of the machines. Moreover while repair and services of the machine, it would be essential to replace some parts, in such cases not only an expert repairer is required but also an genuine part with high quality is too important to assure the accuracy and perfection of the task. Hydraulic oil and used parts including filters, hoses ingredients of the pump and even screws, washers, keys, pins and so on must be under the standard of the machine manufactured company.

Surveys performed from dealers of the spare parts of the ICM. Company proved the fact that most of the spar parts available in the market are not under the standard of the Company and actually are not original. In addition, on of the culprits causing malfunction in the system, is hurrying at running the machine for harvesting the crop at particular times. On those occasions usually initial inspections of the machine are not made as well as operator doesn't let the machine to warm up. Therefore the machine will depreciate sooner.

In addition to above-mentioned subjects, as the achieved results demonstrated the mainly problems are connected to the hydraulic pump of the system. Utilizing two separate pumps for each circuit, it will be feasible to supply oil for both circuits consistently and eliminate the priority valve inside the pump. Moreover, using an extra filter in the return line of oil (so that prevent from pressure loss) would bring about substantial decrease in problems associated with the pump.

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REFERENCES

Berg, M.P., 1995. The marginal cost analysis and its application to repair and replacement policies. J. Eur. Operat. Res., 82: 214-224.

Dalayeli, H. and A.R. Madineh, 2002. Industrial Hydraulic and Hydraulic Systems Design. 2nd Edn., Kanoon Pazhohesh Press, Esfehan, Iran.

Darling, J. and D.G. Tilley, 1999. A centralized hydraulic system for passenger cars. J. Automobile Eng., 213: 425-434.

Kargar, R.K. and M. Shakeri, 2007. Statistical analysis of the defect's reasons and troubleshooting of MF 285 tractor. The Third Specialized Confernce of Troubleshooting and Condition Monitoring.

Karim, M.R. and K. Suzuki, 2005. Analysis of warranty claim data: A literature review. Int. J. Q. Reliability Manage., 22: 667-686.

Lapa, C.M.F., C.M.N.A. Pereira and M.P. De-Barros, 2006. A model for preventive maintenance planning by genetic algorithms. J. Reliability Eng. Syst. Safety, 91: 233-240.

Marseguerra, M. and E. Zio, 2000. Optimizing maintenance and repair policies via a combination of genetic algorithms and Monte Carlo simulation. Reliability Eng. Syst. Safety, 68: 69-83.

Morris, J., 1988. Estimation of tractor repair and maintenance costs. J. Agric. Eng. Res., 41: 191-200.

Mullen, J.K. and M. Williams, 2004. Maintenance and repair expenditures: Determinants and tradeoffs with new capital goods. J. Econ. Bus., 56: 483-499.

Neves, L.C., D.M. Frangopol and P.S. Cruz, 2004. Cost of life extension of deteriorating structures under reliability-based maintenance. J. Comput. Struct., 82: 1077-1089.

Rad, D.M., 2004. Grain Harvester Machine: Tractors and Agricultural Machinery. 5th Edn., Abuali Sina University Press, Hamedan, Iran.

Riahee. M. and M.R. Asnaashari, 2006. Detection of defect reasons of hydrostatic power train performance in road and construction with the application of the statistical methods and optimization point of view. The Third National Confernce Maintenance and Repair.

Samatliý-Pac, G. and M.R. Taner, 2009. The role of repair strategy in warranty cost minimization: An investigation via quasi-renewal processes. Eur. J. Operat. Res., 197: 632-641.

Smidt-Destombes, K.S.D., M.C.V. Der-Heijden and A. Van-Harten, 2009. Joint optimization of spare part inventory,maintenance frequency and repair capacity for k-out-of-N systems. Int. J. Prod. Econ., 118: 260-268.

Wang, H. and H. Pham, 2006. Availability and maintenance of series systems subject to imperfect repair and correlated failure and repair. Eur. J. Operat. Res., 174: 1706-1722.