Analysing the defects of the pumps composing the lubricating system of the pressure bearing of the EsRc 1400 type excavator

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Abstract: - The lubricating system of the pressure bearing of the bucket wheel excavator, which is used in the brown coal quarries, underwent a series of changes during the period of operation of this machinery (over 40 years), its operation being either positively or negatively influenced. The initial design of the lubricating system included the D11 type pump while the other components were adopted in correspondence to the pump. Once the pump was modified, for various reasons, a number of defects started to appear, leading therefore to frequent interruptions of the operation of the excavator. The paper analyses the causes of the defects of the type of pumps introduced in the structure of the lubricating system of the pressure bearing for the EsRc 1400 type excavator, in order to establish the solution for remediation.

Key-Words: - pumps, lubricating system, excavator, defects, defect remediation time.

1 Introduction

The EsRc1400-30/7 type (either foreign or autochthonous) excavator suffered several changes during time, which were realised in different steps. As the modernisation of the machinery was realised, a unification of the structure of the lubricating system of the pressure bearing was initiated in order to be supplied and maintained easier.

Another hydraulic trajectory for the pipes was tested for the same scope, namely to remove the disfunctionalities which may appear. There are, at present, several hydraulic diagrams for the lubrication of the pressure (slewing) bearing, using different components as well as different types of pumps.

2 The defects of the pumps composing the lubricating system of the pressure bearing

The defects determined during the operation of the lubricating system of the AR_5 type pressure bearing of the EsRc 1400 type excavator, appeared either in the design phase or due to causes related to the construction, operation or maintenance of the machinery. The analysis was carried out for the lubricating system of the pressure bearing [1],[2], considering the four type of pumps existent on the excavators in operation in different Romanian quarries (E.M. Jilţ, E.M. Rovinari, E.M. Roşiuţa), namely the D11 type pump, initially foreseen for the excavators manufactured in Germany, the 6.651.000.600 type pump for autochthonous excavators (as well as those jointly manufactured), the G 3/8'' type pump as a replacement solution of the previous one for autochthonous excavators (as well as those jointly manufactured), the AFUZ type pump used in modernised autochthonous excavators (as well as those jointly manufactured).

The supervision of the operation of these pumps was realised between the 20th of August 2010 and the 1st of March 2012, in order for the causes and frequency of defects to be established. The relative frequencies "f" of the defects and the proportion of the repair time "p_r" corresponding to the causes of the defects were determined based on these data, as they are presented in Tables 1 and 5 for the D11 type pump, Tables 2 and 6 for the 6.651.000.600 type pump, Tables 3 and 7 G 3/8'' type pump, Tables 4 and 8 for the AFUZ type pump. The time required for the repair T_r was therefore considered for this analysis (Tables 5, 6, 7).

Table 1: D11 type pump defects frequency

No.	Defect cause	D11 Type pump					
		Garla quarry		Tismana quarry		Total	
		n	f[%]	n	f[%]	n	f[%]
1	Pipe trajectory	2	28.571	3	30.000	5	29.412
2	Couplings	1	14.286	1	10.000	2	11.765
3	Inherent defects	1	14.286	2	20.000	3	17.646
4	Sealing system	1	14.286	1	10.000	2	11.765
5	Lubricant	2	28.571	3	30.000	5	29.412
	TOTAL	7	100	10	100	17	100

Table 2: Pump code 6.651.000.600 defects frequency

No	Defect cause	Pump code 6.651.000.600					
		Husnicioara quarry		Rosia quarry		Total	
		n	f[%]	n	f[%]	n	f[%]
1	Pipe trajectory	5	26.316	3	25.000	8	25.807
2	Couplings	4	21.053	3	25.000	7	22.580
3	Inherent defects	3	15.789	2	16.667	5	16.129
4	Sealing systems	4	21.053	1	8.333	5	16.129
5	Lubricant	3	15.789	3	25.000	6	19.355
	TOTAL	19	100	12	100	31	100

