College of Engineering
LAMAR UNIVERSITY™

Departments of Mechanical and Industrial Engineering
It Is Rocket Science

Golden Pass Compressor Failure

Introduction

Kobelco Kobe Steel Group was founded in 1905 and started building screw compressors in 1955. They construct all the main types of gas-powered compressors. Those include the rotary screw, centrifugal, and reciprocating compressors. In the 1990s, they started to use roller bearings, which became their new standard. Advances in technology and a growing demand for compressors in multiple industries, the natural gas industry for example, have helped motivate Kobelco to enhance their products.

This failure occurred on February 19, 2021, following the freeze that occurred during the prior week. The **objective** of the project was to perform a root cause analysis to determine potential causes of the failure. In addition, the team modeled each individual part and assembled them in SolidWorks. A stress simulation was performed based off the assembly. SEM imaging was utilized to compare damaged and undamaged pieces of the rotors. Hand calculations were completed in order to compare them with the simulation results and add more depth to the project. Lastly, a data analysis was done to compare the compressor operation from January to the month of February.

Design Assumptions:

1. 3000 RPM
2. Solid Shaft
3. Factor of safety is 8
4. Uniform torque
5. Endurance limit is half the von Mises stress

FEA Analysis

A stress simulation was run on the compressor rotor models to determine the von Mises stress. The von Mises stress concentration in the simulation is lower than the hand calculation since it doesn't take surface contact into consideration. According to the simulation, the von Mises stress is 99.9 psi.

