

Material Matters

Practical Failure Avoidance and Prevention (Analysis of a Heat Stress Damaged Slurry Pump)

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The Question:

Why is my slurry pump wearing out faster than normal? What has happened to the suction cover and what is the cause of the extensive surface cracking that is seen?

The Problem:

A slurry pump suction cover supplied in an abrasion resistant HC600 high chromium iron was experiencing excessive wear and reduced life. Little information was provided regarding the pump operating conditions or service history, and little detail was provided to document the remaining condition of the other pump components.

The condition of the returned, badly worn and extensively cracked cover is shown in Figure 1.

What's Going On?

Evidence of severe abrasive and dynamic erosive wear as well as thermal fatigue cracking or "heat checking" can be clearly seen in the damage features. Symptoms of thermal fatigue by excessive friction heating are indicated by the characteristic cross hair line "heat checks" or "craze cracking" surface features shown in Figure 2. The cause of cracking of this nature results from the presence of steep temperature gradients generated by frictional contact heating which produces strains in the surface, which is



Figure 2. Close-up of extensive "Heat checking" characteristic of thermal fatigue cracking.

also accompanied by high contact stress and surface heat stress due to thermal expansion. Loss of specified clearance between the cover and impeller is believed to have occurred at some earlier point in the service operation, resulting in rubbing contact and frictional heating. It appears that the pump housing adjusting bolts may not have been properly tightened or improper impeller adjustments were made that allowed the impeller to make contact with the suction cover. At the interface between the cover and impeller surfaces damage rapidly escalated, accompanied by gross overheating and thermal stress cracking due to contact rubbing. A close-up of the worn and "heat check" thermal fatigue cracked surface is shown in Figure 2.

The source of extensive cover cracking and accelerated wear is believed to be the direct result of localized surface heating. The effects of heating not only creates thermal fatigue stress cracks, but also introduces a thermal tempering effect resulting in microstructure transformation

changes and metal softening that reduces the overall hardness and the high chromium iron wear resistance, leading to accelerated and premature wear damage.

Metallographic examination of a section taken from the worn and damaged surface revealed that the microstructure immediately below the degraded surface contained transformation products and an altered microstructure confirming exposure to elevated frictional heating. It is apparent that frictional rubbing during service operation was sufficient to heat the suction cover resulting in the observed "heat check" damage shown in Figure 2. During the pump operational cycles, alternate heating and cooling must have occurred at some point, which resulted in localized surface thermal fatigue cracking.

It also appears from the abrasive and erosive wear scar features that the pump continued to operate for some time after the prior surface thermal cracking event occurred.

Final Comments For Failure Avoidance:

Cross cracking or "heat checking" is primarily due to mechanical or thermal overload. Mechanical and thermal stress fluctuations initiated the observed fine hair line cracks on the suction cover surface, which can continue to grow larger and ultimately propagate to catastrophic failure if gone unnoticed.

Making impeller adjustments and maintaining proper clearances are necessary to avoid frictional rubbing and excessive heat damage at contact surfaces. Inadequate or improper tightening of bolts after making any adjustments must be avoided. Verification of correct bolt torque and impeller clearance adjustments can not be over-emphasized to avoid severe damage from thermal stress and contact wear. ■



Figure 1. Condition of the severely damaged suction cover