Nederlandse praktijkrichtlijn

NPR-ISO/TR 15144-1

(en)

Calculation of micropitting load capacity of cylindrical spur and helical gears - Part 1: Introduction and basic principles (ISO/TR 15144-1:2010,IDT)

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Preview

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TECHNICAL
REPORT

ISO/TR
15144-1

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Calculation of micropitting load capacity of cylindrical spur and helical gears —

Part 1:
Introduction and basic principles

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

Partie 1: Introduction et principes fondamentaux

Reference number
ISO/TR 15144-1:2010(E)

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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 2.

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is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 15144-1 was prepared by Technical Committee ISO/TC 60, *Gears*, Subcommittee SC 2, *Gear capacity calculation*.

ISO/TR 15144 consists of the following parts, under the general title *Calculation of micropitting load capacity of cylindrical spur and helical gears*:

— *Part 1: Introduction and basic principles*

Introduction

This part of ISO/TR 15144 provides principles for the calculation of the micropitting load capacity of cylindrical involute spur and helical gears with external teeth.

The basis for the calculation of the micropitting load capacity of a gear set is the model of the minimum operating specific lubricant film thickness in the contact zone. There are many influence parameters, such as surface topology, contact stress level, and lubricant chemistry. Whilst these parameters are known to affect the performance of micropitting for a gear set, it must be stated that the subject area remains a topic of research and, as such, the science has not yet developed to allow these specific parameters to be included directly in the calculation methods. Furthermore, the correct application of tip and root relief (involute modification) has been found to greatly influence micropitting; the suitable values should therefore be applied. Surface finish is another crucial parameter. At present *R*a is used, but other aspects such as *R*z or skewness have been observed to have significant effects which could be reflected in the finishing process applied.

Although the calculation of specific lubricant film thickness does not provide a direct method for assessing micropitting load capacity, it can serve as an evaluation criterion when applied as part of a suitable comparative procedure based on known gear performance.

Calculation of micropitting load capacity of cylindrical spur and helical gears —

Part 1:
Introduction and basic principles

1 Scope

This part of ISO/TR 15144 describes a procedure for the calculation of the micropitting load capacity of cylindrical gears with external teeth. It has been developed on the basis of testing and observation of oil-lubricated gear transmissions with modules between 3 mm and 11 mm and pitch line velocities of 8 m/s to 60 m/s. However, the procedure is applicable to any gear pair where suitable reference data is available, providing the criteria specified below are satisfied.

The formulae specified are applicable for driving as well as for driven cylindrical gears with tooth profiles in accordance with the basic rack specified in ISO 53. They are also applicable for teeth conjugate to other basic racks where the virtual contact ratio is less than $\varepsilon_{\alpha n} = 2{,}5$. The results are in good agreement with other methods for normal working pressure angles up to 25°, reference helix angles up to 25° and in cases where pitch line velocity is higher than 2 m/s.

This part of ISO/TR 15144 is not applicable for the assessment of types of gear tooth surface damage other than micropitting.

2 Normative references

The following referenced documents are indispensable for the application 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 53:1998, *Cylindrical gears for general and heavy engineering — Standard basic rack tooth profile*

ISO 1122-1:1998, *Vocabulary of gear terms — Part 1: Definitions related to geometry*

ISO 1328-1:1995, *Cylindrical gears — ISO system of accuracy — Part 1: Definitions and allowable values of deviations relevant to corresponding flanks of gear teeth*

ISO 6336-1:2006, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and general influence factors*

ISO 6336-2:2006, *Calculation of load capacity of spur and helical gears — Part 2: Calculation of surface durability (pitting)*

ISO 21771:2007, *Gears — Cylindrical involute gears and gear pairs — Concepts and geometry*

ISO/TR 13989-1:2000, *Calculation of scuffing load capacity of cylindrical, bevel and hypoid gears — Part 1: Flash temperature method*

ISO/TR 13989-2:2000, *Calculation of scuffing load capacity of cylindrical, bevel and hypoid gears — Part 2: Integral temperature method*

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1122-1, ISO 6336-1 and ISO 6336-2 apply.