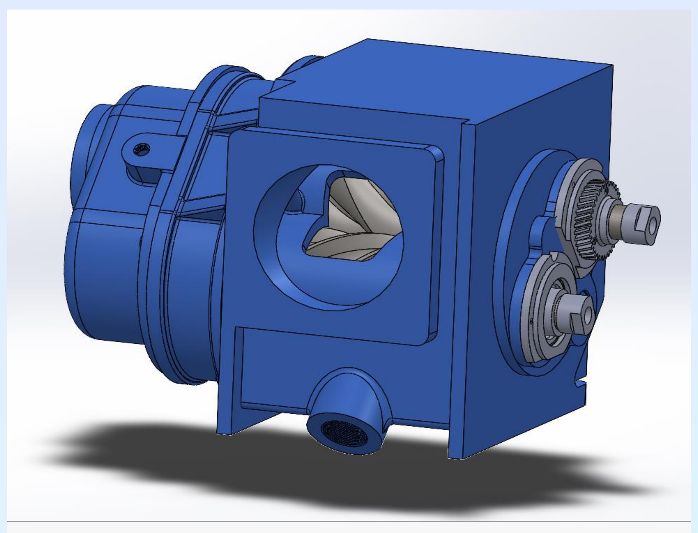

Figure 1: Compressor Model Assembly

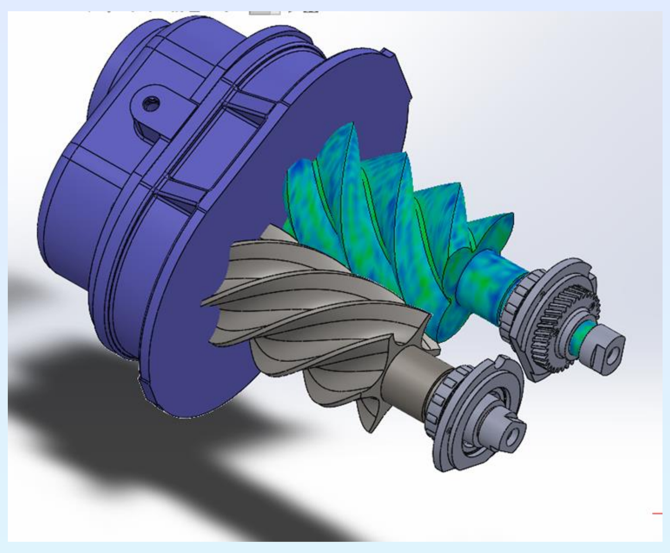

Figure 2: Rotor Simulation

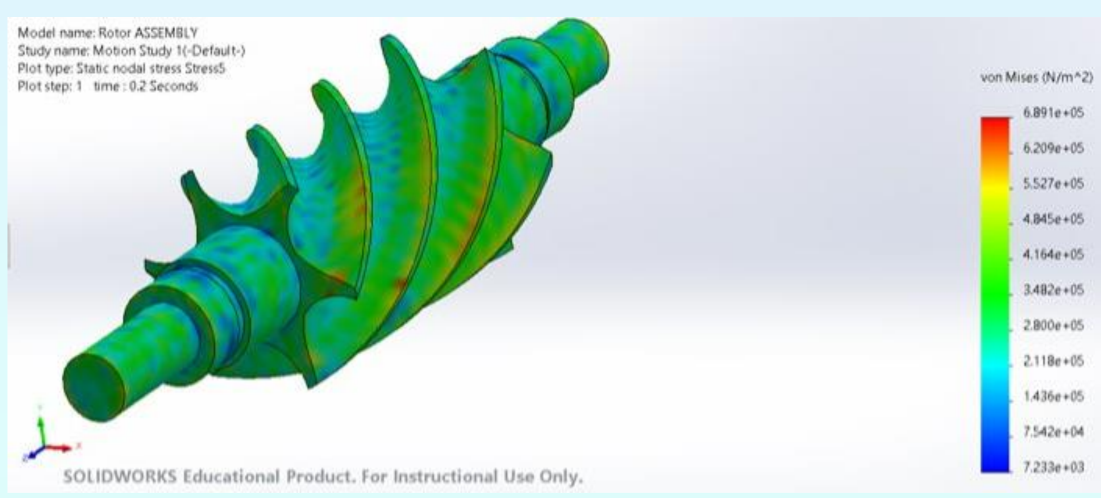

Figure 3: Rotor Simulation Close-Up

In addition to the simulation not accounting for surface contact, the dimensions compared to the actual compressor are different. The team had to use calipers and tape measures in order to model the parts, which will cause some error. The way the compressor is manufactured is also supposed to minimize stress.

Conclusion

The team was able to complete all the objectives of the project. The main goal was to determine what caused the compressor to fail. Three possible causes were theorized, but the most reasonable one is poor lubrication since there is more evidence to support it. In addition, the team was able to see the heat damage and annealed Teflon on the rotors through SEM imaging.

Exposing the team to an authentic engineering problem has allowed them to utilize and understand many methods that are employed by professionals around the world. Some of those methods include performing root cause analyses, running FEA analyses, calculating different stresses, and determining bearing and compressor life.

Root Cause and Data Analysis

Based on the operational data, the fatigue life, torque, shear stress, von Mises stress, and allowable stress were calculated for the rotor shaft. In addition, the loads on the gears and bearings, along with the bearing life of both bearings, were determined. The results are shown in the tables below.

Table 1: Torque, Fatigue, and Stress Results

Torque (lb-ft)	437.7	**Shear stress (psi)**	10,223.3
Fatigue life (years)	29.1	**Von Mises stress (psi)**	30,671.1
Bearing life (hours)	16,701.9	**Allowable stress (psi)**	11,237.5

Table 2: Gear and Bearing Loads

	Radial load	Tangential load	Axial load
Small gear loads (lb)	999.8	3,318.8	1,466.5
Large gear loads (lb)	676.5	2,245.6	992.3
Bearing B Loads (lb)	3,545.6	-	-
Bearing C Loads (lb)	2,267.9	-	-

After inspecting the physical compressor and looking over the operational data, the following root cause diagram was created. The diagram contains only possible causes, but the team can't know for sure what the actual problem was.

