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SIMULATION OF MECHANICAL STRESS SUPPORTED BY MARINE DIESEL ENGINE'S FIXED PARTS

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Abstract: *This paper studies the stresses occuring in large fixed parts of marine diesel engine because of thermal processes from inside the combustion chamber.The MAN B&W K80 MC-C engine is aimed, an engine still widely used in the world fleet of merchant ships, and stresses values are obtained through dedicated computer simulator software.*
Key words*: marine engine, diesel, simulation, bedplate, frame box*

1. Introduction

Still very common on commercial vessels' propulsion instalations, the K80 MC-C engine produced by MAN B&W was found to be very reliable.
Based on service reports made by producer during overhauls of engines, fatique cracks has been discovered in the lifting bracked on bedplates (figure 1) or in the cylinder frame (figure 2) due to stay bolts covers.

Figure 1. Cracks of lifting bracket [3, p.17]

Figure 2. Cracks of cylinder frame [3, p.18]

In order to make a contribution in this direction of research, the present study includes a simulation of stresses occurring in the bedplate and frame box for the MAN B&W K80 MC-C marine diesel engine.

2. Engine thermal, kinematic and dynamic calculation

Engine manufacturing program has evolved since the 80's adopting bores from 260 [mm] to1080 [mm] with powers up to 100000 kW, propelling commercial vessels of all sizes and even becoming an industry standard equipment for certain types of ships.
K80 MC-C engines were introduced in service in 1988 and use the conventional chain driven camshaft for the injection pumps and exhaust valves command [5, p.47].
The MC-C engine version is shorter and more compact than MC version, it is designed for container ships where engine room has a reduced size[4, p.21].
A cross section of the engine is shown in figure 3 and its main features are given below:
- bore: 800 [mm];
- stroke: 2300 [mm];
- connecting rod length: 2920 [mm];
- number of cylinders: 7;
- power: 25270 [kW];
- rotation: 104 [rpm];
- mean effective pressure: 18 [bar];
- compression ratio: 13.3;
- weight: 830 [5].

The maximum cylinder pressure calculated was 112,84 bar, and for obtaining an accurate simulation results, we will take into account the pressure value recorder by monitoring system of engine (figure 4), to whitch add a margin value of 10 bar, resulting a total value of 142 bar.

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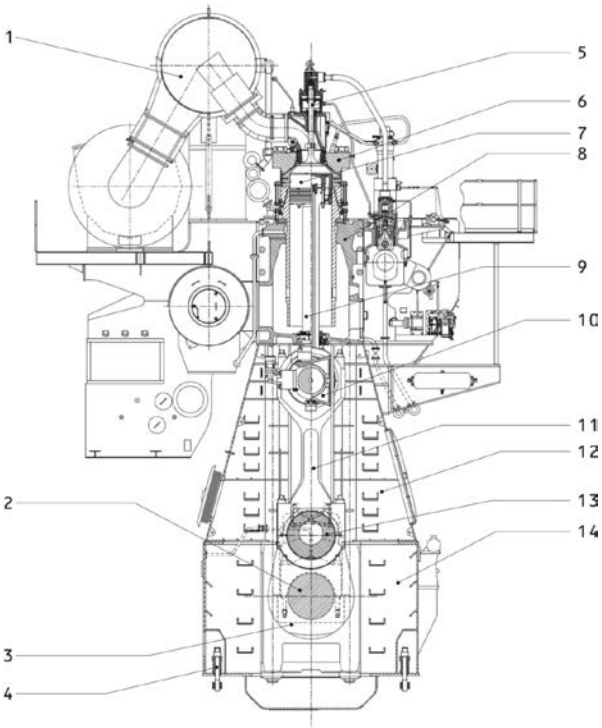

Figure 3. MAN B&W K80 MC-C engine cross section: 1 – exhaust manifold, 2 – spindle pin, 3 – crankpin, 4 – engine mounting stud, 5 – exhaust valve assembly, 6 – cylinder head, 7 – piston, 8 – cylinder block, 9 – piston rod, 10 – cross head, 11 – connecting rod, 12 – frame box, 13 – crankpin, 14 – bedplate [adopted from 2, p.35]

