STORK Redesigns LP Row 4 Rotor Blades

FREQUENCY PROBLEMS LEAD TO INNOVATIVE TURBINE SOLUTIONS

STORK TURBO BLADING CO-ORDINATED THE REDESIGN OF LP ROW 4 ROTOR BLADES FOR A CUSTOMER, DUE TO ISSUES WITH EIGENFREQUENCIES, VIBRATIONS AND FATIGUE CRACKING OF ROTOR BLADES.

THE REDESIGN HAS ENSURED THAT THE OPERATING FREQUENCIES OF THE ROTOR BLADES ARE SIGNIFICANTLY REMOVED FROM EXCITATION FREQUENCIES, ENSURING A LONGER LIFESPAN AND A DECREASED RISK OF FAILURE DUE TO FATIGUE.

LP4 Blade Assembly with Shroud & Wheel

The Customer

One of our UK customers asked if we had prior experience and know-how in regards to Natural (Eigen-) Frequency modelling, Stress Analysis and Blade Redesign, with the primary goal of reducing risk of failure & increasing the product lifespan. Based on our extensive knowledge of turbo machinery, Stork accepted this challenge and ensured that the LP turbine remains operational for a longer period of time and that the Natural (Eigen-) Frequencies are fine-tuned for optimal operating conditions.

The Challenge

The redesign was required for the fourth stage of a 660MW LP steam turbine. The LP4 Rotor Blades have undergone several stages of redesign due to problems with natural (Eigen-) Frequencies, the initial redesign from Mark 1.0 to Mark 2.0 has been done by the OEM. In conjunction with the customer our experts mapped all changes as devised by the OEM to figure out how the changes affected the properties of the blades. The table below highlights some important changes:

Mark	Design Changes
Mark 1.0	Original Design by OEM
Mark 1.1	Additional mass added to the blade tip
Mark 1.3	Blend radius of Mark 2.0
Mark 1.5	Mark 1.0 with Mark 2.0 Shroud
Mark 2.0	Improved Design by OEM

Although the improved design resolved some issues, Eigen Frequencies at operational speeds still proved problematic, the primary issues with the Mark 1.0 and the Mark 2.0 were extensive high cycle fatigue cracking of shrouding and fishplates with some cracking of blade root pinned connections.

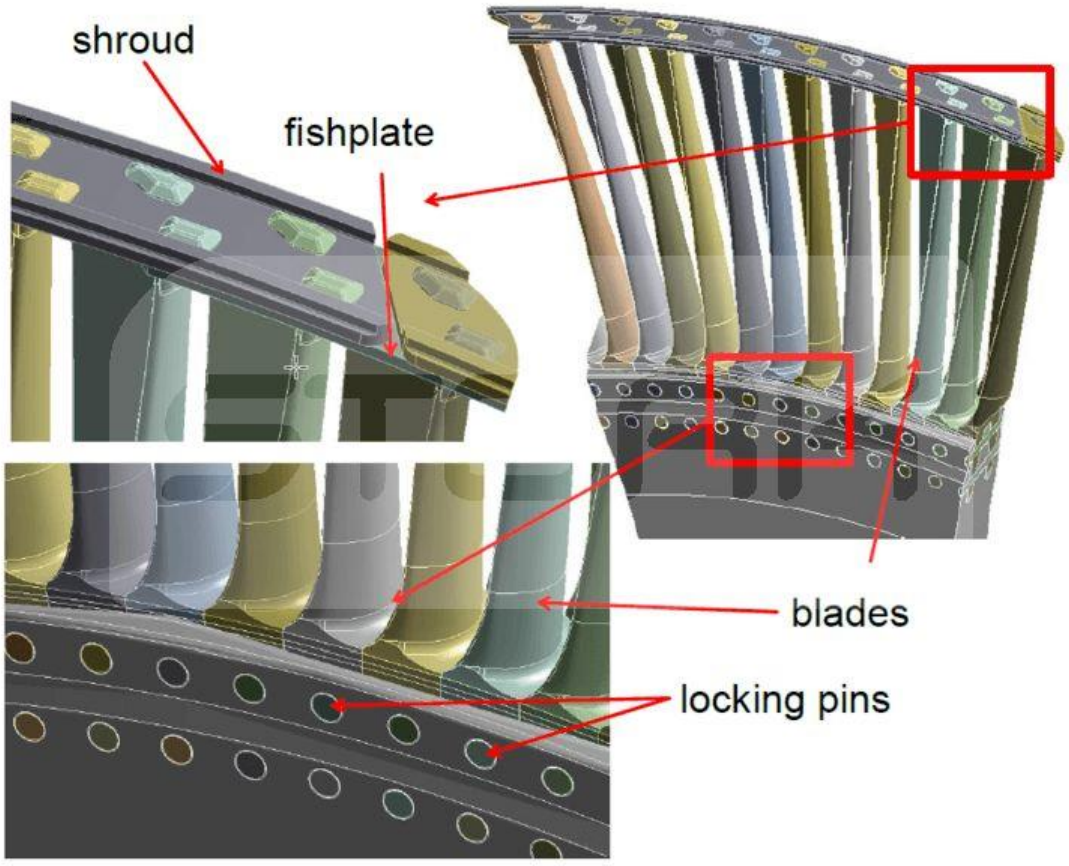
In order to solve this problem with cracking due to centrifugal forces and fatigue stress, Stork was asked to provide a solution based on our broad and in-depth understanding of blade behaviour, as well as experience with FEM simulations.

