EQUIPMENT ENGINEERING

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Solving The Crimper Enigma

Part III

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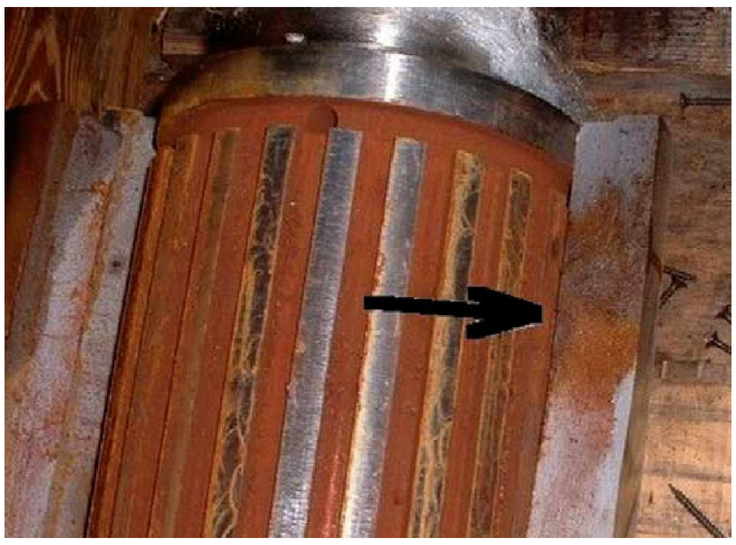
e`nig´ma something that is mysterious and seems impossible to understand completely

In the first two parts of this series, we examined causes and cures for tow input failure and discussed crimper maintenance and what to expect from a repair facility. Now we are going to look at the materials of critical components, before we take a look inside the crimper roll.

STUFFING BOX

The selection of brass or stainless steel for stuffing boxes is often emotional. There are dedicated advocates of each material. Actually, there are few brass components used. That yellow metal is really bronze. Brass is a copper alloyed with zinc and is not satisfactory for stuffing box construction. Brass has insufficient strength for most applications.



Cracked roll

Bronze is a copper alloy with tin as a major alloying component and is significantly stronger than brass. The typical bronze alloy used in stuffing boxes is selected for a combination of strength and wear resistance. The hardened stainless steel commonly used is an alloy of iron with more than 15% chromium. Both bronze and stainless steel are used as stuffing box components. Both materials resist corrosion in the wet crimper process, and either can be fabricated into satisfactory side plates and doctor blades.

Proponents of each material have their talking points in the debate. The ultimate argument from the bronze advocates is that it protects the crimper rolls when they come in contact with the side plates or doctor blades. In properly maintained and adjusted crimpers, however, only a bearing failure or loosened fastener will allow the rolls to contact the stuffing box. Since bronze is softer than stainless steel it does polish to a neutral surface faster than stainless steel. It also shows greater wear. Hardened stainless steel is significantly stronger than bronze, and as a result is much less susceptible to bending, particularly at the doctor blade tips. Although our customers specify their material preference, DM&E would recommend stainless steel as a preferred material in this application.

CHEEK PLATES

Cheek plates come with their own mysterious material properties. The cheek plates seal the edges of the rolls. They prevent the crimped fiber from escaping out of the edges of the roll, forcing the fiber to continue down the stuffing box. Metal cheek plates may be bronze or brass. The brass used is specially alloyed to produce a hard casting for machining to shape. Bronze is intrinsically harder and also alloyed for the application. Bronze or brass cheek plates must be run wet. Without wetting, the surface of the cheek plate will weld to the end of the roll. This roughens the roll end surface, which in turn roughens the cheek plate leading to even more welding. The selvage of the tow will be destroyed.

Not just any brass or bronze will offer superior performance. Cheek plates are replaced often, and the expense of purchasing and resurfacing can seem expensive. The cost of using an inferior material should be carefully weighed against cheek plate performance.

We also find cheek plates made of carbon, PTFE and ceramic. For dry applications, i.e. tow that cannot or should not be wetted, metal cheek plates are unsatisfactory. If the mechanism that holds the cheek plate in place against the roll results in constant pressure against the roll ends, the cheek plate must be self-lubricating. This requirement usually dictates some PTFE composition. The PTFE may be reinforced with aramid fiber to increase cheek plate life. PTFE cheek plates cannot approach the life of brass or bronze cheek plates. Ceramic, stellite and other very hard materials can be used dry, but the cheek plate mechanism must hold the cheek plate at zero clearance to the roll ends without applying any pressure to the roll ends. This can be a difficult mechanism to perfect and maintain.

CRIMPER ROLLS

Stuffing box components and cheek plates easily reveal their mysteries. The construction is simple, and easily perceived. Apart from eliminating physical damage and executing proper maintenance and setup, little can be done to extend the life of the components. Crimper rolls for the most part remain enigmatic. The outer form and shape is readily apparent while the inner architecture and purpose remains a mystery to many. They are also a component of the crimper that can suffer the most from benign neglect. Crimper rolls are complex structures. The inner shafts must have exceptional strength and fatigue resistance. The tire surface must have excellent wear resistance.

The inner shaft is the first component in the crimper roll. It is usually a carbon steel shaft with chromium and molybdenum as alloys. The shaft is carefully machined with attention given to reducing any stress concentrations that could lead to premature failure. A center hole is used to supply temperature-controlling fluid to the inner surface of the tire. (We'll come back to this later).

