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EXPERIMENTAL STUDY OF THE MATERIAL USED FOR THE HOUSING OF AN ADDER BOX

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Abstract: *The paper aims to study the material from which a summing box is manufactured that equips a heavy truck, to determine its mechanical properties. In order to achieve the objective of the paper, an experimental set is made, with the help of which the experimental determinations presented in the paper are made.*
Keywords*: adder box, finite element*

1. INTRODUCTION

The paper presents the results obtained from experiments performed on a housing material of the summing and distribution box CSD 4000 to determine the mechanical characteristics of this box.
The box is intended for drilling chassis equipped with two CATERPILAR engine groups with an ALLISON automatic gearbox. The adder box is a mechanical construction comprising geared gears, in steps, and has the role of summing the power of the two power groups and distributing it to the drive axles or to a total power take-off.

Figure 1. The adder box

The adder box is shown in Figure 1, where the notations have the following meanings:

A - The input shafts, which receive the movement from the gearboxes of the power groups, by means of cardan transmissions, have the possibility to engage or disengage the power groups according to the needs. On these shafts are mounted gimbal flanges to which the power groups and gears are coupled.

B - Intermediate shafts I, which transmit the power flow to the power take-off shaft and drive two hydraulic pumps at the same time, which can be coupled as required.

C - The shaft of the power take-off, which ensures the transmission of the power flow to the drilling rig and to the drive axles, by means of two gears provided with coupling mechanisms with nails and the cardan flange for driving the drilling rig. On the side opposite the drive flange of the unit, there is a pump with radial pistons which ensures the lubrication of the box.

D - Intermediate shaft II which ensures, by means of a gear, the transmission of the power flow to the interaxial differential, driving at the same time the additional steering pump and the gear with crossed axes for the velocograph.
E - The output shaft, which contains the interaxial differential, the drive toothed ring, the differential locking mechanism and the cardan flanges related to the cardan transmissions to the chassis axles.

2. EXPERIMENTAL SETUP

In order to achieve the structural optimization of the adder box housing, in addition to finite element modeling, it is also necessary to determine the physical properties, mechanical characteristics and strength limits of the housing material [1-9].
The adder and distribution box has a housing consisting of four plate-type elements, two assembled by welding with the third side wall element, and the fourth (cover) assembled by screws. Figure 2 shows the assembled box housing.

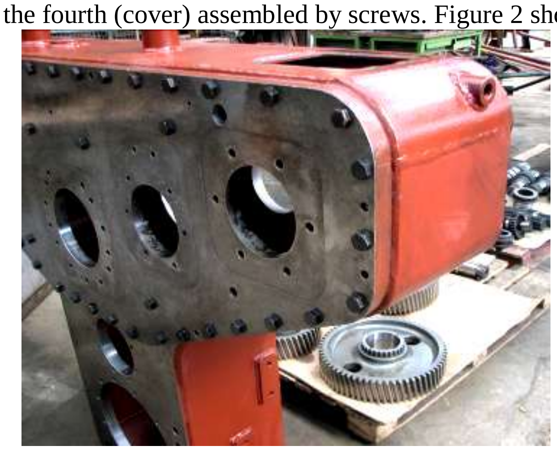

Figure 2 Assembled box housing with large cover

In accordance with the standard SR EN 10002-1 Standards "Tensile test" 4 specimens marked with E1, E2, E3 and E4, taken from the material of the adder and distribution box housing, were subjected to tensile tests. The specimens were executed in accordance with the requirements of Annex C of the SR EN 10002-1 standard. For the fatigue test and the determination of the resistance limit in operation, two EI and EII specimens were taken and subjected to bending with alternating - symmetrical stress cycles, also from the housing material. The material provided in the documentation for the housing is OLC 37.3. Figure 3 shows the stand and the equipment used for the traction test.

Figure 3. Tensile test stand

The following equipment was used to perform the tests and determinations:

- HA-80 servo-hydraulic stand - complex 1;
- Servo-hydraulic cylinder PZ 250 kN;
- Command, measurement and control cabinet;
- Force transducer of 250 kN;
- Stroke transducer ± 50 mm;
- X-Y recorder;
- Hammer Charpy;
- External caliper 150 mm;
- Hydraulic stand for shock absorber test adapted for testing specimens;
- 25 kN force transducer;
- Amplifier HOTINGER 3082;
- Digital voltmeter E 0302.

3. RESULTS

Table 1 summarizes the results of the tensile test for the four test pieces numbered E1, E2, E3 and E4.

Table 1

Symbol	**M.U.**	**DEFINITION**	**VALUES**			
			E1	**E2**	**E3**	**E4**
DIMENSIONS OF THE SPECIMENS						
A	mm	Sample thickness	7,7	7,9	7,9	7,9
B	mm	Width of the calibrated area	18,8	18,9	19	19
L_0	mm	Initial lenght between marks	110	110	110	110
L_C	mm	Length of the calibrated area	145	145	145	145
L_U	mm	Final lenght between marks	140,75	143,5	147,5	144
S_0	mm^2	Initial area of the calibrated section	144,76	149,31	150,1	150,1
S_U	mm^2	Minimal section after tear	50,66	51,66	48,36	50,4
Z	%	Tear coefficient $((S_0 – S_U)/S_0)$x 100	65	65,4	67,7	66,4
	ALUNGIRE					
$L_U – L_0$	mm	Remanent strain after tear	30,75	33,5	37,5	34
$A_{(2)}$	%	Procentual strain after tear $((L_U – L_0)/L_0)$x100	27,95	30,45	34,09	30,9
A_{gt}	%	Procentual strain as force F_m	22,72	22,72	24,57	24,57
A_t	%	Total strain, percentage	28,63	31,32	34,54	31,36
	FORCE					
F_m	daN	Maximum force	6120	6210	6180	6240
LIMITE DE CURGERE – REZISTENŢĂ LA RUPERE – REZILIENŢĂ						
R_{eH}	daN/mm^2	Superior flow limit	32,33	33,35	31,57	32,37
R_{eL}	daN/mm^2	Inferior flow limit	31,08	31,34	30,97	31,57