The Simulation

The simulation was executed in collaboration with B&B-Agema from Germany, and consists of an entire assembly including all small components such as locking pins, fish plates, shrouds etc. This produces a result that is as accurate as possible and provides proper insight into the dynamic behavior of the bladed wheel and blade loadings under operating conditions.

Stork ensures that the simulations are accurate and verify that the simulations come as close to real life as possible, with proper constraint selection, mesh configuration, force directions, operating conditions and so on.

Physical material properties were also finely adjusted to accurately calculate and simulate the existing design, and come as close to real life as possible. In order to verify that the simulations are accurate, validation and verification measurements were conducted, such as frequency measurements and material testing. The end result is a simulation that comes as close to reality as possible. Static and dynamic vibration data for the mark 1.0 and mark 2.0 designs were available to enable verification of the model. In addition, single blade vibration measurements were undertaken of both mark 1.0 and 2.0, and with the redesigned blades to compare the values with the calculated values.



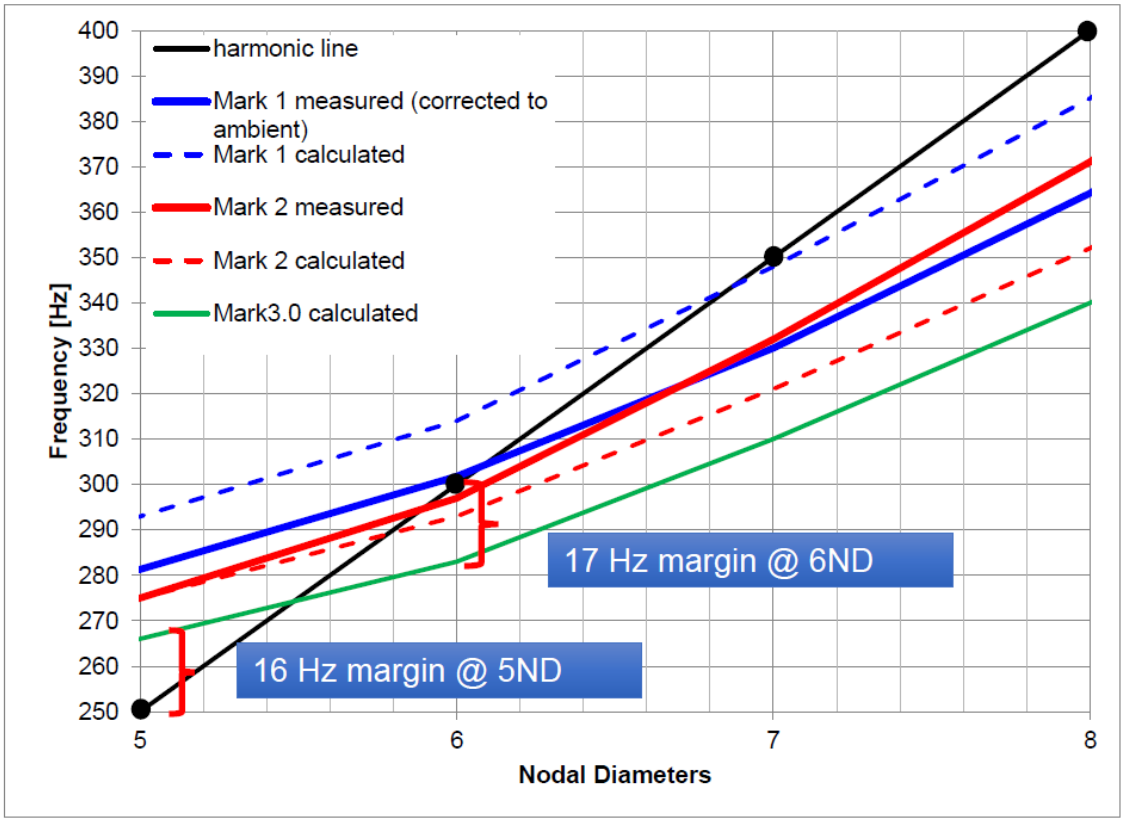
Detailed view of LP4 Assembly

The Solution

Stork redesigned the rotor blades wiith several design changes, to constantly monitor the effects that minute changes in the design apply to the Eigen-Frequencies as well as peak stress levels within the components. This was done to ensure that the design changes result in the desired blade behavior and design demands, and led to several new design marks. Mark 3.1 proved to have the right Eigen-Frequencies as well as optimal stress levels well within the material specifications. As such mark 3.1 is the preferred and finalized design that we recommended to our customer.

