Torsional & Lateral Critical Speed Analysis

Our customer is an EPC contractor who is constructing Circulating Water System for a Chemical Process Plant. Our scope of supply is Vertical Turbine pumps for cooling water. Each Pump is driven by 2800 kW/ 10 Pole Electric Motor. Considering the size of the pumping equipment and criticality of the application,, customer wanted to ascertain the mechanical design of the pumping equipment.

DeMaas Tech was engaged in carrying out the Torsional and Lateral Critical Speed analysis of the Pumping equipment. Analysis was carried out using ANSYS® software. Modal analysis was carried out by modelling the Rotor assembly as Beam. Torsional frequencies were extracted and tabulated as shown in Table 1 and the Mode shapes for extracted frequencies are as shown in Figures 2 to 4.

Critical Speed for Various excitation frequencies like 1X , 2X , 7X, 8X, 5.05 X (50 Hz Supply), 10.1 X (2 Time of supply frequency) and 10 X (Motor Pole pass frequency). Critical speeds are plotted using Campbell Diagram.
Lateral analysis is carried out by " Torque response analysis", Static analysis for getting the stress on the shaft which is further used for carrying out fatigue calculations. Stress location and distribution is represented using Goodman's diagram and SN Curve.

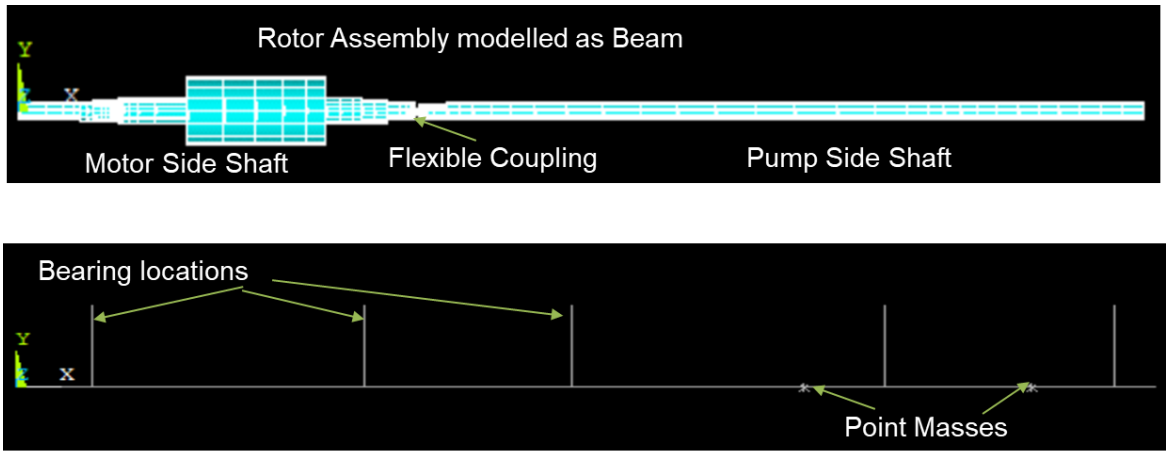


Figure 1 FE Model for Analysis (Beam and point masses)