R_m	daN/mm^2	Tear resistance, traction	42,27	41,79	41,17	41,57
KV	J	Energy of tear with shock	72	94	93	92
KCV	J/cm^2	Resilience	91,13	117,5	114,8	113,5

Table 2 presents a comparison of the chemical elements of the tested material with the chemical elements of the OL material 37.3.

Table 2

CHEMICAL ANALYSIS				
Values	**C max. [%]**	**Mn max. [%]**	**P max. [%]**	**S max. [%]**
OL 37.3 - estimated	0,22	1,55	0,055	0,055
Measured	0,113	0,54	0,0084	0,0295
MECHANICAL TEST				
Duritate HB - Obtained Values				
130 -133 HB				

The mechanical properties of the material of the test specimens E1, E2, E3 and E4 tested fall within the limits imposed on the material OL37.3. Table 3 shows the comparison of the values obtained with those imposed.

Table 3

Characteristic	**Estimate value**	**Measured value**
Flow limit	21 ÷ 24 daN/mm^2	30,97 ÷ 33,35 daN/mm^2
Tear resistance	36 ÷ 44 daN/mm^2	41,17 ÷ 42,27 daN/mm^2
Relativ strain at tear	min. 26%	28,63 ÷ 34,54 %
Tear energy KV	min. 27J	72 ÷ 94 J
Resilience KCV	-	91,13 ÷ 117,5 J/cm^2
Stiffness	-	130 ÷ 133 HB

The values of the flow stress and breaking forces, for the four specimens, are presented in Table 4.

Table 4

E 1	**E 2**	**E 3**	**E 4**
σ_c = 31,08 daN/mm^2	σ_c = 31,34 daN/mm^2	σ_c = 30,97 daN/mm^2	σ_c = 31,57 daN/mm^2
σ_r = 42,27daN/mm^2	σ_r = 41,79 daN/mm^2	σ_r = 41,17 daN/mm^2	σ_r = 41,57daN/mm^2

In the literature [10] the unlimited fatigue strength (σ-1) for OL 37.3 is estimated at (0.45 ÷ 0.5) σ_r. For the choice of the fatigue test regime, the unlimited fatigue strength was calculated at 0.45 σ_r = 18.9 daN/mm^2 (approx. 19 daN/mm^2). Fatigue breakage of construction elements, required variably over time, depends on several factors. The most important factors that determine the values of fatigue strength are: material and manufacturing technology, nature of stress, stress concentrators, condition of parts surfaces, overload and underload.

Taking into account all these influencing factors, the determination of the fatigue test regime was made by choosing a global influence coefficient (chosen from the literature [10]) worth 1.50 in which the largest share is the technological factor welding, the housing being made of welded elements. The unlimited fatigue resistance σ_{-1} (0.45 σ_r = 19 daN/mm^2) is corrected with this coefficient of influence, obtaining σ_{-1k} with a value between 12.66 ÷ 13 daN/mm2.

Under these conditions, the unit effort for the fatigue test (σ_{max}) was chosen at 22 daN/ mm^2 for the EI specimen and at 17 daN/mm^2 for the EII specimen. These stress values are greater than the unlimited fatigue strength precisely to determine the Wöhler curve for the two specimens. A point of the Wöhler curve for the material is obtained from the knowledge of the stress for a very small number of cycles (1 ... 1000 cycles for 9/10 of σ_r). The second point of the Wöhler curve for the material represents the unlimited fatigue strength corrected by the overall coefficient of influence for 2x106 cycles. These points are joined by a straight line to obtain the Wöhler curve for the material.

Figure 4

Specimen tests loaded with higher forces break at a smaller number of cycles than those loaded with lower forces. EI and EII specimens were tested at the two stress regimes in order to obtain the Wöhler curve for the welded carcass material. The behavior of the test specimens for fatigue is shown in Table 5.

Table 5

No.	Name of the specimen	Level of load	Nr. of cycles to rupture	
			Estimated	Accomplished
1	EI	22 daN/mm^2	50 000	40 000
2	EII	17 daN/mm^2	250 000	198 000

Figure 5.

Figure 5 shows the broken EI specimen as well as details with the breaking section. In the section it is observed that the test piece was subjected to high bending efforts (small area of fatigue and inclusions in the material).

CONCLUSIONS

Following the bending fatigue test of the EI and EII specimens, it was found that the EI and EII specimens performed well in fatigue withstanding a number of stress cycles that placed them near the Wöhler curve for OL material 37.3. Material OL 37.3 is recommended for welded metal construction elements, subject to medium stresses.

In conclusion, the maximum stresses in the material of the box of the adder box must not exceed the unlimited fatigue strength estimated at 13 da /mm2 for the material OL37.3.

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