TECHNICAL SPECIFICATION

ISO/TS 6336-20

First edition
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Calculation of load capacity of spur and helical gears —

Part 20:
Calculation of scuffing load capacity (also applicable to bevel and hypoid gears) — Flash temperature method

Calcul de la capacité de charge des engrenages cylindriques à dentures droite et hélicoïdale —

Partie 20: Calcul de la capacité de charge au grippage (applicable également aux engrenages conique et hypoïde) - Méthode de la température flash

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 60, *Gears*, Subcommittee SC 2, *Gear capacity calculation*.

This first edition of ISO/TS 6336-20 cancels and replaces ISO/TR 13989-1.

A list of all parts in the ISO 6336 series can be found on the ISO website. See also the Introduction for an overview.

Introduction

The ISO 6336 series consists of International Standards, Technical Specifications (TS) and Technical Reports (TR) under the general title *Calculation of load capacity of spur and helical gears* (see Table 1).

— International Standards contain calculation methods that are based on widely accepted practices and have been validated.

— TS contain calculation methods that are still subject to further development.

— TR contain data that is informative, such as example calculations.

The procedures specified in ISO 6336-1 to ISO 6336-19 cover fatigue analyses for gear rating. The procedures described in ISO 6336-20 to ISO 6336-29 are predominantly related to the tribological behaviour of the lubricated flank surface contact. ISO 6336-30 to ISO 6336-39 include example calculations. The ISO 6336 series allows the addition of new parts under appropriate numbers to reflect knowledge gained in the future.

Requesting standardized calculations according to ISO 6336 without referring to specific parts requires the use of only those parts that are currently designated as International Standards (see Table 1 for listing). When requesting further calculations, the relevant part or parts of ISO 6336 need to be specified. Use of a Technical Specification as acceptance criteria for a specific design needs to be agreed in advance between manufacturer and purchaser.

Table 1 — Overview of ISO 6336

Calculation of load capacity of spur and helical gears	International Standard	Technical Specification	Technical Report
Part 1: Basic principles, introduction and general influence factors	X		
Part 2: Calculation of surface durability (pitting)	X		
Part 3: Calculation of tooth bending strength	X		
Part 4: Calculation of tooth flank fracture load capacity		X	
Part 5: Strength and quality of materials	X		
Part 6: Calculation of service life under variable load	X		
Part 20: Calculation of scuffing load capacity (also applicable to bevel and hypoid gears) — Flash temperature method (Replaces ISO/TR 13989-1)		X	
Part 21: Calculation of scuffing load capacity (also applicable to bevel and hypoid gears) — Integral temperature method (Replaces ISO/TR 13989-2)		X	
Part 22: Calculation of micropitting load capacity (Replaces ISO/TR 15144-1)		X	
Part 30: Calculation examples for the application of ISO 6336-1, ISO 6336-2, ISO 6336-3 and ISO 6336-5			X
Part 31: Calculation examples of micropitting load capacity (Replaces: ISO/TR 15144-2)			X
At the time of publication of this document, some of the parts listed here were under development. Consult the ISO website.			

Since 1990, the flash temperature method has been enriched with research for short exposure times, consideration of transition diagrams, new approximations for the coefficient of friction, and completely renewed load sharing factors. In 1991, the extension of Blok's flash temperature formula made it directly applicable to hypoid gears.

The integral temperature, presented in ISO/TS 6336-21, averages the flash temperature and supplements empirical influence factors to the hidden load sharing factor. The resulting value approximates the maximum contact temperature, thus yielding about the same assessment of scuffing risk as the flash temperature method of this document. The integral temperature method is less sensitive for those cases where there are local temperature peaks, usually in gearsets that have low contact ratio or contact near the base circle or other sensitive geometries.

The risk of scuffing damage varies with the properties of gear materials, the lubricant used, the surface roughness of tooth flanks, the sliding velocities and the load. In contrast to the relatively long time of development of fatigue damage, one single momentary overload can initiate scuffing damage of such severity that affected gears may no longer be used. According to Blok[12][13][14][15][16][17], high contact temperatures of lubricant and tooth surfaces at the instantaneous contact position may effect a breakdown of the lubricant film at the contact interface.

The interfacial contact temperature is conceived as the sum of two components.

— The interfacial bulk temperature of the moving interface, which, if varying, does so only comparatively slowly. The bulk temperature, θ^M, is the equilibrium temperature of the surface of the gear teeth before they enter the contact zone. For evaluating this component, it may be suitably averaged from the two overall bulk temperatures of the two rubbing teeth. The latter two bulk temperatures follow from the thermal network theory[18].

— The rapidly fluctuating flash temperature of the moving faces in contact. The flash temperature is the calculated increase in gear tooth surface temperature at a given point along the path of contact resulting from the combined effects of gear tooth geometry, load, friction, velocity and material properties during operation. Special attention has to be paid to the coefficient of friction. A common practice is the use of a coefficient of friction valid for regular working conditions, although it may be stated that at incipient scuffing, the coefficient of friction has significantly higher values.

The complex relationship between mechanical, hydrodynamical, thermodynamical and chemical phenomena has been the object of extensive research and experiment. Experimental investigations may induce empirical influence factors. A direct substitution of empirical influence factors may enforce the related functional factors in the main formula to be fixated to average values. However, correct treatment of functional factors (e.g. coefficient of friction, load sharing factor, thermal contact coefficient) keeps the main formula intact, in confirmation with the experiments and practice.

Next to the maximum contact temperature, the progress of the contact temperature along the path of contact provides necessary information to the gear design.

Calculation of load capacity of spur and helical gears —

Part 20: Calculation of scuffing load capacity (also applicable to bevel and hypoid gears) — Flash temperature method

1 Scope

This document specifies methods and formulae for evaluating the risk of scuffing, based on Blok's contact temperature concept.

The fundamental concept is applicable to all machine elements with moving contact zones. The flash temperature formulae are valid for a band-shaped or approximately band-shaped Hertzian contact zone and working conditions characterized by sufficiently high Péclet numbers.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1122-1, *Vocabulary of gear terms — Part 1: Definitions related to geometry*

ISO 6336-1, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and general influence factors*

ISO 10300-1:2014, *Calculation of load capacity of bevel gears — Part 1: Introduction and general influence factors*

ISO 10825, *Gears — Wear and damage to gear teeth — Terminology*

3 Terms and definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1122-1 and ISO 10825 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.2 Symbols and units

The symbols used in the formulae are shown in Table 2. The units of length, metre, millimetre and micrometre, have been chosen in accordance with common practice. To achieve a “coherent” system, the units for B_M, c_γ and X_M have been adapted to the mixed application of metre and millimetre or millimetre and micrometre.