Problem solved: Engineers take on challenge of failing equipment at paper mill

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INTRODUCTION:

An important aspect of engineering is the application of math and science to solve real-world problems. Case studies illustrate the role of engineering in analyzing, identifying and solving operational problems in a production environment.

An example can be found in the case of a large paper mill in the southeastern United States incurring increased maintenance cost and time spent servicing the machine's aging steam system, which had been installed in the mid 90's. The mill's primary pain point was to address high levels of water in its oil lubrication system which reduced equipment life and increased downtime. There was also the danger of unforeseen equipment failure. The company's specifications made an allowance for water levels in the oil lube system up to 0.03%, but samples showed levels as high as 0.26%.

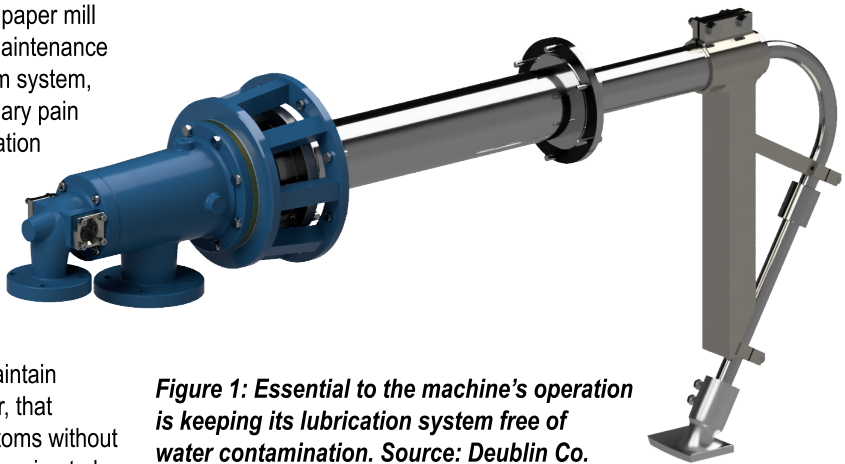

Figure 1: Essential to the machine's operation is keeping its lubrication system free of water contamination. Source: Deublin Co.

The mill's current solution was to deploy and maintain costly dehydrators to reduce the excess water. However, that solution was merely a Band-Aid, treating only the symptoms without addressing the root cause. The problem, moreover, was going to be progressively worse over time, as the mill was routinely experiencing bearing failures. Meanwhile, the temporary solution represented an exorbitant expenditure for the company.

Engineers at Deublin Company, an American manufacturer of rotary unions and steam joints, had an alternative idea. By examining the problem and analyzing its root cause, they were able to devise a solution to help reduce the machine's overall operating costs, improve dryer efficiency and even present an opportunity for modernizing the machine's existing steam joints.

Investigating the problem

The papermaking process involves combining pulp made from cellulose fibers with water, then placing it onto a machine to form it, dry it and ultimately produce rolls of paper. There are separate sections within the machine for each of these tasks. Each section makes use of rolling elements with bearings that need to be kept lubricated, either with circulating oil or grease. Essential to the machine's operation is keeping its lubrication system free of water contamination.

This can be especially challenging in the machine's dryer section, where critical drying takes place in the paper making process. This is achieved, in part, by drying cylinders heated by steam supplied through steam joints, as shown in Figure 1.

At this particular paper mill, the steam joints were at least 20 years old, and each contained a carbon steel journal insulating sleeve. When functioning normally, these sleeves would create air cavities to provide thermal insulation from convective heat transfer of steam. Boundary air and the sleeve material would protect the inner bearing from thermal stress; this protection is particularly important for machines operating with higher steam pressures, such as those used to produce brown-grade paper. When properly sealed, the sleeves would also prevent water contamination of the circulating oil.

As an insulating material, carbon steel is susceptible to "steam cuts" — small pits on the surface of the material, as shown in Figure 2, that diminish seal integrity. Steam cuts are caused by exposure to high-pressure, high-temperature steam over time. Considering the age of the equipment and the composition of the material, Deublin engineers correctly reasoned that the excess water in the mill's oil lubrication system was the result of leakage in the steam joints.

Devising a solution

Although the mill had arrived at an intermediate fix — removing excess water using dehydrators — it was not a sustainable solution for the long term. The dehydrators were being rented at a cost exceeding the value of the failing steam joints, the condition of which would only grow worse over time.

Deublin engineers decided to integrate a new material into the steam joints: stainless steel. Compared to carbon steel, which had been used by the original equipment manufacturer (OEM) for the composition of the steam joint insulating sleeves, the benefits of stainless steel can be seen in the next column.

