

Low Noise Marine Gears

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American Gear Manufacturers Association



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ABSTRACT:

Reduction gears for frigates, corvettes, destroyers and submarines have to be reliable, durable, easy to maintain, small in size and as light as possible. In principle, there are two ways of reducing structure borne noise emission of gear boxes: primary and secondary. This paper will deal with primary measures, those which tend to eliminate the generation of noise at its source.

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LOW NOISE MARINE GEARS

Design Principles and New Developments in Finishing Hardened Gears

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1. INTRODUCTION

Reduction gears for frigates, corvettes, destroyers and submarines have to be reliable, durable, easy to maintain, small in size and as light as possible.

Today, electronic warfare has an increasing importance. The Gulf war has clearly shown that such instruments may be responsible for success or failure of military operations. Therefore, it is of great importance that warships are not to be detected by modern sonar instrumentation of the enemy, or that detection is delayed as long as possible. This leads to the requirement that modern warship propulsion equipment, such as gas turbines, diesel engines, propellers and gears, must radiate only a minimum of structure borne noise into the sea water. That requirement has reached almost the same importance as reliability and low weight.

The gears in a propulsion system will radiate very characteristic and discrete frequencies. A main source of gearbox noise is the gear mesh itself. The related frequency is a function of both rotating speed and number of teeth which makes it possible not only to detect a ship, but also to identify the gearbox and the ship.

In principle, there are two ways of reducing structure borne noise emission of gearboxes:

a) Primary measures

These are measures which tend to elimin-

ate the generation of noise at its source. Since the gear mesh is the main source of gearbox noise, aspects such as general gear design, toothing design and machining accuracy become critical. The know-how of the gearbox manufacturer has a major influence on noise radiation.

b) Secondary measures

With secondary measures one attempts to damp the structure borne noise on its path from the gear to the sea water. Commonly known methods are resilient mounting of the gear or damping structures with changing impedances in the gears or ships structures. Secondary measures can only be applied, if all boundary conditions are met. A resilient mounting for example, only makes sense if the main propeller thrust bearing is not integrated in the gearbox. In addition, secondary measures always mean more weight and more complications in design and maintenance.

The gearbox manufacturer has the full responsibility and all possibilities to make use of primary measures. They must and can be applied for any marine gear. Secondary measures if applicable, should just be an addition to primary measures. The special know-how of the gear manufacturer is not needed, general rules of structural physics can be applied by both the yard and the propulsion unit manufacturer.

This paper will deal with primary measures.

2. GENERAL DESIGN PRINCIPLES

Modern warships are most often equipped with a combined propulsion system. They combine diesel motors and gas turbines to work with one or two propellers. CODOG and GOGOG (combined diesel or gas, gas or gas) systems are in operation on many frigates, destroyers and corvettes. Namely on submarines, one or two steam turbines per propeller are used as prime movers.

The given propulsion power often exceeds 20 MW per propeller. The gears have to reduce the relatively high input speed of the gas turbine to the slow propeller speed. Gear ratios of 15 or more are required. This can only be done with two stage reduction gears. The following types are basically known and have been designed for many applications:

- Type T: Tandem
- Type TA: Tandem Articulated
- Type DT: Dual Tandem
- Type DTA: Dual Tandem Articulated (Figure 1)