Mark	Design Changes
Mark 2.1	Mark 2.0 with additional mass
Mark 3.0	Mark 2.1 with more additional mass
Mark 3.1	Final design, aligned tenon blades, chamfered and enlarged pin holes

In regards to optimal material selection, Stork once again proved its capabilities by selecting a new material for the LP4 blades with a higher tensile strength, in order to counter the increased centrifugal forces within the roots as a result of the added mass. This was done to retain margins over the increased root stresses caused nu the heavier blades.



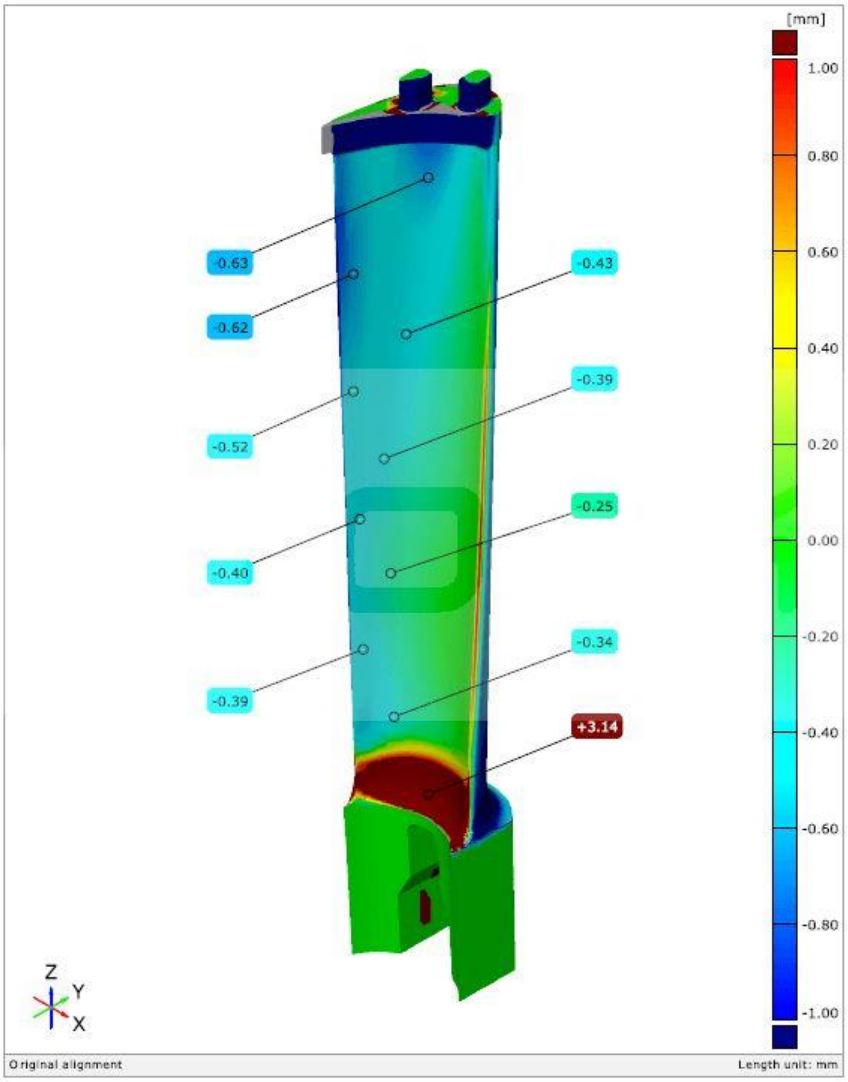
Frequency Differences between OEM Design & Improved Design

The verification and validation has been done for each design feature, no matter how small, to map the influences on the Natural (Eigen-) Frequencies and stress levels of this particular blade. This enabled the influence of the various design changes on the dynamic frequencies to be determined.

The Advantages

The redesign of the blades has generated the following advantages:

- Nullified fatigue crack initiation due to vibration as a result of Eigen-Frequencies.
- Achieve better blade behavior.
- Increased the lifespan of the redesigned components.
- Increased tensile strength due to different material choice.
- Lessen the risk of component failure.
- Limit and decrease peak dynamic stresses
- Tuning of bladed wheel away from excitation of resonant vibration



Example of CAD model dimensional checks

The Experience

Stork has extensive and in-depth knowledge of turbo machinery components for both Steam- & Gas turbines. We are a crucial partner and primary asset for longevity of your turbo machinery. The redesign of the LP4 Rotor blades is an addition to our extensive portfolio and highlights our capabilities once again when it comes to Engineering, Material Recommendation, Quality Assurance & Customer Satisfaction.

In Conclusion

In short, we can look back at a successful project and are satisfied that our customer was pleased with the end result. We will continue to strive for High Quality and work hard to remain a trusted source for turbo machinery components globally, while expanding our knowledge base and upgrade our technologies to maintain the highest standard possible.