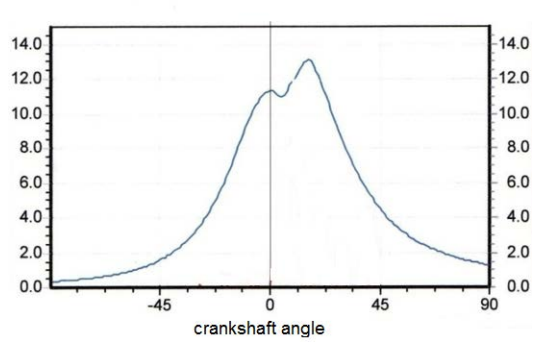

Figure 4. The pressure inside the cylinder number seven, measured after 36660 operating hours [5, p.81]

The force thus obtained has a value of N_{MAX}=631,25kN, and is schematically shown in figure 5.

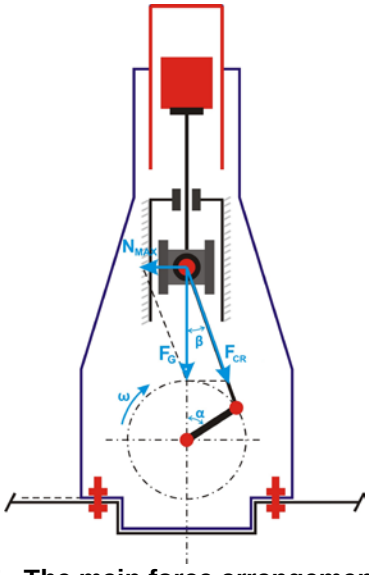

Figure 5. The main force arrangement due to combustion process in the cylinder (F_G – cylinder gases force, F_{CC} – force along connecting rod, N_{MAX} – perpendicular force)[5, p.85]

3. Engine components modeling

For the modeling purpose of the engine main components, dimensional data are shown in figure 6.

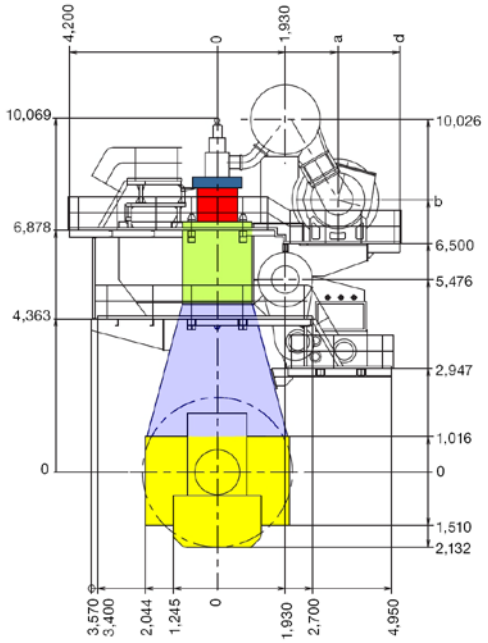

Figure 6. Engine dimensional data (values in mm) [4, p.124]

The Ansys three-dimensional representation of a cylinder related section of engine is shown below, along with meshing illustration.

