Deep Pitting on Bronze Worm Wheels and Cold Welding During Cable Sheave Assembly

Two Mechanisms of Material Transfer

Technical Note

In elevator worm gear reducers, two distinct material transfer phenomena are observed. Although they occur in different contexts, both share the same fundamental physical mechanism: cold welding.

1. Deep Pitting on the Bronze Worm Wheel

During operation, bronze worm wheels can develop cavities of significant size, frequently reaching 10 mm in depth and width. These cavities do not correspond to casting porosity but result from material detachment.

The mechanism begins with the localized rupture of the lubricating film. Under normal operating conditions, the oil film separates the surfaces of the steel worm and the bronze wheel, preventing direct metallic contact. When this film breaks down — due to overload, lubricant degradation, elevated temperature or excessive vibration — the asperities of the two surfaces come into contact under high contact pressure.

This pressure removes the surface oxide layers, exposing clean metal. Metallic junctions then form by cold welding.

At the atomic level, the formation of these junctions occurs because, once the oxide layers and the lubricating film have been removed, the clean metallic surfaces are forced into proximity on the order of a few angstroms. Under these conditions, the delocalized valence electrons of both metals interact across the interface, establishing continuous metallic bonds. This atomic-level adhesion constitutes cold welding.

The subsequent relative motion causes the fracture of these junctions. As bronze has lower mechanical strength, material is torn away in the form of multiple crystals, producing the deep cavities characteristic of pitting. This is therefore a combined process of adhesive wear and surface fatigue.

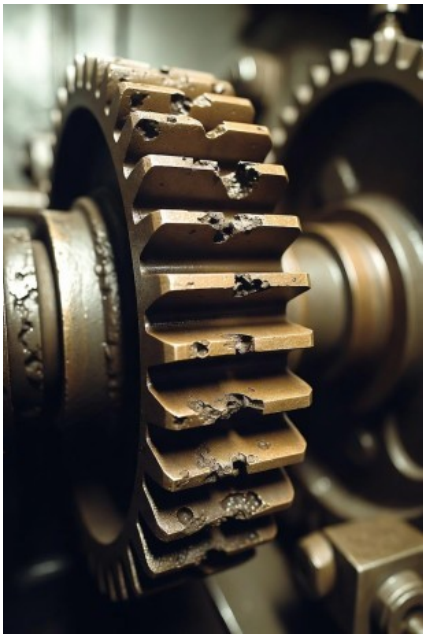

Figure 1 – Deep pitting cavities on bronze worm wheel teeth

2. Cold Welding During Cable Sheave Assembly

The second phenomenon occurs during the assembly of the cable sheave onto the output shaft of the reducer.

When the sheave (cast iron) is fitted onto the steel shaft with misalignment, highly localized pressures are generated. These pressures rupture the oxide layers, promoting the tearing of material from the steel shaft. The detached material is subsequently crushed and plastically deformed at the interface between the two components, establishing metallic bridges by cold welding.

From the perspective of ultrasonic testing, these metallic bridges have a relevant consequence: they allow transmission of the ultrasonic beam across the interface. As a result, indications are generated that may be erroneously interpreted as cracks. In reality, these indications correspond to the transferred and plastically deformed material produced during misaligned assembly.

Common Principle

In both cases the following sequence is observed:

1. Removal of the protective barrier (lubricating film or oxide layer);
2. Intimate contact of clean metallic surfaces under high pressure;
3. Interaction of delocalized valence electrons across the interface, with formation of continuous metallic bonds (cold welding);
4. Material transfer or detachment.

The difference lies solely in the context of occurrence:

- In the first case, the phenomenon develops in service and degrades the active surface of the worm wheel;
- In the second case, it occurs during assembly and produces false discontinuity indications during ultrasonic inspection.