Table 1 Torsional Modes and Frequencies

Mode	Frequency (Hz)
1	14.6
2	157.6
3	396.1
4	651.5
5	721.0

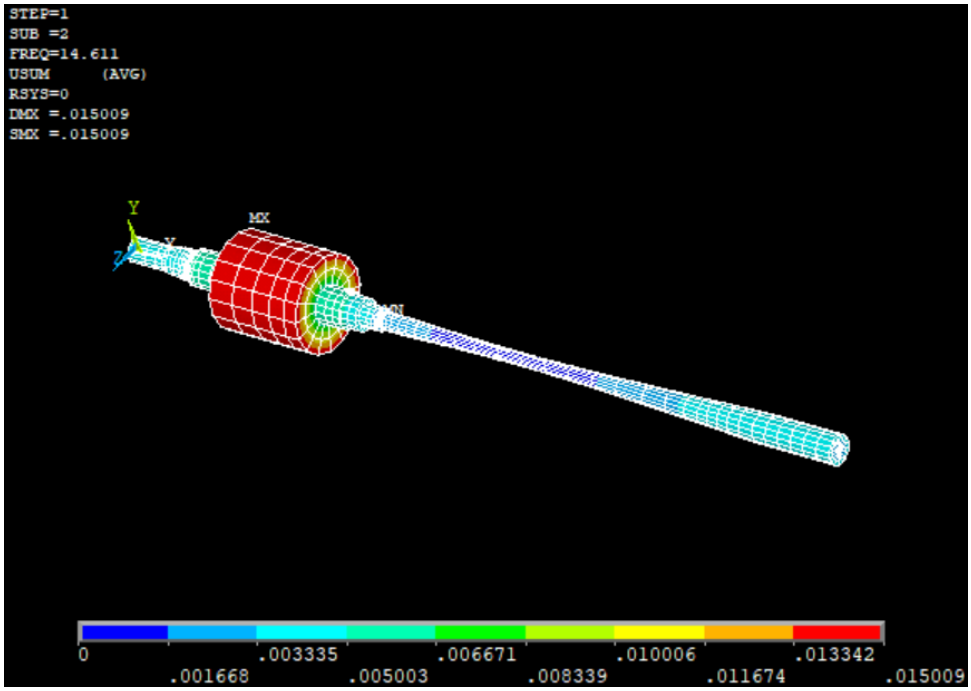


Figure 2 Mode shape 1 (Freq. 14.6 Hz)

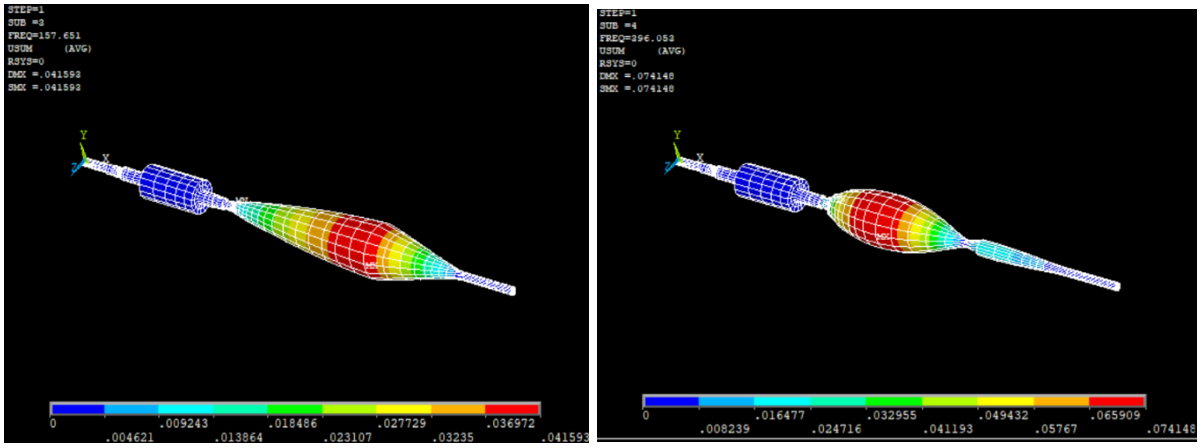


Figure 3 Mode shape 2 (Freq. 157.6 Hz) & Mode shape 3 (Freq. 396.1 Hz)