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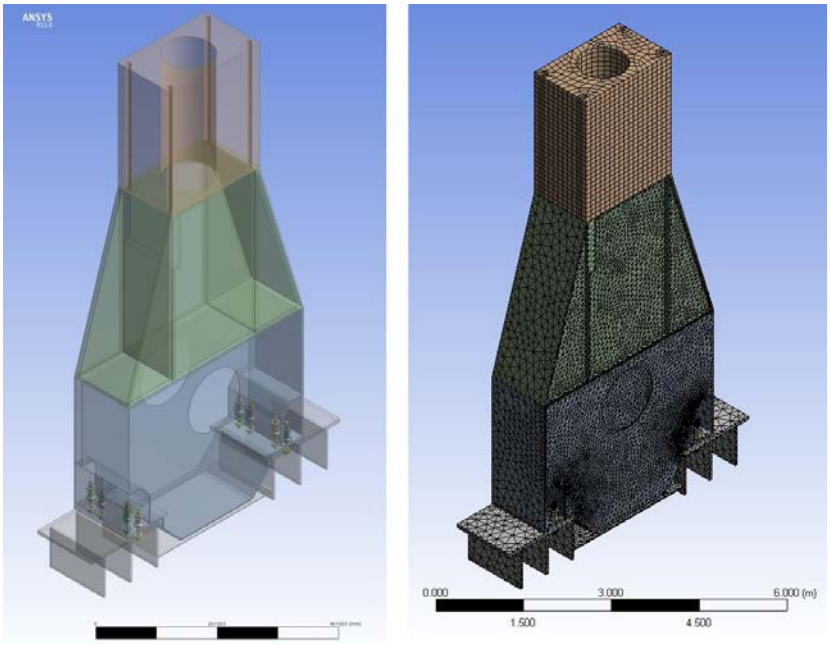

Figure 7. Cylinder related section of engine[5, p.199]

The forces were applied according to calculations made in chapter 2, and after specific finite element method operations of meshing, processing and post-processing, the results are graphically shown in figures 8 and 9 and numericallysynthesized in table 1.