3.2 Symbols and units

The symbols used in this document are given in Table 1. The units of length metre, millimetre and micrometre are chosen in accordance with common practice. The conversions of the units are already included in the given equations.

Table 1 — Symbols and units

Symbol	Description	Unit
a	centre distance	mm
B_{M1}	thermal contact coefficient of pinion	$N/(m \cdot s^{0,5} \cdot K)$
B_{M2}	thermal contact coefficient of wheel	$N/(m \cdot s^{0,5} \cdot K)$
b	face width	mm
C_{a1}	tip relief of pinion	µm
C_{a2}	tip relief of wheel	µm
C_{eff}	effective tip relief	µm
c_{M1}	specific heat per unit mass of pinion	J/(kg·K)
c_{M2}	specific heat per unit mass of wheel	J/(kg·K)
c'	maximum tooth stiffness per unit face width (single stiffness) of a tooth pair	N/(mm·µm)
$c_{\gamma\alpha}$	mean value of mesh stiffness per unit face width	N/(mm·µm)
d_{a1}	tip diameter of pinion	mm
d_{a2}	tip diameter of wheel	mm
d_{b1}	base diameter of pinion	mm
d_{b2}	base diameter of wheel	mm
d_{w1}	pitch diameter of pinion	mm
d_{w2}	pitch diameter of wheel	mm
d_{Y1}	Y-circle diameter of pinion	mm
d_{Y2}	Y-circle diameter of wheel	mm
E_r	reduced modulus of elasticity	N/mm^2
E_1	modulus of elasticity of pinion	N/mm^2
E_2	modulus of elasticity of wheel	N/mm^2
F_{bt}	nominal transverse load in plane of action (base tangent plane)	N
F_t	(nominal) transverse tangential load at reference cylinder per mesh	N
G_M	material parameter	–
g_Y	parameter on the path of contact (distance of point Y from point A)	mm
g_α	length of path of contact	mm
H_v	load losses factor	–

Table 1 (*continued*)

Symbol	Description	Unit
h_{Y}	local lubricant film thickness	µm
K_{A}	application factor	–
$K_{\mathrm{H}\alpha}$	transverse load factor	–
$K_{\mathrm{H}\beta}$	face load factor	–
K_{v}	dynamic factor	–
n_1	rotation speed of pinion	min^{-1}
P	transmitted power	kW
p_{et}	transverse base pitch on the path of contact	mm
$p_{\mathrm{dyn,Y}}$	local Hertzian contact stress including the load factors K	$\mathrm{N/mm}^2$
$p_{\mathrm{H,Y}}$	local nominal Hertzian contact stress	$\mathrm{N/mm}^2$
Ra	effective arithmetic mean roughness value	µm
Ra_1	arithmetic mean roughness value of pinion	µm
Ra_2	arithmetic mean roughness value of wheel	µm
$S_{\mathrm{GF,Y}}$	local sliding parameter	–
S_{λ}	safety factor against micropitting	–
$S_{\lambda,\mathrm{min}}$	minimum required safety factor against micropitting	–
T_1	nominal torque at the pinion	Nm
U_{Y}	local velocity parameter	–
u	gear ratio	–
$v_{\mathrm{g,Y}}$	local sliding velocity	m/s
$v_{\mathrm{r1,Y}}$	local tangential velocity on pinion	m/s
$v_{\mathrm{r2,Y}}$	local tangential velocity on wheel	m/s
$v_{\Sigma,\mathrm{C}}$	sum of tangential velocities at pitch point	m/s
$v_{\Sigma,\mathrm{Y}}$	sum of tangential velocities at point Y	m/s
W_{W}	material factor	–
W_{Y}	local load parameter	–
$X_{\mathrm{but,Y}}$	local buttressing factor	–
X_{Ca}	tip relief factor	–
X_{L}	lubricant factor	–
X_{R}	roughness factor	–
X_{S}	lubrication factor	–
X_{Y}	local load sharing factor	–
Z_{E}	elasticity factor	$(\mathrm{N/mm}^2)^{0,5}$
z_1	number of teeth of pinion	–
z_2	number of teeth of wheel	–
α_{t}	transverse pressure angle	°
α_{wt}	pressure angle at the pitch cylinder	°
$\alpha_{\theta\mathrm{B,Y}}$	pressure-viscosity coefficient at local contact temperature	m^2/N
$\alpha_{\theta\mathrm{M}}$	pressure-viscosity coefficient at bulk temperature	m^2/N
α_{38}	pressure-viscosity coefficient at 38 °C	m^2/N
β_{b}	base helix angle	°

