The 4th International Conference
"Computational Mechanics
and Virtual Engineering"
COMEC 2011
20-22 OCTOBER 2011, Brasov, Romania

ASPECTS REGARDING THE DEGRADATION OF THE IN LINE INJECTION PUMPS ELEMENTS

Gh. Brătucu[1], A. Danciu[2], C.G. Păunescu[1]
[1] Transilvania University of Brasov, ROMANIA, gh.bratucu@unitbv.ro
[2] INMA, Bucharest, ROMANIA, danciu_aurel1@yahoo.com

Abstract: *In the paper is analyzed the technical degradation pf the injection pumps elements which equip D105 engines on U 650M tractors. Is find the irregular character of the aging on the circumference and height piston and bush element. It presents the results obtained by applying technologies reconditioning. The most economical results are obtained through re-coupling technology, which can be used due the initial selective montage of the two parts. Are presented and other reconditioning technologies which lead to corresponding results under technical aspects, but also satisfying under economical aspect. Is signaled the lack of government interest for researches financing and assuring the material base for applying the reconditioning technologies of the injection pumps elements, the present services resuming to correct functioning adjusting or to their reform.*
Keywords: *injection pumps, elements, reconditioning.*

1. INTRODUCTION

Through the element of the injection pump from Diesel engines is understood the ensemble formed by a piston 1 and a cylinder (nut) 2 (figure 1), each of them having the ensemble surfaces made in precisions 4-5 and qualities 0.4…0.2 µm, situations which are obtained through manufacture technologies and procedures specific to fine mechanic and through selective ensemble. After running in ensemble condition the surface quality of these two parts reaches to the value of 0.05 µm. In figure 1,a is presented the position of these two parts at debiting start and in figure 1,b their position at debiting stop [4].

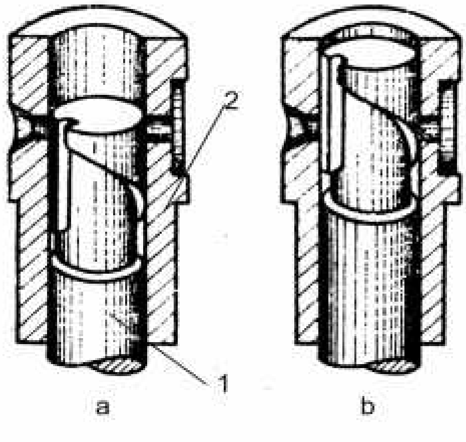

Figure 1: Injection pump element

The role of such an element in the diesel fuel alimentation system of the engines consist in assuring a superior pressure comparative with the adjustment pressure of the injector, but and in dosing the diesel fuel quantity send in the cylinder, concordant with the engine functioning regime at a certain moment. Because the montage spaces of this two parts is not exceeding 1 µm neither the admitted wore can't exceed this value, else it can't be assured the necessary pressure for sending the fuel for forming a fine and homogeny mix to light its self and burn in a very short time. For maintaining the function situation of the wore elements from injection pumps are used different reconditioning methods and procedures, like re-mating, pistons loading with chrome galvanic deposits, replacing one of this two parts with a new part etc. At dimensions exiting from de manufacture field the pistons are reconditioned and the nut is reformed [1].

2. MATERIAL AND METHOD

To reflect the dimensions and forms of the element piston and cylinder after realizing a functioning cycle on the engine, was considered a sample of 141 elements from the injection pumps RO – PES4A90D410RS-2240 which equips diesel engines D-103 and D-110. The complex symbolist of this pump contain data referring to the constructive characteristics like: RO – manufactured in Romania, under BOSH license; PE – injection pump with self training; S – flange mounting; 4 – the pumping section number; A – the pump size; 90 – the element piston diameter in tenths of mm; C – modification letter towards the base type; 410 – with regulator on the left, with alimentation pump without automatic advance regulator, having the camshaft with montage mark in the right; R – camshaft rotation towards right viewed from the drive; S-2240 – the execution number. Both to the pistons and to the nuts the nominal diameters were of 9 mm. The 141 elements came from tractors owning units from Deta (Timiş) – 31, Adamclisi (Constanţa) – 30; Ştefăneşti (Ilfov) – 20; Măgurele (Ilfov) – 30 and Cărcea (Dolj) – 30 [2].
In order to verify through measurement the technical condition, the elements were washed in special vats, blown in compressed air and dried, taking care to not unmatched them. In figures 2 and 3 are illustrated the execution drawings for the element two components

