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The Development of a Practical Thermal Rating Method for Enclosed Gear Drives

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TECHNICAL PAPER

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

This thermal rating method balances the sum of the load-independent losses and the load-dependent losses against the heat dissipation capability of the gear case. Empirical factors are determined which calibrate the calculations against the test results for assembled gear reducers. The results of this calculation method are compared to the test results from 251 gear reducer tests. In addition, since losses are calculated, this method can be used to calculate the efficiency of the gear drive for the operating conditions.

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1. NOMENCLATURE

The symbols used in this paper are defined in table 1. These symbols may be unique to this paper and are therefore not necessarily the same as the symbols and definitions used in other AGMA papers or standard practices.

2. INTRODUCTION

The present AGMA method for calculating the thermal rating of enclosed gear drives is presented in AGMA 6010-E88, Practice for Enclosed Speed Reducers or Increases Using Spur, Helical, Herringbone and Spiral Bevel Gears [1]. This present practice is an empirical method developed more than 30 years ago from tests run on offset parallel shaft reducers using through hardened gear sets.

Modern gear reducers are usually designed with carburized and hardened gear sets and with power densities far exceeding those of 30 years ago. Consequently, the present thermal rating practices can no longer be used for modern gear reducers. Therefore, it is necessary to develop a method to calculate the thermal rating of a gear reducer which recognizes the tooth pressures and power densities of today's designs.

The thermal rating method presented in this paper is an empirical method that was developed from 251 tests run on a family of gear reducers using carburized gear sets. It involves calibrating the equations which represent the individual items contributing to heat generation to match the test results. It is not intended to be used to calculate each component of the power loss independently.

This empirical procedure should be used in its entirety. Do not use other methods for calculating the power loss of individual components without adjusting the calibrating constants and exponents.

3. PRODUCT TESTED

The reducers tested were concentric shaft reducers. Gears and pinions were carburized and hardened with the tooth flanks either honed or profile ground. All shafts were supported on tapered roller bearings. A photograph of one of the reducers is shown in figure 1 and a cross section showing the typical design and construction is shown in figure 2. All reducers were two stage reducers with total ratios ranging from 5:1 to 25 :1. The reducers ranged in size from 10"x10"x12" and 125 lb. to 36"x32"x33" and 4000 lb. Test loads ranged from no-load to 200 hp and input speeds were 1750, 1450, 1170 and 870 rpm. The oil used in all of the tests was Exxon Teresstic 220. A complete description of the range of test parameters can be found in table 2.

A total of 251 tests were run under the following load conditions: 84 at no-load, 83 at mid load and 84 at maximum load. No-load was the load required to rotate the test equipment without applying any additional load through the dynamometer. Maximum load was defined as the lesser of the following:

- the reducer mechanical capacity.
- a sump temperature of approximately 210 °F.
- test stand horsepower capability.

Mid load was defined as a load approximately half way between the no-load and the maximum load test points.

Since the no-load tests did in fact have some load applied to the reducer, the no-load temperatures were determined by plotting the no-load, mid-load and maximum load temperatures versus their respective loads and extending the plot back to zero transmitted load.

The data from all tests was included. No test data was thrown out.

The purpose for performing these tests was to determine the thermal horsepower ratings to use in the catalog for the Dodge MAXUM concentric shaft reducer.