Table 3: G 3/8’’ type pump defects frequency

No	Defect cause	G 3/8’’ type pump							
		Jilt South quarry		Jilt South quarry		Jilt South quarry		Total	
		n	f[%]	n	f[%]	n	f[%]	n	f[%]
1	Pipe trajectory	4	20.000	4	19.048	3	23.077	11	20.370
2	Couplings	4	20.000	6	28.571	4	30.769	14	25.926
3	Inherent defects	4	20.000	3	14.286	3	23.077	10	18.519
4	Sealing system	5	25.000	5	23.809	2	15.385	12	22.222
5	Lubricant	3	15.000	3	15.286	1	7.692	7	12.963
	TOTAL	20	100	21	100	13	100	54	100

Table 4: AFUZ type pump defects frequency

No.	Defect cause	AFUZ type pump							
		Rosiuta quarry		Rosiuta quarry		Rosiuta quarry		Total	
		n	f[%]	n	f[%]	n	f[%]	n	f[%]
1	Pipe trajectory	3	20.000	1	9.091	3	27.272	7	18.919
2	Couplings	2	13.333	3	27.272	2	18.182	7	18.919
3	Inherent defects	6	40.000	2	18.182	3	27.272	11	29.730
4	Sealing system	2	13.333	3	27.272	2	18.182	7	18.919
5	Lubricant	2	13.333	2	18.182	1	9.091	5	13.513
	TOTAL	15	99.999	11	99.999	11	99.999	37	100

Table 5: Repair time proportion for the D11 type pump

No.	Defect cause	D11 type pump					
		Garla quarry		Tismana quarry		Total	
		Tr[hours]	p_r[%]	Tr[hours]	p_r[%]	Tr[hours]	p_r[%]
1	Pipe trajectory	6	54.546	8.85	49.580	14.85	51.473
2	Couplings	0.75	6.818	1.50	8.403	2.25	7.799
3	Inherent defects	2	18.182	2.2	12.325	4.2	14.558
4	Sealing system	0.5	4.545	0.6	3.362	1.1	3.813
5	Lubricant	1.75	15.909	4.7	26.330	6.45	22.357
	TOTAL	11	100	17.850	100	28.850	100

Table 6: Repair time proportion for the 6.651.000.600 code pump

No.	Defect cause	6.651.000.600 code pump					
		Husnicioara quarry		Rosia quarry		Total	
		Tr[hours]	p_r[%]	Tr[hours]	p_r[%]	Tr[hours]	p_r[%]
1	Pipe trajectory	5	21.468	10.25	50.0	15.25	34.825
2	Couplings	4.76	20.438	3.27	15.951	8.03	18.338
3	Inherent defects	6.95	29.841	2.3	11.220	9.25	21.124
4	Sealing system	2.78	11.937	0.68	3.317	3.46	7.901
5	Lubricant	3.8	16.316	4	19.512	7.8	17.812
	TOTAL	23.29	100	20.5	100	43.79	100

Table 7: Repair time proportion for the G 3/8'' type pump

No.	Defect cause	G 3/8'' type pump							
		Jilt South quarry		Jilt South quarry		Jilt South quarry		Total	
		Tr[hours]	p_r[%]	Tr[hours]	p_r[%]	Tr[hours]	p_r[%]	Tr[hours]	p_r[%]
1	Pipe trajectory	2.65	19.925	3.5	20.686	6.5	35.022	12.65	25.933
2	Couplings	4.8	36.090	2.86	16.903	2.76	14.871	10.42	21.361
3	Inherent defects	2.45	18.421	3.5	20.686	5	26.939	10.95	22.448
4	Sealing system	1.9	14.286	4.56	26.950	0.8	4.310	7.26	14.883
5	Lubricant	1.5	11.278	2.5	14.775	3.5	18.858	7.5	15.375
	TOTAL	13.3	100	16.92	100	18.56	100	48.78	100