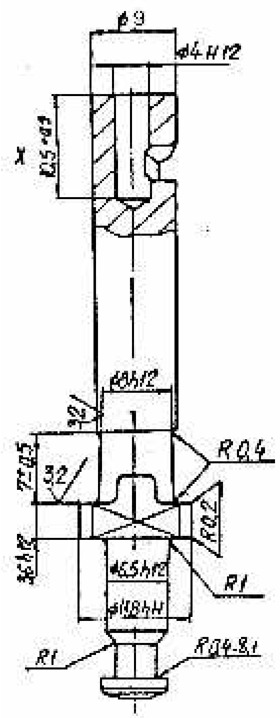

Figure 2: Piston execution drawing

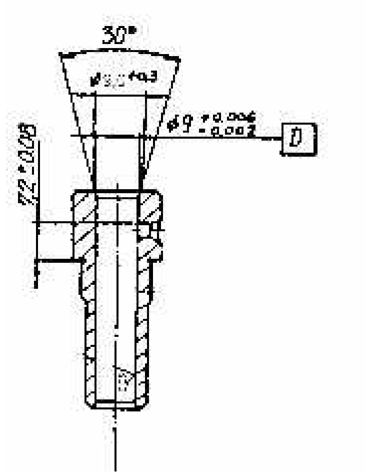

Figure 3: Cylinder (bush) execution drawing

The functioning conditions of these two parts leads to uneven wore on theirs lengths and diameters: on the length is manifested a taper and on the diameter an chamber. From factory the pistons and cylinder taper and chamber are admitted until the maximum value of 0.001 mm, the maximum taper, respectively the cone large base being to the end of the screw channel, namely to the dosing part – element pumping [3].
For establishing the wore and the deviations from the geometrical form, both pistons and cylinders were measured on two perpendicular directions and in three plans on height, as follows:

- A-A direction – parallel with the slot (to piston), respectively with the inlet (to cylinder)
- B-B direction – perpendicular on the slot (to piston) or on the inlet (to cylinder)
- measurement plan I – at 5 mm form the front seating area on the valve seat;
- measurement plan II – at 11 mm form the front seating area on the valve seat;
- measurement plan III – at 17 mm form the front seating area on the valve seat;

The wore pistons dimension measurement were made with the help of a ortotest manufactured at IMF – Bucureşti, with a 0,001 mm precision (distance between two divisions on the scale), at a temperature of $20 \pm 0,1^{o}C$ and to cylinder the measurements were made with a internal comparator with a 0.001 mm precision manufactured by Carl Zeiss Jena company.

3. RESULTS AND DISCUSSIONS

In table 1 are presented a part from the pistons and cylinders measurement results

Table 1: Wore pistons and cylinders measurement results

No. crt.	Pistons Dimensions						Cylinder Dimensions					
	A-A Direction			B-B Direction			A-A Direction			B-B Direction		
	Plan I	Plan II	Plan III	Plan I	Plan II	Plan III	Plan I	Plan II	Plan III	Plan I	Plan II	Plan III
1	9.108	9.109	9.108	9.108	9.109	9.109	9.117	9.118	9.119	9.116	9.117	9.119
2	9.139	9.139	9.139	9.140	9.139	9.140	9.150	9.149	9.149	9.150	9.150	9.150
3	9.119	9.120	9.120	9.120	9.120	9.120	9.130	9.129	9.130	9.130	9.129	9.129
4	8.997	8.996	8.995	8.996	8.996	8.996	9.005	9.003	9.003	9.005	9.003	9.003
-	-	-	-	-	-	-	-	-	-	-	-	-
138	9.101	9.102	9.102	9.102	9.101	9.101	9.108	9.107	9.107	9.108	9.108	9.107
139	9.119	9.117	9.117	9.118	9.118	9.117	9.124	9.125	9.125	9.124	9.124	9.125
140	9.061	9.061	9.060	9.061	9.060	9.060	9.066	9.066	9.065	9.064	9.064	9.065
141	9.104	9.103	9.102	9.104	9.103	9.102	9.116	9.114	9.112	9.114	9.114	9.113

