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REPORT

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Gears — Thermal capacity —

Part 1:
Rating gear drives with thermal equilibrium at 95 °C sump temperature

Engrenages — Capacité thermique —

Partie 1: Capacité des transmissions par engrenages pour une température de bain d'huile de 95 °C

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this part of ISO/TR 14179 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 14179-1 was prepared by Technical Committee ISO/TC 60, *Gears*, Subcommittee SC 2, *Gear capacity calculation*.

ISO/TR 14179 consists of the following parts, under the general title *Gears — Thermal capacity*:

— *Part 1: Rating gear drives with thermal equilibrium at 95 °C sump temperature*

— *Part 2: Thermal load-carrying capacity*

Introduction

ISO/TR 14179 consists of two parts.

This part of ISO/TR 14179 is the American proposal. It utilizes an analytical heat balance model to calculate the thermal transmittable power for a single or multiple stage gear drive lubricated with mineral oil. Many of the factors in the analytical model can trace their roots to published works of various authors.

The procedure is based on the calculation method presented in AGMA (American Gear Manufacturers Association) Technical Paper 96FTM9 [1]. The bearing losses are calculated from catalogue information supplied by bearing manufacturers, which in turn can be traced to the work of Palmgren. The gear windage and churning loss formulations originally appeared in work presented by Dudley, and have been modified to account for the effects of changes in lubricant viscosity and amount of gear submergence. The gear load losses are derived from the early investigators of rolling and sliding friction who approximated gear tooth action by means of disk testers. The coefficients in the load loss equation were then developed from a multiple parameter regression analysis of experimental data from a large population of tests in typical industrial gear drives. These gear drives were subjected to testing which varied operating conditions over a wide range. Operating condition parameters in the test matrix included speed, power, direction of rotation and amount of lubricant. The formulation has been verified by cross checking predicted results to experimental data for various gear drive configurations from several manufacturers.

ISO/TR 14179-2 is based on a German proposal whereby the thermal equilibrium between power loss and dissipated heat is calculated. From this equilibrium, the expected gear oil sump temperature for a given transmitted power, as well as the maximum transmittable power for a given maximum oil sump temperature, can be calculated. For spray lubrication, it is also possible to calculate the amount of external cooling necessary for maintaining a given oil inlet temperature. The calculation is an iterative method.

The power loss of cylindrical, bevel, hypoid and worm gears can be calculated according to theoretical and experimental investigations of these different gear types undertaken at the Technical University in Munich. The load dependent gear power loss results in the calculation of the coefficient of mesh friction. The influence of the main parameters of load, speed, viscosity and surface roughness on the coefficient of friction were measured individually in twin disk tests and verified in gear experiments. The same equations for the coefficient of friction are used in ISO/TR 13989 for the calculation of the scuffing load capacity of gears, and are used in German standard methods for the calculation of the relevant temperature for oil film thickness to evaluate the risk of wear and micropitting. The no-load power loss of gears is derived from systematic experiments with various parameters from published research projects. The power loss calculation of the anti-friction bearings was taken from the experience of the bearing manufacturers, as published in their most recent catalogues.

The equations for heat dissipation are based on theoretical considerations combined with experimental investigations on model gear cases using different gear wall configurations in natural and forced convection. Radiation from the housing is based on the Stefan-Boltzman law, with measured values of the relative radiation coefficient measured for different surface finish and coatings of the gear case surface. Also included are equations for the calculation of the heat transfer from rotating parts and to the foundation. The results were verified with heat dissipation measurements in practical gear drives. A computer programme, "WAEPRO", with the proposed thermal calculation method, was developed within a research project of the FVA (Forschungsvereinigung Antriebstechnik e.V., Frankfurt) and is widely used in the German gear industry.