Topology optimisation of in-line engine turbocharger bracket

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Summary. This article describes the use of the TOSCA software in the design process of a turbocharger bracket of a medium speed gas or diesel engine. TOSCA is a topology optimisation software from Dassault Systemes. This paper shows some intermediate optimized results as wells as the final design.

Key words: Wärtsilä, turbocharger bracket, FEM, topology optimization, Tosca

Introduction

Genset dynamics is one of the most challenging aspects in the medium speed engine design process. There are a wide variety of different engine excitations to be considered from gas pressure [1], gear train [8], rotating [3] and oscillating masses [7] as well as all kinds of peculiar grid behaviors [5]. The concept calculation [4] tries to find the best compromise structure where the main natural frequencies are tuned to avoid the main excitations frequencies. The topology optimisation [2] of a turbocharger bracket with the TOSCA software can be used to achieve this.

Lastly the simulation data and requirement management had to be done correctly in order to utilize the full benefits of the topology optimisation. In this case it is done in the Wärtsila Digital Design Platform [6].

Formulation of the problem for Tosca software

Topology optimisation is a mathematical method that optimizes the material layout within a given design space, for a given set of loads, boundary conditions and constraints with the goal of maximizing the performance of the system. The current case had the problem that was described earlier. All current turbocharger bracket designs gave results where the natural frequency of the turbocharger was matching the firing frequency of the main engine case (the case where the engine is not mounted to a hull or is not in assembly
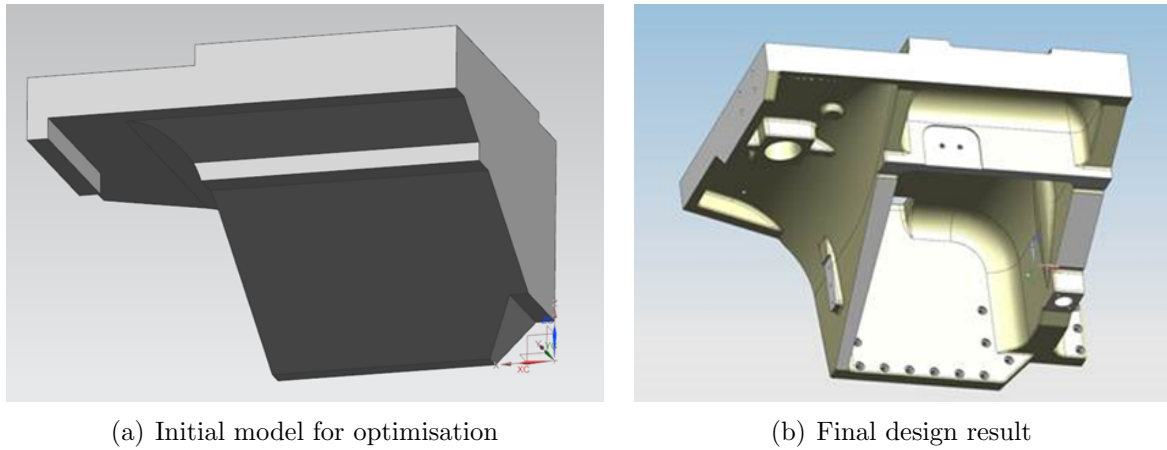
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(a) Initial model for optimisation

(b) Final design result

Figure 1. Initial model and final designed bracket after the optimisation.

(a) Results given by Tosca

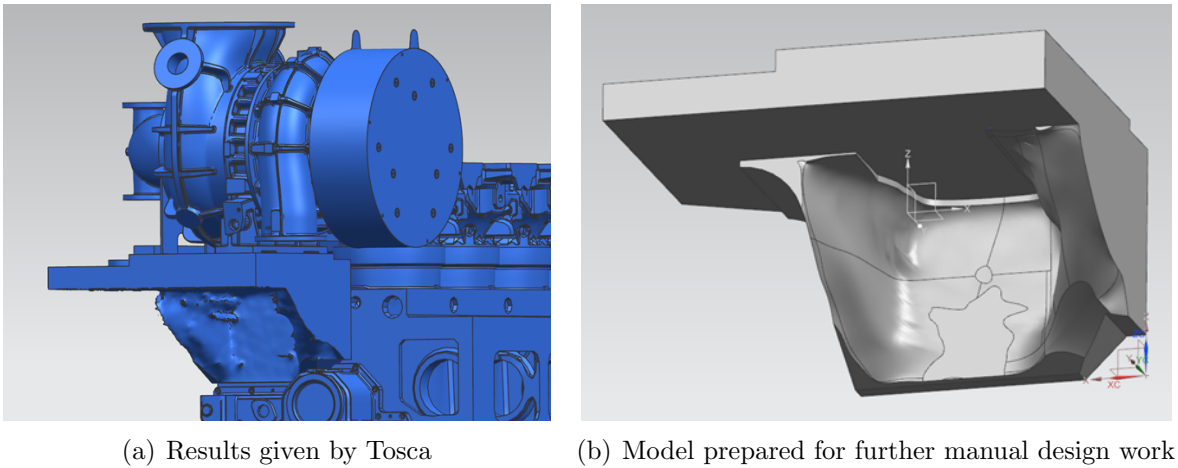(b) Model prepared for further manual design work

Figure 2. Tosca optimization results.

with a genset). Therefore there were two options of design changes for the turbocharger bracket: to make the natural frequency higher than the firing frequency with a new turbocharger bracket design, or to make it lower. To check the first option, it was necessary to evaluate the maximum possible natural frequency of the turbocharger bracket within the maximum possible overall dimensions. The base model created for the initial natural frequency calculation is shown on Figure 1(a).

The results of the natural frequency calculation of turbocharger with the initial base bracket model showed that the sought-for natural frequency is 6-7 Hz higher than the firing frequency and that the other turbocharger natural frequency looks fine as well. Therefore the Tosca Software problem became very easy to define. The desired natural frequencies of turbocharger bracket should remain at its level, while the volume of the turbocharger bracket should be reduced as material is predefined for turbochrger: minimizing the volume with fixing natural frequencies of turbocharger bracket.

Conclusions

The results were obtained with Tosca and presented in Figure 2(a) and Figure 2(b). They required some further manual design work (such as bolt holes and auxlary systems holes) and a final checkup. The final model is shown on Figure 1(b).

It can be concluded that topology optimisation brings a lot of added value to simulation driven design process through shortening the overall development time and making first time right designs. Like in this short paper, first the concept design is found by using the topology optimisation software Tosca. Secondly, follow-up work which is not presented here, is to make a final virtual validation calculation to the final model shown on Figure 1(b) and make sure that the final design also fulfills the requirements.

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