Observation: The others results are available at the authors

In table 2 are presented in the same manner the chamber situation of the pistons and cylinders and in table 3 their taper situation

Table 2: Pistons and Cylinders chamber values

No. crt.	Pistons average diameter			Cylinder average diameter			Pistons chamber situation			Cylinder chamber situation		
	A-A Direction			B-B Direction			A-A Direction			B-B Direction		
	Plan I	Plan II	Plan III	Plan I	Plan II	Plan III	Plan I	Plan II	Plan III	Plan I	Plan II	Plan III
1	9.1080	9.1090	9.1085	9.1165	9.1175	9.1190	0	0	0.001	0.001	0.001	0
2	9.1395	9.1390	9.1395	9.1500	9.1495	9.1495	0.001	0	0.001	0	0.001	0.001
3	9.1195	9.1200	9.1200	9.1300	9.1290	9.1295	0.001	0	0	0	0	0.001
4	8.9965	8.9960	8.9955	9.0050	9.0030	9.0030	0.001	0	0.001	0	0	0
-	-	-	-	-	-	-	-	-	-	-	-	-
138	9.1015	9.1015	9.1015	9.1080	9.1075	9.1070	0.001	0.001	0.001	0	0.001	0
139	9.1185	9.1175	9.1170	9.1240	9.1245	9.1250	0.001	0.001	0	0	0.001	0
140	9.0610	9.0605	9.0600	9.0650	9.0650	9.0650	0	0.001	0	0.002	0.002	0
141	9.1040	9.1030	9.1020	9.1150	9.1140	9.1125	0	0	0	0.002	0	0.001

Observation: The others results are available at the authors

Table 3: The values of pistons and cylinder taper and of spaces between them

No. crt	Average Taper		Average Spaces		
	Pistons	Cylinders	A-A and B-B Directions	A-A and B-B Directions	A-A and B-B Directions
			Plan I	Plan II	Plan III
1	0.0005	0.0025	0.0085	0.0085	0.0105
2	0	0.0005	0.0105	0.0105	0.0100
3	0.0005	0.0005	0.0105	0.0090	0.0095
4	0.0010	0.0020	0.0085	0.0070	0.0075
-	-	-	-	-	-
138	0	0.0010	0.0065	0.0060	0.0055
139	0.0015	0.0010	0.0055	0.0070	0.0080
140	0.0010	0	0.0040	0.0045	0.0050
141	0.0020	0.0025	0.0110	0.0110	0.0105

Observation: The others results are available at the authors

For results interpretation it was made their systematization, firstly through the elimination of about 0.5 % from the noted dimensions and deviations, considered accidental and non-characteristic, after which were extracted from tables 1, 2 and 3 $d_{ef\,min}$ and $d_{ef\,max}$ for pistons, respectively $D_{ef\,min}$ and $D_{ef\,max}$ for bushes, after which were calculated the wore amplitudes w – for pistons and W – for cylinders, using the relations:

$$w = d_{ef\,max} - d_{ef\,min}; \quad \textbf{(1)}$$

$$W = D_{ef\,max} - D_{ef\,min}, \qquad \textbf{(2)}$$

in which: $d_{ef\ max}$, $d_{ef\ min}$ are the minimum and maximum effective diameters noted for pistons; $D_{ef\ max}$, $D_{ef\ min}$ – the minimum and maximum effective diameters noted for cylinders [5].
According to table 4, in which are presented the averages dimensions for minimum and maximum effective diameters for pistons and cylinders obtained through two measurement directions in three plans, in increasing order of the results, the minimum and maximum values are:

- for pistons : $d_{ef\,min}$ = 8,899 mm and $d_{ef\,max}$ = 9,2125 mm;
- for cylinders: $D_{ef\,min}$ = 8,908 mm and $D_{ef\,max}$ =9,235 mm.

