Case Study

Hayward Tyler

IDAC performs CFD and Structural FEA Analyses on a Pump Case

Company Profile

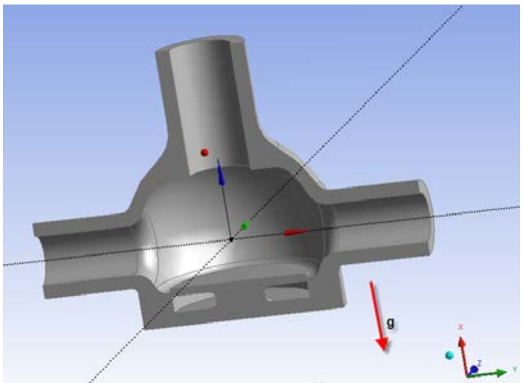
Hayward Tyler was established in 1815 and almost 200 years later their engineering excellence places them at the forefront of engineered solutions for critical application in Power Generation and Offshore Oil and Gas Technology.

Their products are custom designed and built to superior standards, ensuring endurance in demanding conditions.

Hayward Tyler's primary markets are Oil & Gas, Power Generation, Renewable Energy and Chemical Processing industries.

Hayward Tyler pumps are installed all over the world. They are the preferred choice for operators who have to ensure total reliability and a long life. They supply two thirds of the world's boiler circulation pumps as they are renowned for their reliability, often running continuously for years and years, non-stop. Their pumps are designed to meet the most demanding of applications.

Background



Hayward Tyler was required by their client to provide a pump casing which was able to withstand a temperature increase of 56ºC in 3 seconds. The casing was for a 500MW double discharge pump used to circulate water into a boiler, being used in the power generation industry.

Hayward Tyler designed a pump for this application and as a part of the design process required IDAC to carry out Computational Fluid Dynamic (CFD) analyses and subsequent Finite Element Analyses (FEA) in order to verify that there would not be any excessive stresses in the structure due to the thermal stress and the internal pressure of 211bar.

This required a Fluid Structure Interaction (FSI) solution to be performed. The ANSYS range of products allows the interaction between fluids and surrounding structures to be solved. Products within the ANSYS Suite can be combined to perform one-way and two-way FSI. For the purpose of this project a one-way FSI solution was carried out. ANSYS CFX was used to carry out the fluid/thermal analysis and this was followed by an FEA analysis carried out in ANSYS/Mechanical in order to obtain an accurate stress solution.

Analysis

The pump casing was made of carbon steel, and the branches of the pump were connected to pipes. The geometry of the pump-motor assembly along with the sealing gasket between the pump and motor was supplied by Hayward Tyler as a single 3D model STEP file.

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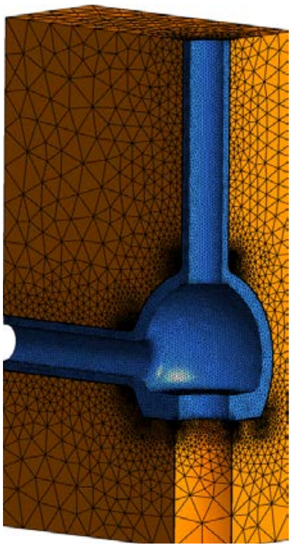
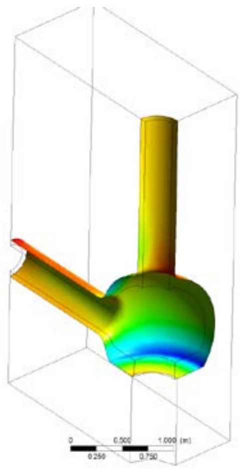


The CFD model was created by importing the 3D geometry into ANSYS DesignModeler and creating a volume of ambient air around it. For the FE model, fine details deemed to be inconsequential to the analysis were removed from the geometry, in order to produce a more efficient mesh.

The pump inlet and outlet pipes were extended at either end to ensure an adequate representation of the natural convection flow around the assembly, and also to accurately capture the axial stresses in the pipes.

The geometry was meshed with 3D tetrahedral elements for both the fluid and the structural regions using ANSYS Workbench version 13.0. The graphic to the left shows the mesh used. The areas near the external air and pump interface were locally refined to obtain a high density of elements leading to an accurate resolution of the heat transfer coefficient calculated at the pump walls.

The design temperature of the pump was 370ºC and the design pressure 211bar. The pump could be subjected to situations when water (maintained at temperature of 367°C) sat inside the pump for weeks together. Hence the internal walls of the pump were given a boundary condition of the water temperature instead of modelling the water flow through the pump. The objective of the analysis was to check the stresses on the branches of the pump case at the design condition. As the pump was located at a place where there would be just still air around it without any externally driven (fan) cooling, the external heat loss was only through natural convection. This was modelled within ANSYS CFX.



The project was split into two stages as follows:

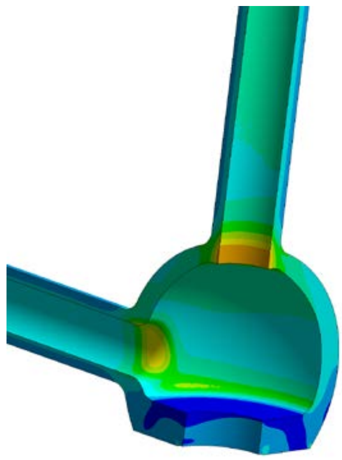
1. The first stage involved solving a thermal analysis within ANSYS CFX, where the analysis type was considered to be steady state, incompressible, thermal, single fluid CFD analysis including heat transfer through the solid components of the assembly. The ambient air fed into the fluid domain was set at 40°C. However, the local air temperature in the domain would vary depending upon the heat gained from the pump-motor assembly. A fixed temperature of 367ºC was set for the inner wet surfaces of the pump wall. The analysis calculated the temperature distribution through the casing wall and the convection film coefficient on the outer surfaces.

   The graphic to the right top shows the temperature distribution on the outer walls of the pump.

2. The second stage used the thermal results from stage 1 of the solution in an FEA model in order to accurately obtain stress results. The temperature distribution derived from the first stage CFD analysis was imported and applied to the body as a load along with the internal pressure load of 211bar on the inner wet surfaces of the pump walls.

   The analysis type considered was a steady state analysis with stresses being computed both due to the thermal load as well as the pressure load on the pump walls. The graphic to the right bottom, shows the equivalent stress distribution.

   Linearised stress distributions were obtained in critical locations and the radius of the pump casing was also changed by Hayward Tyler in order to see its effect on the stress distribution and hence lead to a better design of the pump casing.



It was concluded from the analyses that the design requirements to increase the design ΔT of 56ºC in 3seconds for the pump casing, met the design criteria. Over the life cycle of the pump it was found to be fit for purpose.

Design Benefit

Rupert Knowles of Hayward Tyler says: "Working with IDAC has enabled us to complete a complex and detailed analysis which met the design criteria. We have used IDAC on a number of occasions over the last six years, and have always been pleased with the response and performance of IDAC. We have always been confident with the output received from IDAC which gives credibility to our designs."

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