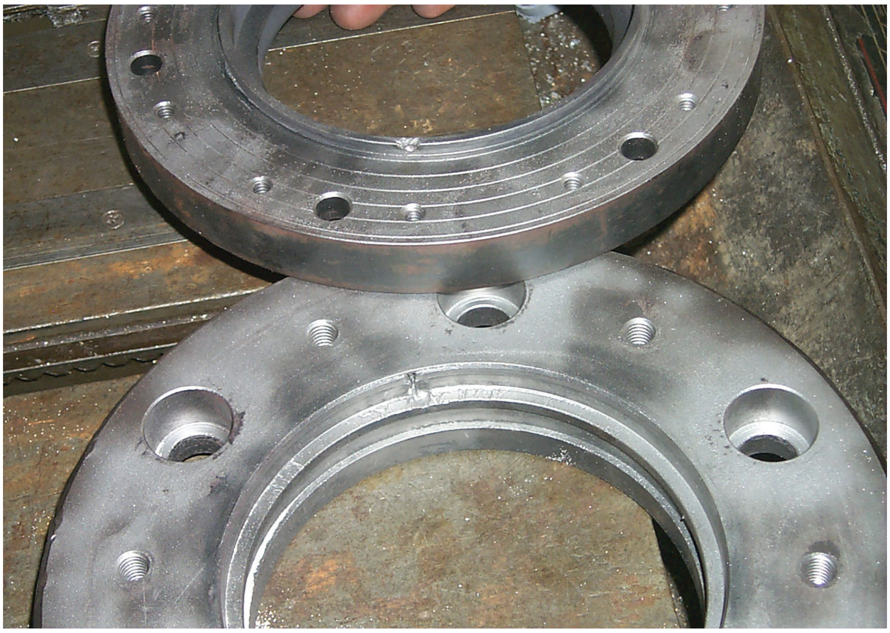

Figure 2: Steam cuts are small pits caused by exposure to high-pressure, high-temperature steam. Source: Deublin Co.

stainless steel

- Better insulation at the temperatures in dryer sections
- Lower thermal conductivity (approximately 30% of carbon steel conductivity)
- Increased material hardness
- Greater resistance to corrosion and steam cuts

It is not accurate to state that carbon steel should have no place in the composition of steam joint journals. Compared to stainless steel, the material's lower coefficient of thermal expansion is ideal for protecting equipment during transient conditions such as startup, shutdown and changes in pressure.

This is where true engineering ingenuity came into play. As shown in Figure 3, Deublin devised a custom solution that incorporated the essential properties of both materials — one that incorporated carbon steel to allow for thermal expansion, without compromising the advantages offered by stainless steel. A carbon steel journal flange was used to make contact with the dryer, while a stainless-steel insert was positioned inside the flange. This brought the differing thermal expansion rates of the two materials into sync, producing the same level of thermal expansion between the flange and journal.

Considering the potential impact of stainless-steel thermal expansion on seal integrity, Deublin also positioned static sealing elements in the external counter flange, around the diameter of the stainless-steel sleeve. Each element was chosen for their resilience to high temperatures. These included a Slyd-Ring, an Aflas O-ring and a Teflon C-ring inside a stainless-steel insert applied by interference in the adapting flange. A weep hole in the external adapting flange was incorporated for leak detection and identification in case of a static seal breach.

Building a system

Deublin's approach looked beyond the immediate concern of protecting the machine's bearings, toward building a whole system with long-term viability. Its custom-designed insulating sleeve is just one element designed to reduce water contamination and extend system life.

Another feature of the system design is an isolation tube that allows for the passage of steam without contact with the mechanical seal. The space between the inside diameter of the insulating sleeve and the outside diameter of the isolation tube is filled with saturated steam from inside the dryer. The seal surfaces are exposed only to saturated steam and not dry superheated steam. Due to the high level of water content, saturated steam serves as a thin film of lubrication between the two rotating seals, extending seal life.

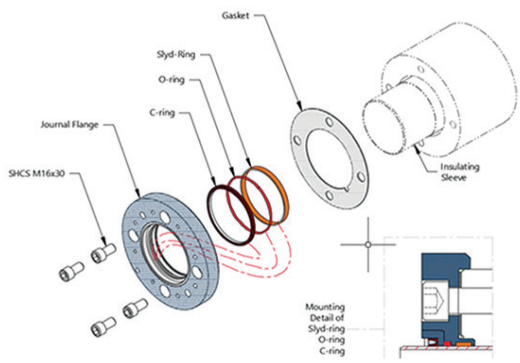

Figure 3: This innovative insulating sleeve employs elements of carbon steel and stainless steel, along with static sealing elements. Source: Deublin Co.

Deublin engineers also took a "proof of concept" approach to ensure their solution would be effective before deploying it throughout the whole system. By starting with a small section of the machine, Deublin engineers were able to demonstrate a measurable result at minimal cost.

They were able to reuse bell and housing components from existing joints to save on metal costs, effectively upgrading the plant's equipment without major expense. See Figure 4 for competitor comparison of the effectiveness of Deublin joints at temperature insulation.

