Case Study

Piper Test and Measurement Ltd
& Siemens AG

Optimised Design of IPP Drive Support Structure

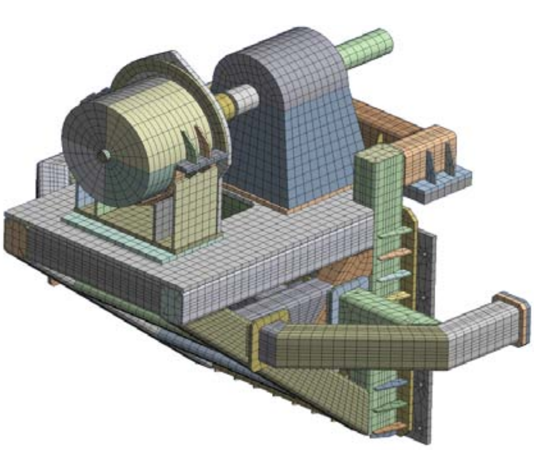
Company Profile

Piper Test and Measurement manufactures engine test systems incorporating its own range of dynamometers for specialist industries. Their instrumentation is comprehensive and ranges from simple analogue to full computer based data acquisition systems.

Component test systems are designed in close co-operation with the customer. Their knowledge of mechanical, electrical and hydraulic systems enables value for money units to be manufactured at short lead times, whilst close co-operation with engine manufacturers enables the most suitable test schedules to be prepared.

Piper Test and Measurement Ltd's dynamometer equipment is used by the majority of engine manufacturers, distributors and their dealers. It was Piper's intimate knowledge of dynamometer and loading systems that convinced Siemens AG to appoint Piper Test and Measurement as a suitable partner in this project.

Background



This case study describes the design and analysis of a support structure for a braking system that was used for a huge flywheel generator. The flywheel generator was designed as a motor generator unit used by the Max-Planck-Institut für Plasmaphysik (IPP) in Garching, Germany, to provide a considerable amount of power for their experiments. IPP is investigating the physical principles underlying a plasma fusion power plant, to produce energy.

Piper Test and Measurement were required to supply a braking system for the flywheel generator. A combination of a hydraulic dynamometer and a water-cooled disc brake was the only possibility as nothing else would have fitted into the building. This braking system allowed the flywheel to come to a standstill in less than ten minutes, without it the generator would have taken a considerable time to slow

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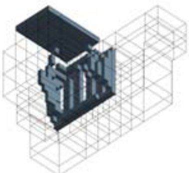
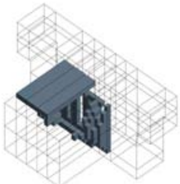
down and stop. The motor-generator was positioned on a concrete isolation block, connected to the floor of the building by damper elements. As a flexible shaft connection did not exist in the required size through which the new brake could have been connected, the braking system had to somehow be fixed onto the concrete foundation. However, the foundation did not have enough space for the new brake assembly simply to be placed onto it. Therefore, a cantilever supporting structure had to be designed for the braking system, which was to be fixed to the concrete block using some pre-existing holes drilled through the front face of the concrete block. IDAC were required by Piper Test and Measurement to carry out Finite Element Analyses (FEA) to evaluate the design of a support structure for the braking system.

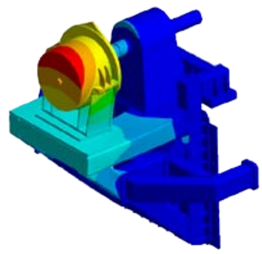
Analysis

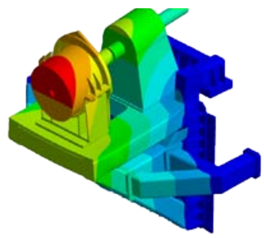


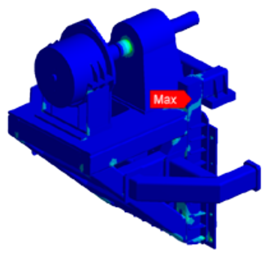
The FEA project carried out by IDAC was split into three phases as follows:

Phase 1 - Shape
A topological optimisation was carried out in order to determine a preliminary design of the support frame. This part of the project was carried out using the Shape Optimiser in ANSYS Mechanical. The software approximated the initial structure as a large volume, which was then "eaten away" at locations with low stresses, leaving a "pixelated" representation of the optimised support structure. The graphics to the left (top) show the starting geometry as a large volume and below this, the initial design shape that was predicted by ANSYS can be seen. An envelope of the initial volume was defined to locate the soleplates for the support structure and to define the position of the side arms. The loading consisted of a static load (weight of the components and platform) and a dynamic load (reaction torque applied by the dynamometer and disc brake).









Phase 2 – Sizing & Dimensioning
Using the topologically optimised solution from Phase 1, a design optimisation was carried out in ANSYS Mechanical APDL. A parametric model of beam and shell elements was created and optimised. The sizes and thicknesses of the beams and shells respectively, were defined as design variables and the mass of the structure as the objective function. The natural frequency was defined as a state variable and the mass of the structure as the objective function to ensure that the natural frequencies of the steel support structure avoided the critical resonant frequencies of the concrete foundation block. One of the mode shape plots can be seen in the graphic to the right (top). The design optimisation allowed the design of the support structure to be refined, and the beams and plates to be sized; this was then forwarded to Whittaker Engineering, who would be manufacturing the support structure. Whittaker Engineering made some manufacturing modifications to the supporting structure design and provided IDAC with an Autodesk Inventor model of the structure for further analysis.

Phase 3 – Manufactured Design
This part of the project involved analysis of the Autodesk Inventor model in ANSYS Mechanical. The solid model of beams and shells was meshed with solid elements and then re-analysed to verify the final design of the support structure. The graphics to the right (middle & bottom) show the deformation and von-Mises stress results.

Design Benefit

Carrying out a shape optimisation within ANSYS Mechanical enabled the design of a supporting structure for the 11 tonne brake assembly to be carried out successfully. The analysis provided a design which made use of minimum weight and space, whilst giving a reliable design and a cost saving. The results from the analyses also showed that maximum performance was attained whilst avoiding the modes of resonance of the concrete foundation block.

Eddy Perk, Managing Director of Piper Test & Measurement says: "IDAC were given a number of criteria which were essential for the successful operation of the system. The thoroughness with which they approached this task was without doubt professional and their capability in applying the ANSYS software impressive. This task would have been both cumbersome and virtually impossible if done without this software. Time and money well spent".

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