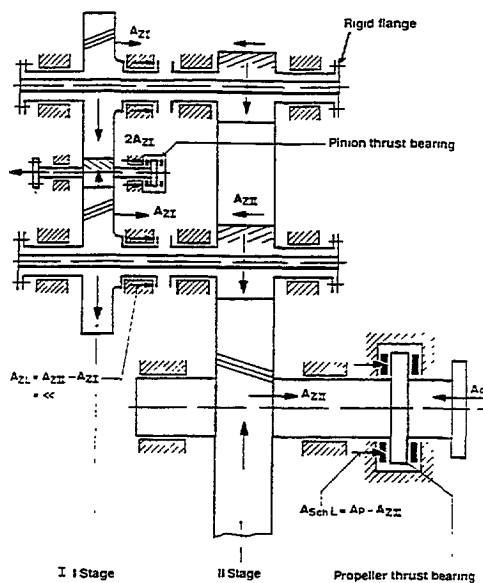


Fig. 1: Dual Tandem Articulated gear (DTA), with single helical toothings

To meet the general requirements for small dimensions and low weight, the mentioned prime mover power has to be split on two parallel gear trains. The best way to realise the power split is to design the gearbox on the DTA principle, where a perfect split is guaranteed by means of quill shafts between the wheels of the first stage and the pinions of the second stage. On smaller ships, as for example corvettes, where the gas turbines power is split on two propellers, the cross connect gear concept is most favourable. In any case, the gear system has to be optimally adopted to the prime movers as well as to the given space situation on board of the ship. The gear as a complete unit consisting of gear-

ing, oil system, clutches and control systems has to be a highly integrated part of the whole propulsion system.

Figure 2 shows a recently built CODOG gear for a destroyer with one gasturbine and one diesel acting on each propeller. Figure 3 illustrates the cross connect gearing for a frigate propulsion system.

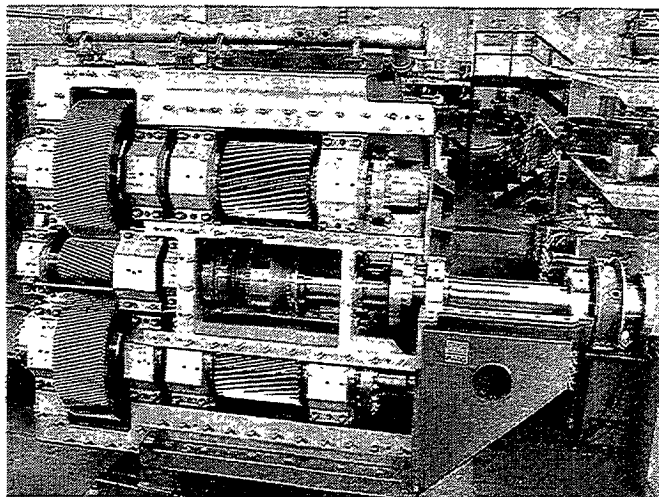


Fig. 2: Destroyer gear (DDG)

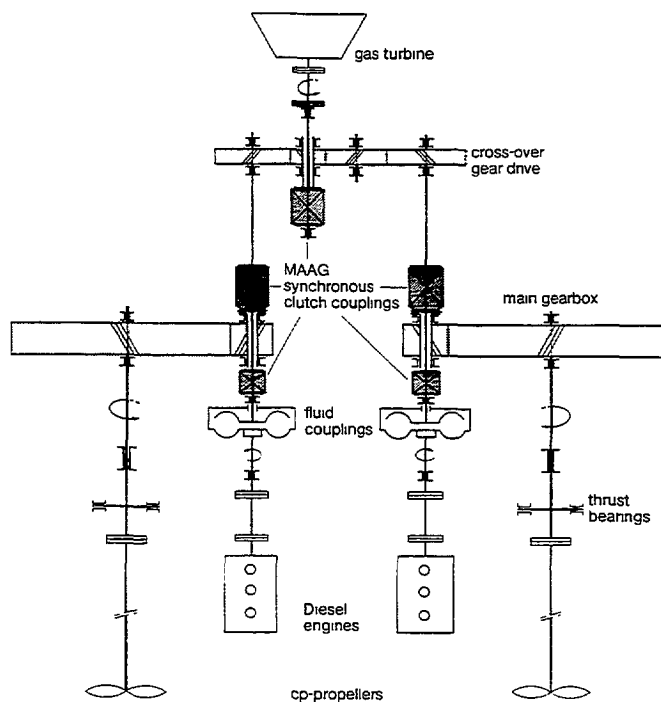


Fig. 3: Frigate gear (ANZAC)

In order to transmit such high power through a small and light gearbox, it is further necessary to harden the gear teeth. This knowledge is nowadays broadly accepted, in spite of the hard resistance of many gear companies in the past, which used