Considering that the shaft is subjected to a high load while rotating continuously over a long period of time, only the best material is satisfactory. Eventually the shaft will fail from fatigue, usually at one of the bearing journals. DM&E has found that there is a correlation of approximately seven years of operation and shaft fatigue failure. We recommend that all shafts of seven years or older be x-rayed before any expensive repair, such as a tire replacement. Considering the cost of replacing a tire, installing bearings, and completing the assembly in a crimper, the cost of an x-ray seems prudent. All DM&E crimper roll shafts are made from 17-4 stainless steel to increase the strength of the shaft, and reduce corrosion.

The second component of the crimper roll is the tire. Although stellite is occasionally used, most crimper roll tires are made from 440 stainless steel. DM&E uses 440C for crimper roll tires. Grades 440A and 440B have less carbon and cannot be treated to the higher hardness of 440C. This is a high carbon stainless steel with 16-18% chrome. It has excellent wear resistance after hardening and good resistance to corrosion. Hardening 440C creates a microscopic carbide matrix within the steel. This structure gives 440C its excellent wear resistance. The tire is held in place on the shaft by friction. The shaft and tire are machined to exacting dimensions; the tire is heated and placed on the shaft. When the tire cools, it shrinks around the shaft giving a watertight permanent grip on the shaft. The tire and shaft assembly is finally ground to precise dimensions for concentricity and bearing clearances. Roll assemblies must be identical in width and diameter for proper crimper performance.

Corroded roll

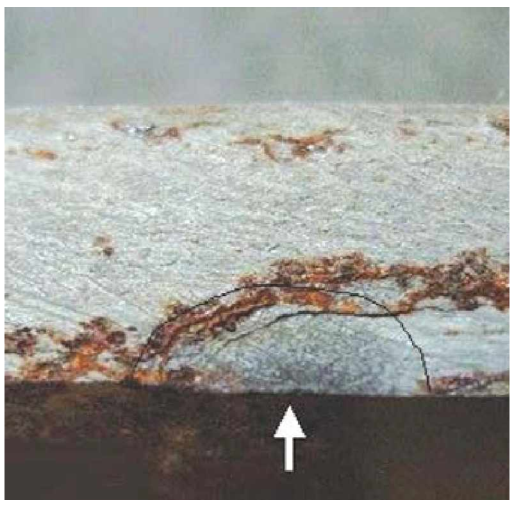
All of this seems simple, and it is. Excluding a physical failure of the shaft, what other problems are there? What can be done to correct the problems?

PROBLEM AREAS

Two major problem areas with crimper rolls are less obvious. Both problems are related to water and are easily corrected. We are not talking about water on the outside of the roll, but water on the inside of the roll. The problems are poor cooling water circulation and tire cracking. We mentioned above that cooling water is circulated around the inner surface of the tire to regulate the tire temperature. Failure to use properly treated water can result in a roll with the cooling channels nearly blocked by rust and mineral deposits.

The second problem of tire cracking is more difficult to explain. Water is still the problem. During the last 10 years DM&E has replaced hundreds of crimper roll tires that have cracked while installed on the shaft. Some have cracked while waiting to be put in service, some have cracked while in storage, and others have cracked while in operation on the crimper. A few tires split with a material defect. All the rest of the tires we examined experienced failure for one reason; stress corrosion.

Independent laboratories have confirmed the problem, and the solution is simple. The explanation is complex, but can be condensed. First, as we described above, the tire is expanded with heat and when cooled shrinks against the outside of the shaft. This leaves the tire stretched over the shaft. The inner fibers of the tire are subjected to the maximum stress. When cooling water containing chlorine is used, the chlorine attacks the inner fibers of the tire, creating



Microscopic crak

small corrosion cracks. The small cracks become a stagnant reservoir, the chlorine concentrates, and the attack continues. As the crack deepens, the process becomes autocatalytic. It becomes self-sustaining and accelerates until the cross section is weakened. Ultimately, the area under attack fails and the crack is propagated down the length of the tire.

So, what is the solution? Oddly, the solution is in the water, and what is not in the water. First, maintain high water flow velocities in the cooling water, eliminating any potentially stagnant areas for the chlorine to begin its attack. Maintaining high water velocity internally in the crimper rolls is difficult with many internal cooling channel designs. Two channel designs are common, one with longitudinal channels parallel to the roll axis and a circular supply at either end of the channels. See the photo of the nearly blocked channels. The other design has a series of circumferential grooves cut in the roll with slots to allow the water to pass from one groove to the next. Both of these designs allow the water to choose its path, and high velocity flow cannot be assured. DM&E crimper rolls use a single spiral groove under the tire. The water path is directed and no potentially stagnant areas exist. All the operator has to do is keep the water velocity high.

Second, eliminate chlorides in the water. Typical city water supplies have 5-10 ppm chlorine. Even this apparently low level of concentration has resulted in some of the cracked rolls having levels of 52,000 ppm at the failure site! The best course for removing the chlorine and obtaining proper pH is to contact a reputable company for a recommendation on water treatment. Follow their recommendations. Monitor the water analysis carefully for chemical depletion. The costs of chemicals and treatment equipment are small when compared to the costs of lost production and repairs from a cracked crimper roll tire.

SOLVING THE ENIGMA

We began to examine the crimper with tow input failure. We continued with an initial look at maintenance of the crimper and its components. Finally we have examined the construction of the critical working components of the crimper. Worldwide competition for the staple fiber market is growing. To survive in this market you must solve the crimper enigma. **IFJ**

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