Table 8: Repair time proportion for the AFUZ type pump

No.	Defect cause	AFUZ type pump							
		Rosiuta quarry		Rosiuta quarry		Rosiuta quarry		Total	
		Tr[hours]	p_r[%]	Tr[hours]	p_r[%]	Tr[hours]	p_r[%]	Tr[hours]	p_r[%]
1	Pipe trajectory	4.15	26.861	5.6	34.356	5.45	39.521	15.2	33.377
2	Couplings	1.25	8.091	3.45	21.166	1.25	9.065	5.95	13.065
3	Inherent defects	6.05	39.158	3.1	19.018	3.74	27.121	12.89	28.305
4	Sealing systems	1.5	9.709	2.35	14.417	2.3	16.679	6.15	13.505
5	Lubricant	2.5	16.181	1.8	11.043	1.05	7.614	5.35	11.748
	TOTAL	15.45	100	16.3	100	13.79	100	45.54	100

Table 9: Centralised comparative data

No.	Defect cause	D11 type pump		6.651.000.600 code pump		G 3/8'' type pump		AFUZ type pump		Total	
		n	f[%]	n	f[%]	n	f[%]	n	f[%]	n	f[%]
1	Pipe trajectory	5	3.597	8	5.755	11	7.914	7	5.036	31	22.302
2	Couplings	2	1.439	7	5.036	14	10.072	7	5.036	30	21.583
3	Inherent defects	3	2.158	5	3.597	10	7.194	11	7.914	29	20.863
4	Sealing system	2	1.439	5	3.597	12	8.633	7	5.036	26	18.705
5	Lubricant	5	3.587	6	4.317	7	5.036	5	3.597	23	16.547
	TOTAL	17	12.230	31	22.302	54	38.849	37	26.619	139	100

Table 10: Centralised comparative data

No	Defect cause	D11 type pump		6.651.000.600 code pump		G 3/8'' type pump		AFUZ type pump		Total	
		Tr [hours]	p_r[%]	Tr[hours]	p_r[%]	Tr [hours]	p_r[%]	Tr [hours]	p_r[%]	Tr [hours]	p_r[%]
1	Pipe trajectory	14.85	8.894	15.25	9.134	12.65	7.577	15.2	9.104	57.95	34.709
2	Couplings	2.25	1.347	8.03	4.810	10.42	6.241	5.95	3.564	26.65	15.962

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3	Inherent defects	4.2	2.515	9.25	5.540	10.95	6.558	12.89	7.720	37.29	22.335
4	Sealing system	1.1	0.659	3.46	2.072	7.26	4.348	6.15	3.684	17.97	10.763
5	Lubricant	6.45	3.863	7.8	4.672	7.5	4.492	5.35	3.204	27.1	16.231
	TOTAL	28.85	17.279	43.79	26.228	48.78	29.21	45.54	27.276	166.96	100

In order to compare the behaviour of the four types of pumps, the data comprised in Tables 1 to 4 were centralised in Table 9 while those presented in tables 5 to 8 were centralised in Table 10.

The data presented in Table 9 have been graphically represented as Pareto diagrams (relative frequency of defects depending on the cause of the defect) in Figure 1. The data regarding the repair time proportion presented in Table 10 have been similarly represented in Figure 2.