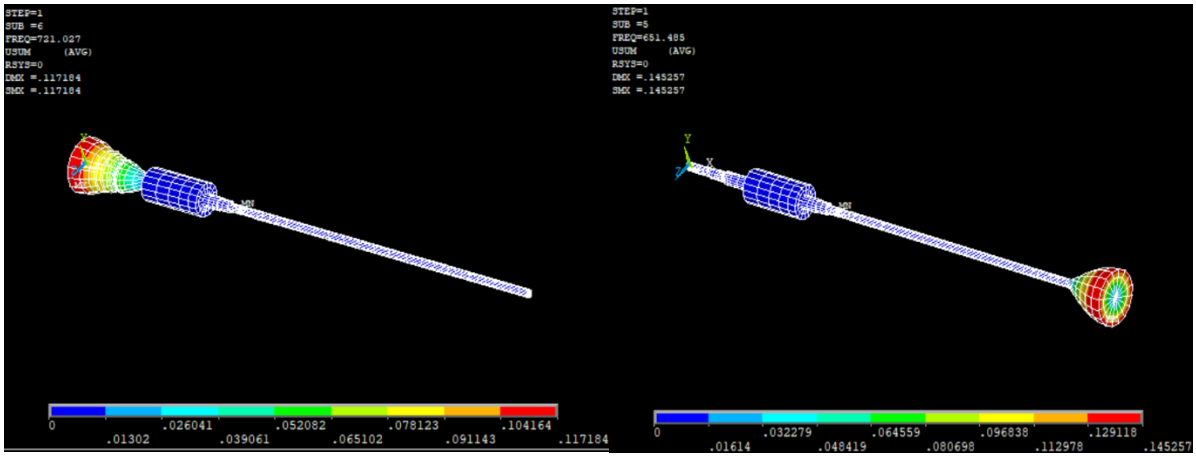
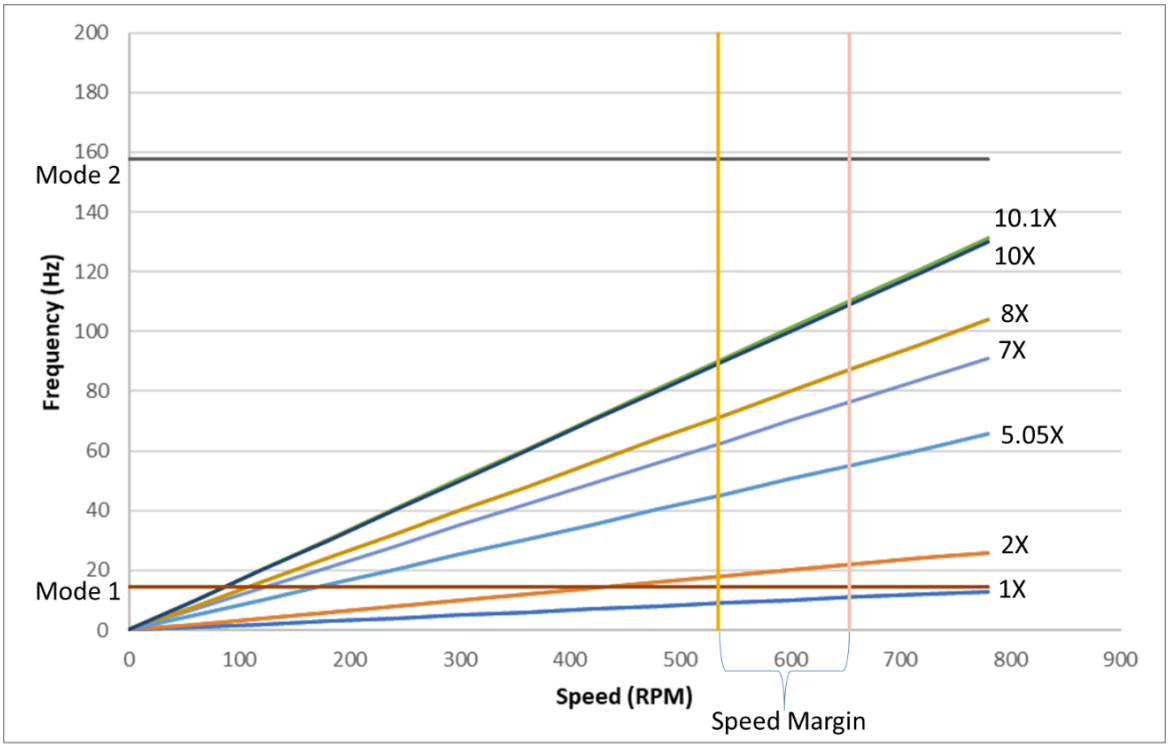