Table 4: Effective diameter averages sorted minimum (to pistons) and maximum (to cylinders) in increasing order

Pistons			Cylinders		
No. crt. sorted	No. crt. measured	Minimum Diameter	No. crt. sorted	No. crt. measured	Maximum Diameter
1	96	8.8990	1	109	8.9080
2	109	8.9015	2	96	8.9058
3	93	8.9020	3	93	8.9100
4	100	8.9030	4	100	8.9100
-	-	-	-	-	-
138	76	9.1595	138	76	9.1760
139	55	9.1940	139	55	9.2070
140	30	9.1965	140	30	9.2210
141	37	9.2125	141	37	9.2350

Observation: The others results are available at the authors

Dimensions amplitude for pistons (w_p) and for cylinders (W_c) elements, calculated with relations (1) and (2) are:

- for pistons: $w_p = d_{ef\,max} - d_{ef\,min}$ = 9,2125 – 8,899 = 0,3135 mm;
- for cylinders: $W_c = D_{ef\,max} - D_{ef\,min}$ = 9,235 – 8,908 = 0,327 mm.

The w_p and W_c amplitudes are grouped in a n_i number of intervals, calculated with relation:

$$n_i = \frac{t_n - t_1}{A}, \qquad \textbf{(3)}$$

in which: t_n is the value of the last information or the maximum average diameter calculated as the average of the diameters measured after the A-A and B-B directions in one of these three plans; t_i- the value of the first information (minimum average diameter); A – the interval size (step) which was chosen of 40 μm, namely as far as it could assure the reading with a 0.001 mm precision with the pneumatic apparatus type Superjet (the measurement interval being of $\pm$20 μm).
In this case the number of intervals of the statistic string will be:

- for pistons: $n_p = \frac{9{,}2125 - 8{,}899}{0{,}04} = 7{,}8375;$
- for cylinders: $n_c = \frac{9{,}235 - 8{,}908}{0{,}04} = 8{,}175.$

It was chosen n_p = 9 intervals for pistons and n_c = 9 intervals for cylinders, to execute pneumatic groups for measurement.
The limits of these 9 intervals of the statistics strings for measured pistons and cylinders and the results frequency on this intervals are presented in table 5 and in figure 4 and 5 are presented the histograms of the processed data from table 5 for pistons and cylinders.

Table 5: Measurement results frequency on dimensions intervals

Nr. crt.	Pistons			Cylinders		
	Heads intervals		Frequency	Heads intervals		Frequency
1	8.881	8.920	17	8.900	8.940	19
2	8.921	8.960	12	8.941	8.980	11
3	8.961	9.000	14	8.981	9.020	24
4	9.001	9.040	36	9.021	9.060	31
5	9.041	9.080	15	9.061	9.100	17
6	9.081	9.120	29	9.101	9.140	24
7	9.121	9.160	15	9.141	9.180	12
8	9.161	9.200	2	9.181	9.220	1
9	9.201	9.240	1	9.221	9.260	2