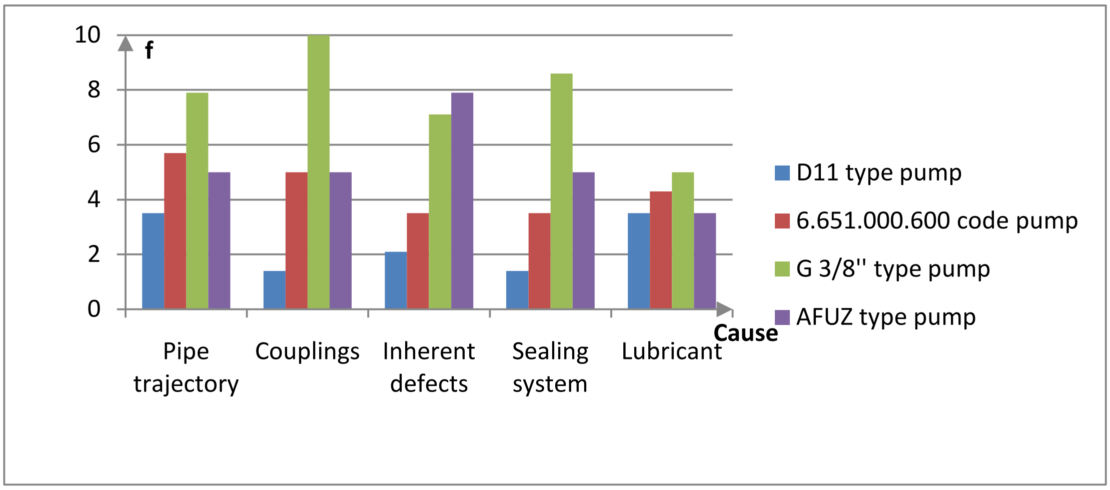

Figure 1 Relative frequency of the defects, f[%]

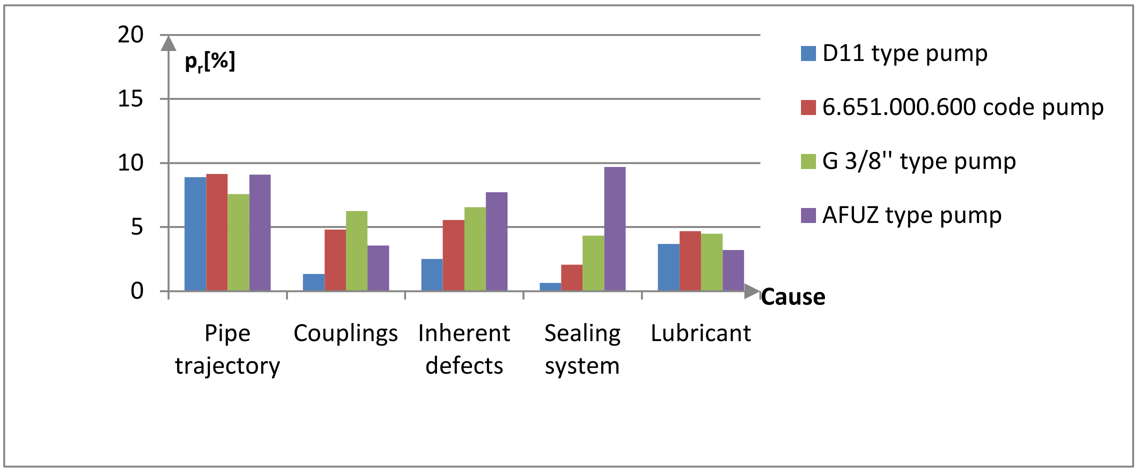

Figure 2 Repair time proportion, p_r.

Moreover, the data presented in Tables 9 and 10 allowed the representation of the Pareto diagrams in Figure 3, resulting therefore a comparison of the four types of pumps from the point of view of the frequency of the defects and the proportion of their repair time.