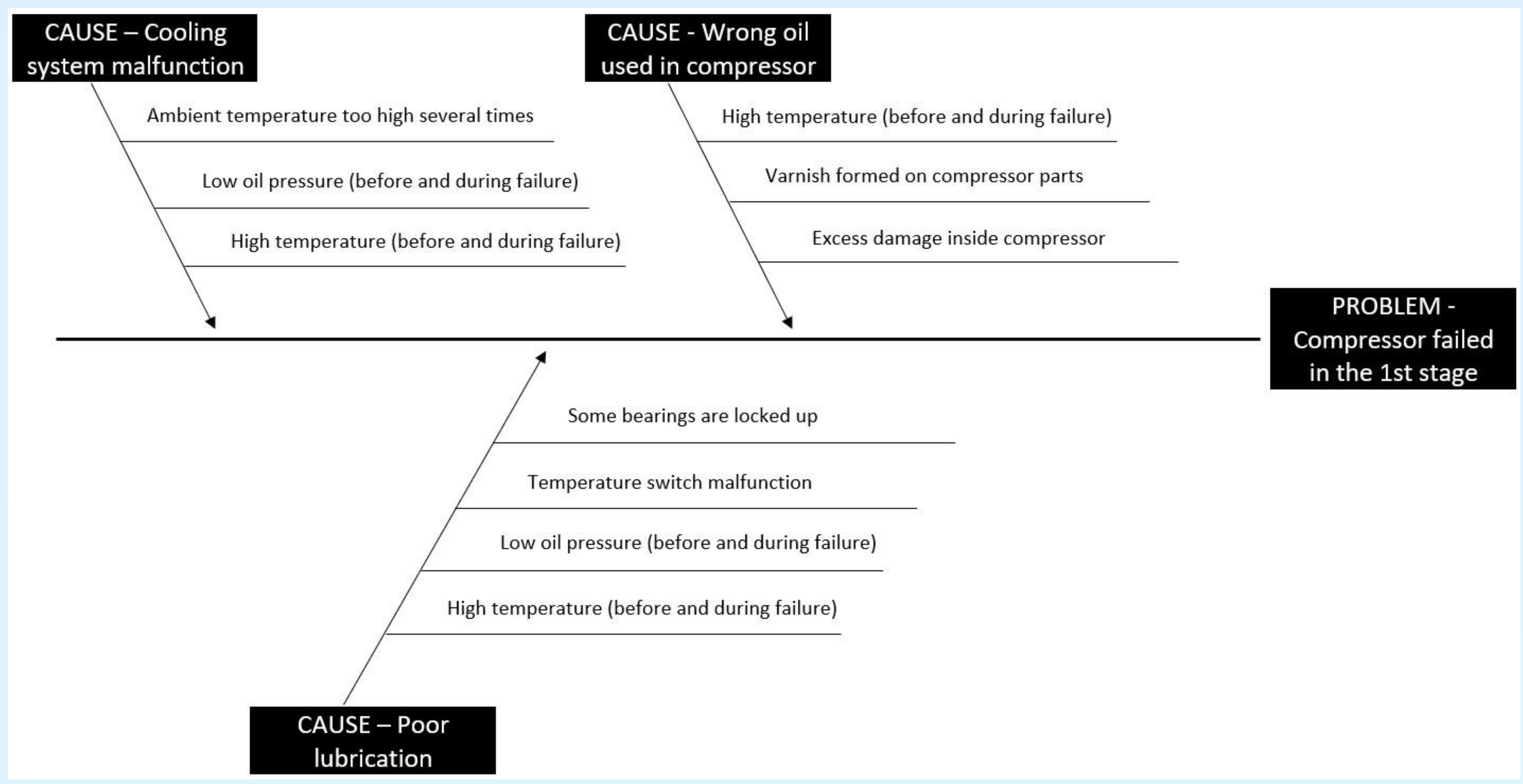

Figure 4: Root Cause Diagram

For the industrial side of the project, the data from January was compared to the data from February to determine if there were any comparisons to be made. They found out that the compressor was running above the shutdown level temperature (310˚ C) during the month of January. Then in February the temperature spiked at 442.3˚ C and the compressor failed.