Figure 4 Mode shape 4 (Freq. 651.5 Hz) & Mode shape 5 (Freq. 721.0 H

Figure 5 Torsional Analysis – Campbell Diagram



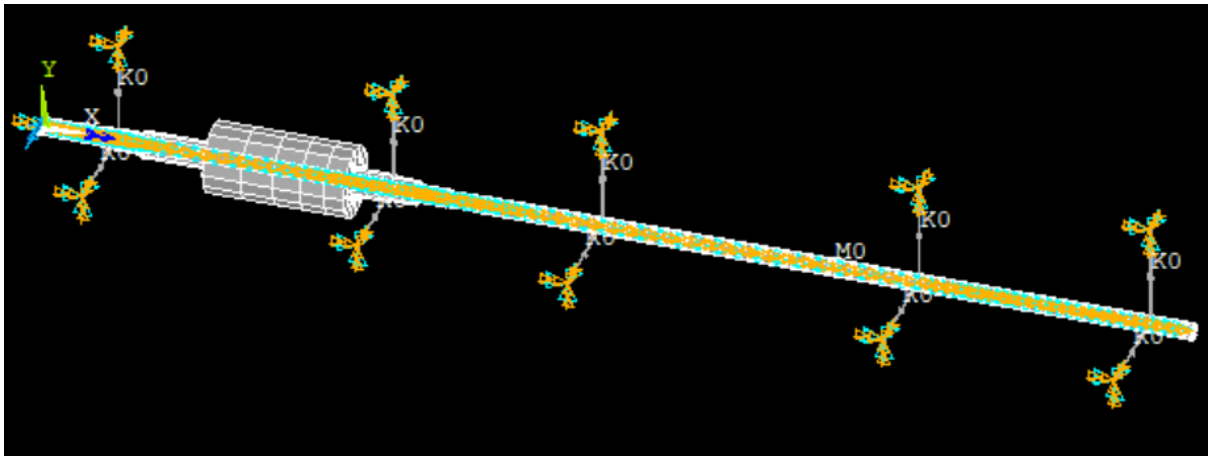


Figure 6 Boundary Condition for Lateral Analysis

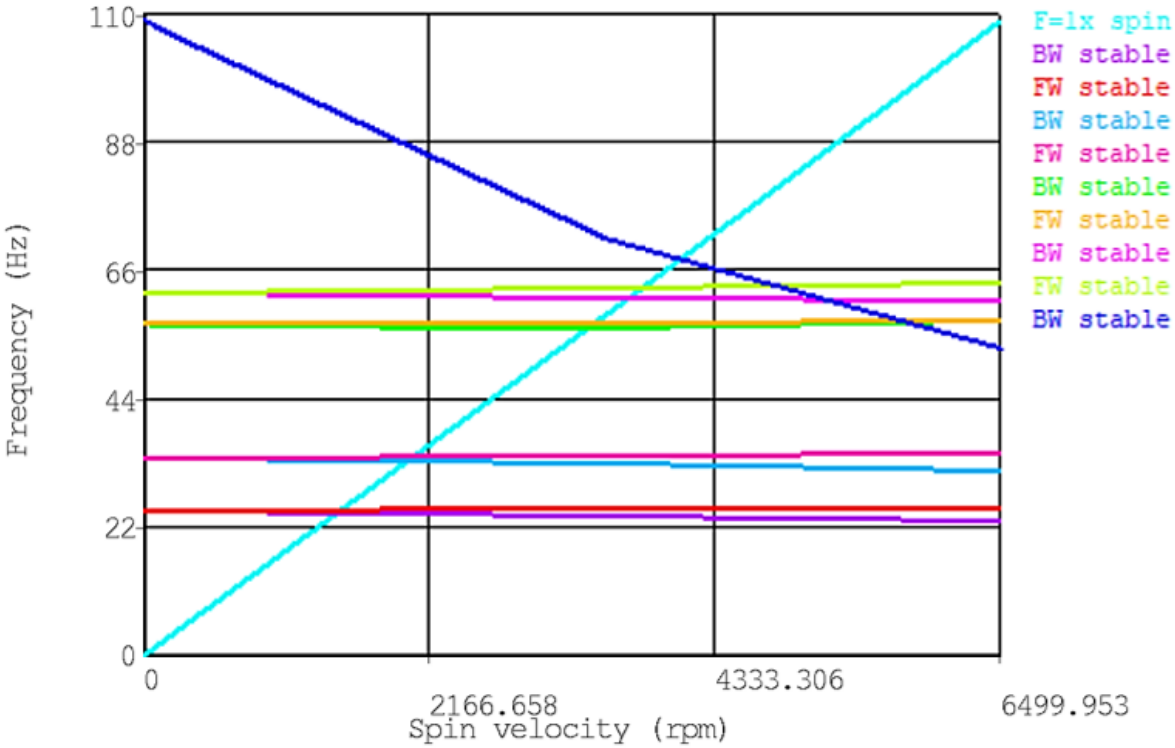


Figure 7 Lateral Analysis - Campbell Diagram

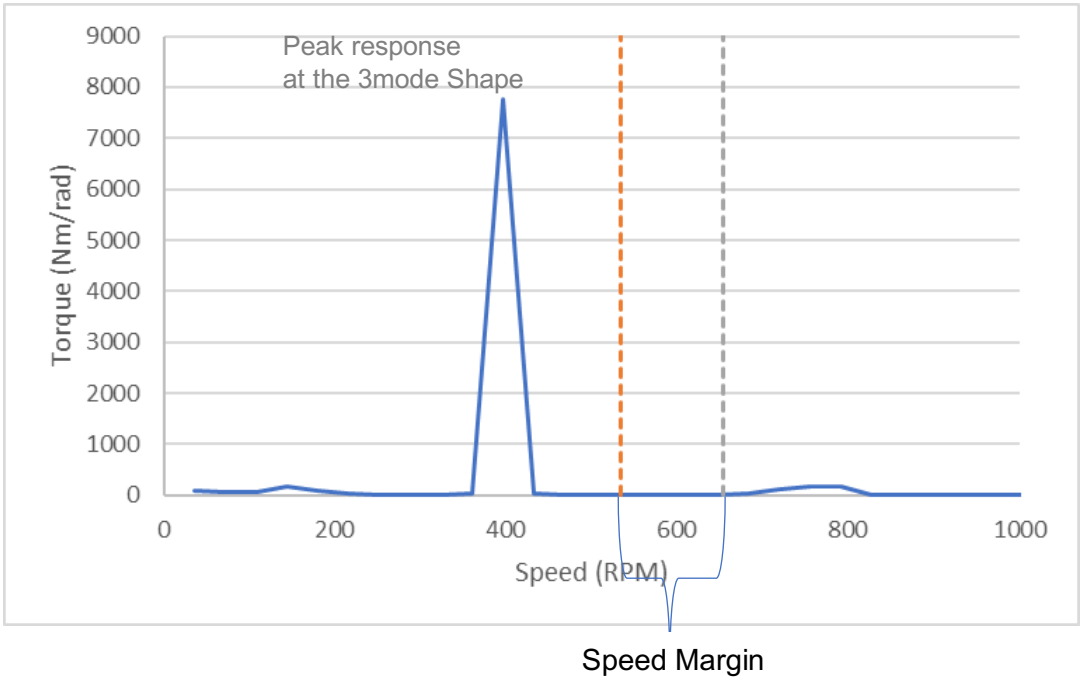