Observation: The others results are available at the authors

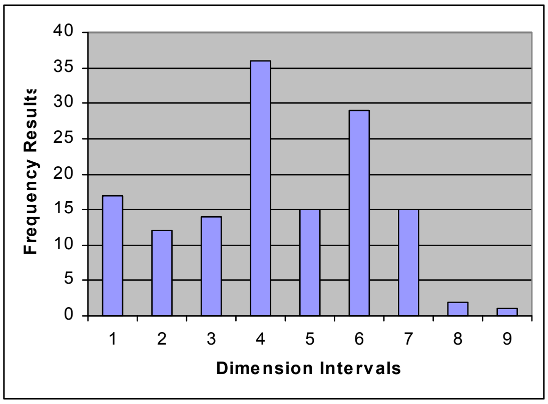

Figure 4: Histogram of measured results frequency on intervals for pistons

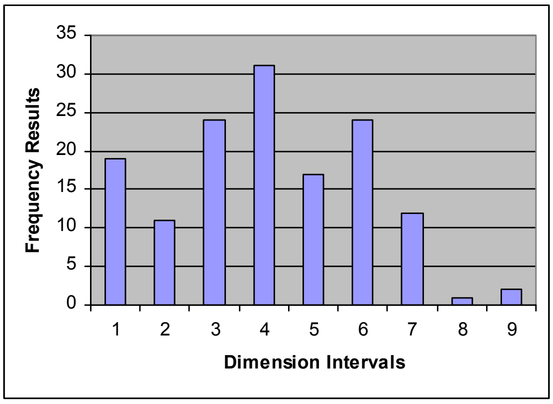

Figure 5: Histogram of measured results frequency on intervals for cylinders

In figure 6 is presented a superposition of the results distribution for pistons and cylinders wore after measurements.

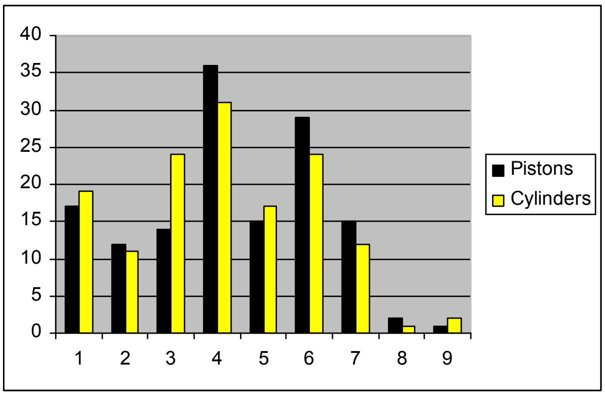

Figure 6: Superposition of the measured results distribution for wore pistons and cylinders

There is observed a close measured results distribution for these two parts on established intervals with maximum values to central intervals and with small reductions towards lateral intervals.

4. CONCLUSIONS

1. The pistons and the cylinders of the injection pump elements are parts manufactured at superior accuracies and surfaces qualities, the montage spaces being of 0.001 mm fact which assures the achievement of a high pressure for the injected fuel in the engine burn chamber.
2. The pistons and the cylinders of the injection pump elements wore are uneven, both on diameter (chamber) and on height (taper). The biggest values of these wore are manifested in the screw channel of the piston, respectively in the cylinder inlet.
3. Restoration of the normal functioning state of the injection pumps elements can be done by re-mating in limits of the manufacture tolerance fields. When these dimensions exit these tolerance fields due to wore, it can be applied to pistons reconditioning through galvanic coverage with chrome or the both parts are reformed.

REFERENCES

[1] Callister W.: Fundamentals of Materials Science and Engineering, John Wiley&Sons, New York, 2001.
[2] Bratucu Gh.: Reparation and Reliability of the Agricultural Equipments, Transilvania University of Brasov, 1992.
[3] Danciu A.: Technology of Technical Revisions and Current Reparation to U – 650 and U – 651M Tractors, Ceres Publishing, Bucharest, 1987.
[4] Doinaru L.: Injection Equipment for Diesel Engines, Technical Publishing Bucharest, 1973.
[5] Grunwald B.: Theory, Calculus and Development of Engines for Automotive, Didactic and Pedagogic Publishing, Bucharest, 1980.
[6] Ionut V., s.a.: Repair Technology and the Reliability of the Agricultural Equipment, Didactic and Pedagogic Publishing, Bucharest, 1983.