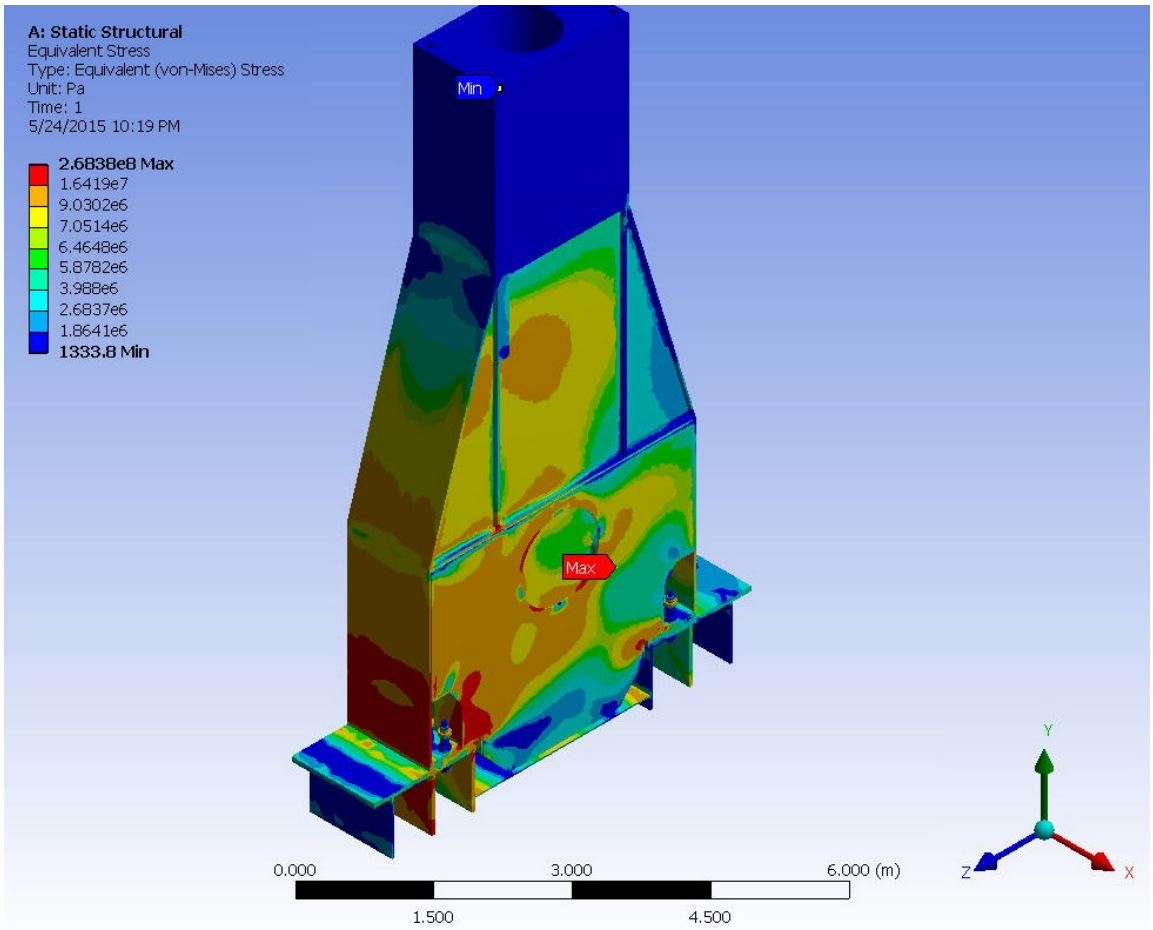

Figure 8. Bedplate and frame box equivalent (von-Mises) stress (perspective view)[5, p.205]

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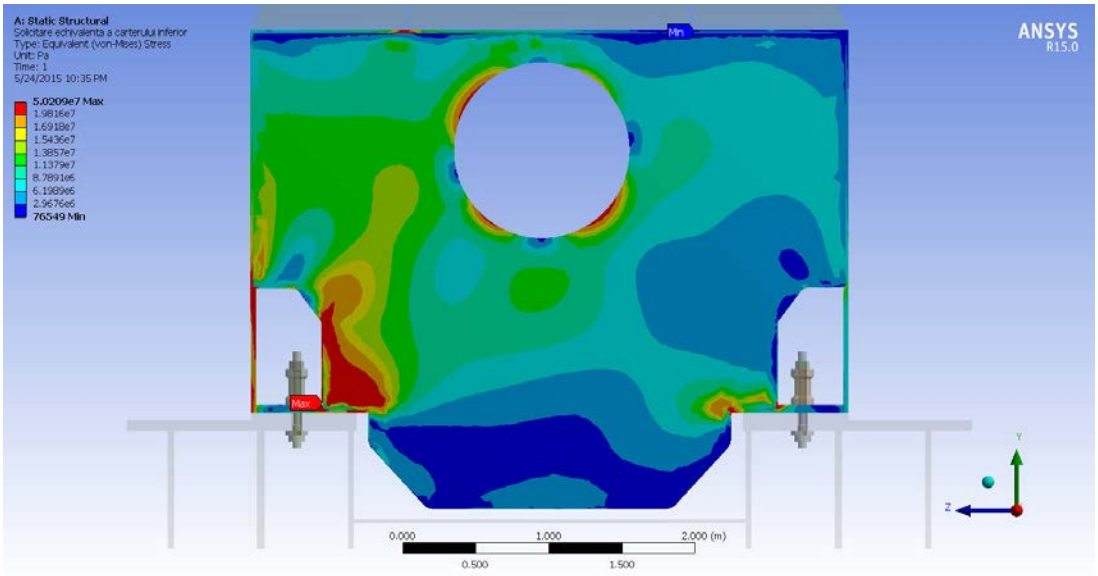

Figure 9. Bedplate equivalent (von-Mises) stress (orthogonal projection)[5, p.206]

Table 1 Obtained results of equivalent stress simulationsupported by targeted engine components

	Tested component		
	All section	Ship's hull	Bedplate
Maximum value	1333.8 Pa	23920 Pa	76549 Pa
Minimum value	2.68 $\cdot 10^8$Pa	3.46 $\cdot 10^7$Pa	5.02 $\cdot 10^7$Pa

Conclusions

The simulation results confirms the intensive stress presence in the area where cracks have been reported by the engines overhauls maintenance teams.
The high combustion pressures within the cylinders, together with engine's high vibrations create a stress within the engine'sbedplate, frame box and cylinder block.
Also, since the correct crankshaft alignment during service is very important for engine proper operation, a permanent research in this direction is needed.

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