

Rerating Damaged Naval Ship Propulsion Gears

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American Gear Manufacturers Association



TECHNICAL PAPER

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ABSTRACT:

When naval ship propulsion gear teeth break, the affected teeth have been "field dressed", so that the units can be put back into service. Then the gears are rerated to a lower rating and used reliably, at least until replacement elements become available. Using sketches or computers, an estimate is made of the instantaneous total length of contact as the damaged sections go through mesh and the results used as a basis of rerating the unit. Consideration is given to end reliefs, the location of the damage on the helix and the nature of the field dressing, and actual material properties. The results of this analysis, together with analysis of the causes of the original failure, provide limits within which the unit can be operated with the same reliability as new.

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Rerating Damaged Naval Ship Propulsion Gears

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SCOPE

It happens on occasion, that gear teeth become damaged. Accidents can damage a gear not in service. In service, damage happens for one of two broad reasons: faulty manufacture, or a mismatch between the service conditions and the design. The "mismatch" can be foreign material passing through mesh, a blunder in the design, or an unforeseen load, alignment or environmental condition. This paper will deal with rerating a gear unit after tooth breakage due to overload.

TYPICAL NAVAL SHIP PROPULSION GEARS

Naval propulsion gears cover a wide range of sizes and configurations. The techniques discussed in this paper have been applied to wide face gears, with pinions one to two feet in diameter, double helical, and a length to diameter ratio up to 2. Materials include steel from 200 BHN to carburized surfaces.

DESCRIPTION OF DAMAGE

Overload failures fall into two broad groups: failure of all or nearly all teeth in essentially the same places, or failure of just a few teeth in significantly different places. Errors in the original rating result in all teeth failing similarly. Many systematic errors in manufacture, such as accuracy errors or material properties, also result in uniform failure around the element. Some manufacturing errors result in many adjacent teeth failing in a similar manner; for example, when service loads cause an element to distort non-uniformly, such as progressive failure of a fabrication weld.

However, when foreign material passes through mesh, adjacent teeth can be damaged in somewhat different places. Figure 1 is

an example of damaged teeth, after cleanup, with this characteristic. This example was taken from a unit which was operating slowly at the time, so only one group of teeth was damaged before the problem was discovered and the unit stopped. If the unit is operating at high speed when the material passes through, it is likely that the damage to the pinion will cause damage to each tooth of the gear meshing with the damaged pinion tooth, and vice versa. This will quickly lead to uniform damage to all teeth in a hunting tooth design.

IMMEDIATE ACTIONS

After the damage is discovered, initial activity usually focuses on determining the causes of failure, and salvaging the damaged gear. Particularly in the case of foreign material causes, there may be significant capacity left in the gear. In fact, some minor damage is possible without affecting capacity. It is necessary therefor to assess the stresses in the damaged gear and possibly rerate the unit. Then the equipment owner can decide whether to use the gears in the damaged condition or replace them with undamaged gears, and what use can be made of the damaged unit until replacement occurs.

When bending failures occur, US Navy experience is that a piece of tooth is released from the bulk. We are aware that an entire tooth can come off in one piece, but we have not experienced this. Perhaps this is due to the large helix angles, typically 30 to 45 degrees, and large length to diameter ratios, often 1.5 to 2.0, used in Navy gears which result in a relatively short instantaneous contact lines, as compared to the face width.