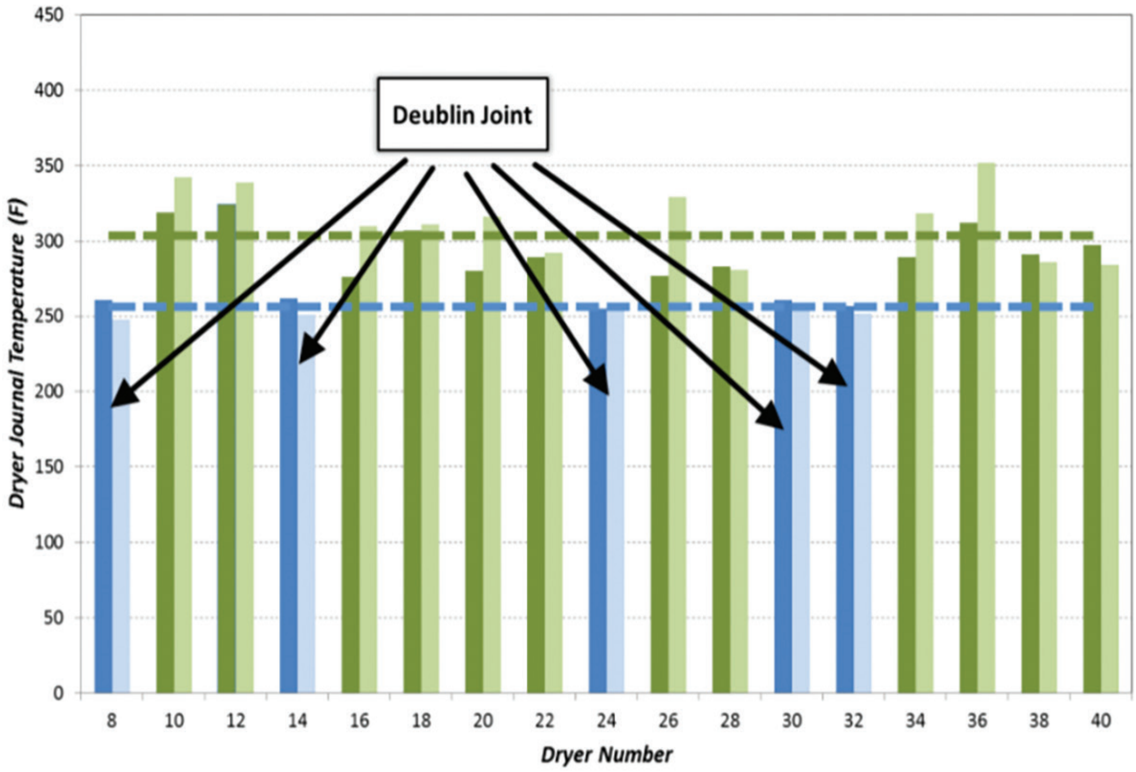

Figure 4: Deublin joints are effective at keeping temperatures at lower levels than those of a competitor (shown in green). Source: Deublin Co.

End results

Once the custom-designed solution was in place, the effectiveness of the Deublin approach could immediately be seen. Testing showed an immediate reduction in water contamination. The mill was able to discontinue dehydrator rental shortly after installation, which took place during an annual outage. Here's a look at the progress in one of the machine's tanks:

- Pre-installation measurements:
- 0.05% water at 493.5 ppm, 2/21/2019
- 0.26% water at 2559.6 ppm, 2/28/2019
- Installation during annual outage, 5/9/2019 to 5/10/2019
- 11 kits installed, five for condensate removal systems and six for steam inlet systems, each including seal conversion, journal flanges, insulating sleeves and siphon conversion
- Post-installation measurements:
- 0.15% water at 484.3 ppm, 5/22/2019 (1st dryer section)
- 0.18% water at 484.3 ppm, 5/22/2019 (2nd dryer section)
- No water detected, 5/22/2019 (3rd and 4th dryer sections)
- 0.03% water at 281.1 ppm, 5/29/2019
- Rental dehydrator removed, 5/31/2019
- No water detected

In terms of expenses saved by Deublin solution, the overall cost metrics indicate that the project paid for itself within the first year of operation.

Engineering answers

The case of the paper mill is just one illustration of how engineering know-how can be used to arrive at solutions that go beyond "quick fixes" that often create more problems than they solve.

Although dehydrator rental offered an intermediary fix, it was both a costly and ultimately unsustainable solution. Deublin engineers looked deeper into the problem, incorporating their knowledge of material properties and their perspective on the whole system. This allowed them to devise an answer that not only solved existing problems in the short term, but also built long-term sustainability into the equation.

To learn more about Deublin's approach, visit their website www.deublin.com.