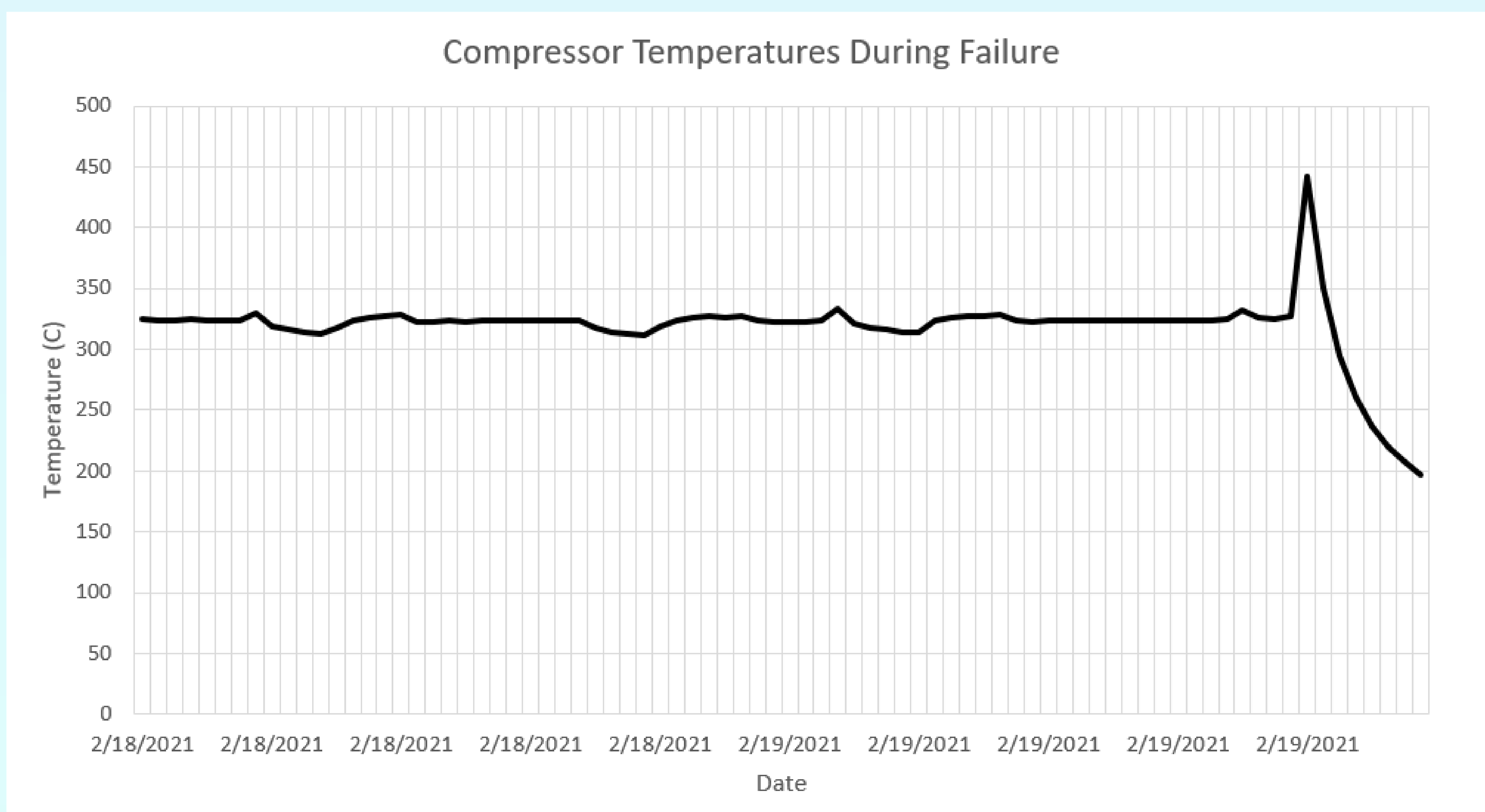

Figure 5: Compressor Temperatures

Figure 5 shows the elevated temperatures the compressor experienced during the failure on February 19th, and right before that on the 18th. The temperature level corroborates the damage to the internal parts and aided in determining the cause of failure. In addition to the other issues, the temperature switch not working leads the team to believe that the cause of failure is likely poor lubrication.

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