Table 1 (*continued*)

Symbol	Description	Unit
ε_{max}	maximum addendum contact ratio	–
ε_{α}	transverse contact ratio	–
$\varepsilon_{\alpha\text{n}}$	virtual contact ratio, transverse contact ratio of a virtual spur gear	–
ε_{β}	overlap ratio	–
ε_{γ}	total contact ratio	–
ε_1	addendum contact ratio of the pinion	–
ε_2	addendum contact ratio of the wheel	–
$\eta_{\theta\text{B,Y}}$	dynamic viscosity at local contact temperature	N·s/m^2
$\eta_{\theta\text{M}}$	dynamic viscosity at bulk temperature	N·s/m^2
$\eta_{\theta\text{oil}}$	dynamic viscosity at oil inlet/sump temperature	N·s/m^2
η_{38}	dynamic viscosity at 38 °C	N·s/m^2
$\theta_{\text{B,Y}}$	local contact temperature	°C
$\theta_{\text{fl,Y}}$	local flash temperature	°C
θ_{M}	bulk temperature	°C
θ_{oil}	oil inlet/sump temperature	°C
$\lambda_{\text{GF,min}}$	minimum specific lubricant film thickness in the contact area	–
$\lambda_{\text{GF,Y}}$	local specific lubricant film thickness	–
λ_{GFP}	permissible specific lubricant film thickness	–
λ_{GFT}	limiting specific lubricant film thickness of the test gears	–
λ_{M1}	specific heat conductivity of pinion	W/(m·K)
λ_{M2}	specific heat conductivity of wheel	W/(m·K)
μ_{m}	mean coefficient of friction	–
$\nu_{\theta\text{B,Y}}$	kinematic viscosity at local contact temperature	mm^2/s
$\nu_{\theta\text{M}}$	kinematic viscosity at bulk temperature	mm^2/s
ν_1	Poisson's ratio of pinion	–
ν_2	Poisson's ratio of wheel	–
ν_{100}	kinematic viscosity at 100 °C	mm^2/s
ν_{40}	kinematic viscosity at 40 °C	mm^2/s
ρ_{M1}	density of pinion	kg/m^3
ρ_{M2}	density of wheel	kg/m^3
$\rho_{\text{n,C}}$	normal radius of relative curvature at pitch diameter	mm
$\rho_{\text{n,Y}}$	normal radius of relative curvature at point Y	mm
$\rho_{\text{t,Y}}$	transverse radius of relative curvature at point Y	mm
$\rho_{\text{t1,Y}}$	transverse radius of curvature of pinion at point Y	mm
$\rho_{\text{t2,Y}}$	transverse radius of curvature of wheel at point Y	mm
$\rho_{\theta\text{B,Y}}$	density of lubricant at local contact temperature	kg/m^3
$\rho_{\theta\text{M}}$	density of lubricant at bulk temperature	kg/m^3
ρ_{15}	density of lubricant at 15 °C	kg/m^3
Subscripts to symbols		
parameter for any contact point Y in the contact area for Method A and on the path of contact for Method B; (all parameters subscript Y have to be calculated with local values)		

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