Figure 8 Torque Response at maximum stress location

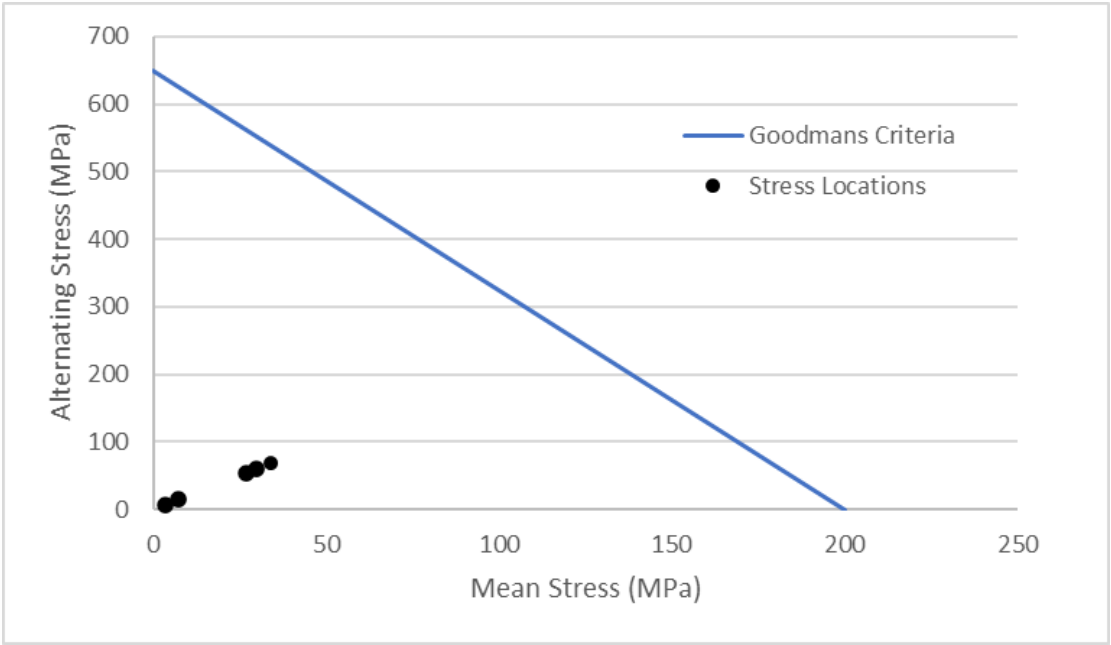


Figure 9 Goodman's Diagram

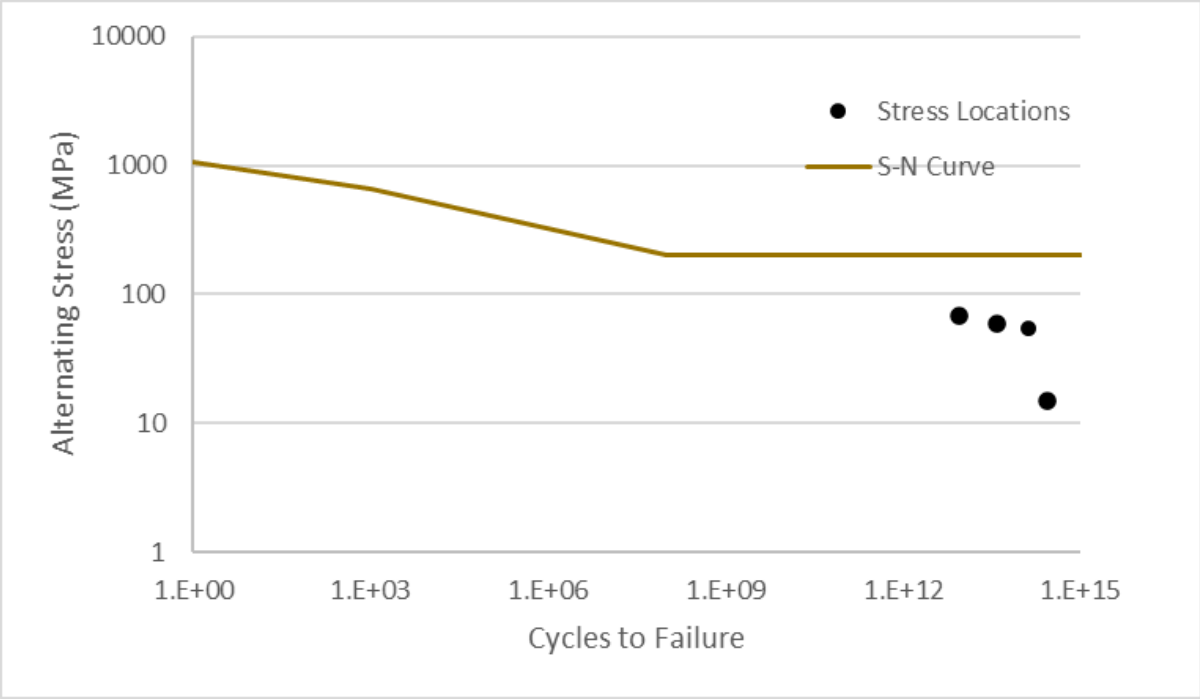


Figure 10 SN Curve, Stress Vs Life

Summary

1. The torsional frequencies and mode shapes are estimated. The Campbell diagram is plotted.
2. From the Campbell diagram it is observed that the torsional frequencies are outside the 10% margin of the operating speed of the rotor.
3. The lateral critical speed estimated is 1457 RPM above the rated speed of 594 RPM.
4. The torsional response analysis is carried out to evaluate the stress. The stress is within allowable limit.
5. The fatigue calculations are carried based on the stress. The fatigue life estimated is above 1e8 cycles or infinite life.