Main dimension optimization of large combustion engines

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ABSTRACT

While electrification and digitalization are popular terms nowadays, large combustion engines still play a big role in various applications. Technology development, hybrid solutions, and alternative cleaner fuels have made large combustion engines more and more efficient and environmentally friendly. Ships and vessels are moving with the power of combustion engines. Engines generate electricity in power plants worldwide as they have many advantages. They can be placed anywhere, like remote islands, and they are fast to start. Increased wind and solar power increase the instability of power generation, which makes combustion engines very useful to stabilize the electric grid, and they can also work as emergency units. The competition in the market is demanding. Environmental regulations are the primary driver of engine technology development, leading to increased engine performance demands. [2] Practically this means increased firing and boost pressures which consequently increases the loading of the engine components. Also, manufacturing cost and power-to-weight ratio play an important role. Big engines are challenging to transport, and ships have limited space in their engine rooms. There is a need to make compact engines with high utilization of the strength of metals. Defining suitable main dimensions of the combustion engine is a complicated puzzle where loading of the components and space reservations need to be considered. At the starting point, the rotating speed and number of cylinders define the engine's possible power output. When the rotating speed is known, the bore and stroke can be selected so that the mechanical loads stay under the limits and the performance targets are obtained. The most important criteria for mechanical loads are related to bearing loads [1], fatigue and fretting fatigue [5]. The firing forces dominate the bearing loads and fatigue. The mass forces define the fretting fatigue risk of the connecting rod [4]. Defining the cylinder distance of the engine becomes complex as the dimensions like bearing widths, crankshaft and counterweight dimensions [3], connecting rod width, cylinder liner diameter, and cylinder head size all affect each other and have their limits. The whole system should be optimized so that everything is reliable and the amount of metal is minimized. First step is to use analytical formula to estimate loads, masses, bolt sizes and critical stress levels without using any 3D models. This enables fast design of experiments and multi-objective optimization of the engine dimensions. Second step is to make 3D models and more detailed simulations of critical components by using flexible multi-body dynamics (MBD) and finite element method (FEM) [2].

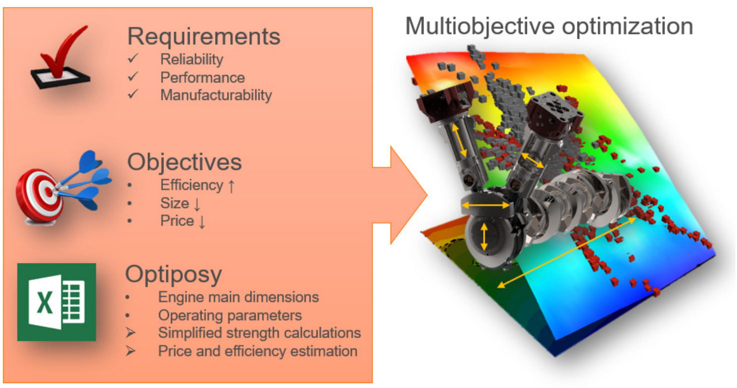

Figure 1. Illustration of combustion engine main dimension optimization.

Keywords: Engine main dimensions, optimization, FEM, MBD, concept calculations

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