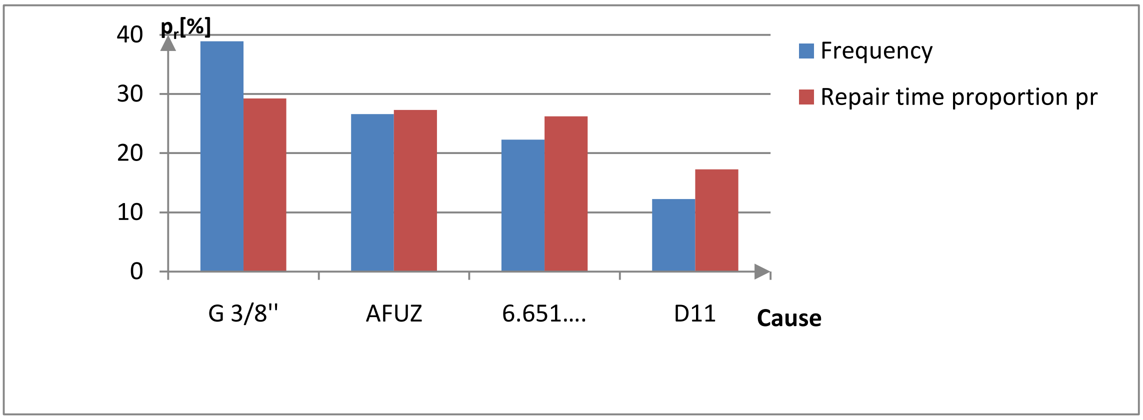

Figure 3 Pump types comparison

The data presented in Tables 1 to 10 and the diagrams presented in Figures 1 to 3 allowed the following conclusions to be drawn:

The change in time of the hydraulic diagrams and of the trajectories of the pipe is the result of the previously mentioned defects, which have negatively influenced the flow of the lubricant towards the lubrication spots. The initial value of the diameter of the pipes (for the pump outlet) was determined to be 6mm, corresponding to the D11 type pump, but as the type of pump changed, the initial dimensions of the pipe proved to be small. Considering the data in Table 9 it may be concluded that the hydraulic diagram, respectively the pipe trajectory, represents the cause for 22.302% of the defects, having therefore the highest proportion of repair time, i.e. 34.709%; in what the repair time frequency for different type of pumps is concerned, the G 3/8'' type pumps and 6.651.000.600. code pumps are highlighted.

The defects of the couplings may very much affect the functionality of the hydraulic installation due to a series of causes, such as: improper alignment, incorrect roughness of the bores, the margins left in the assembly after the repair and wear of the elastic elements. Coupling defects present a 21.583% frequency and a 15.963% proportion of the repair time, being therefore a second cause of the defects (following the pipe trajectory), the highest values being recorded for the G 3/8'' type pump.

The sealing system may cause defects due to the type of material or seal used (either sealing welt or simple gaskets) which may wear prematurely. The relative frequency of the defects caused by the sealing system is 18.705% while the proportion of the repair time is 10.763%. The highest value of the frequency of break downs and the proportion of the repair time is observed for the G3/8'' type pump as well as for the 6.651.000.600 code pump. It has been observed that there are cases of defects caused by the clogging of the transmission systems of the lubricant to the lubrication spots of the bearing.

The defects caused by the lack of lubricant have the smallest relative frequency of break downs, i.e. 16.547% and a proportion of repair time of 16.231%. The smallest values of the relative frequencies of the defects are observed to appear for the AFUZ type pump and respectively the D11 type pump, while the smallest proportion of the repair time is observed for the AFUZ type pump.

3 Problem Solution

Comparing the analysed pumps, the most reliable has proven to be the D11 type one, while the less reliable one was the G3/8'' (the same conclusion is drawn if the average values of the absolute frequency of break downs is taken into consideration).

In what the proportion of the repair time is concerned the highest values are observed as well for the G3/8'' type pump, while the smallest values are observed at the D11 type one (Figure 3). Of all the causes of the defects, the largest influence on the frequency of breakdowns is those caused by the hydraulic diagram, respectively the trajectory of the pipes independent on the type of pump.

The same conclusion may be drawn as well in the case of the proportion of repair time. The solution which results from the analysis presented is that the use of the G3/8'' type pump should be avoided, in order to reduce the number of operational interruptions of the bucket wheel excavator as well as their production losses

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4 Conclusion

The inherent defects of the pumps may have multiple causes related to the exploitation, maintenance and repair as well as the elements of the hydraulic circuits for the lubrication of the support bearing. The inherent defects of all the pumps repreent a frequency of 20.863% and a proportion of the repair time of 22.335% (of the total repair time). Increased values of the frequency of break downs and of the proportion of repair time are observed at the AFUZ type pump as well as at the G3/8'' type

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