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Gears — Wear and damage to gear teeth — Terminology

Engrenages — Usure et défauts des dentures — Terminologie

ICS: 21.200; 01.040.21

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Foreword

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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.

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 10825 was prepared by Technical Committee ISO/TC 60, *Gears*.

This second edition cancels and replaces the first edition (ISO 10825:1995), which has been technically revised. In particular, the following are the major changes:

- the designation of this document has been changed from ISO 10825 to ISO 10825-1 and additional information on failure modes is given in technical report ISO TR 10825-2;
- some additional modes of failures are described
- most figures have been replaced, and are in color.

The foreword, footnotes and annexes in this document are provided for informational purposes only and are not to be construed as a part of ISO 10825.

Introduction

This standard provides a common language to describe gear wear and failure, and serves as a guide to uniformity and consistency in the use of that language. It describes the appearance of gear tooth failure modes. It is intended to improve communication between equipment users and gear manufacturers for failure and wear analysis. Since there can be many different causes for each type of gear tooth wear or failure, it is not possible in the standard to identify a single cause for each type of wear or failure, nor to prescribe remedies.

ISO DTS 10825-1 CD resolution

Gears –Wear and damage to gear teeth - PART 1 - Terminology

1 Scope

This International standard provides nomenclature for general modes of gear tooth wear and failure. It classifies, identifies, and describes the most common types of failure and provides information that will, in many cases, enable the user to identify failure modes and evaluate the degree or change from original condition.

This International standard is based on experience with steel gears; however, many of the failure modes discussed apply to gears made from other materials.

The solution to many gear problems requires detailed investigation and analysis by specialists and is beyond the scope and intent of this standard.

This Standard specifies only the terminology that is intended to help the recognition and reporting of the appearance and conditions of gears after a period of operation. Neither causes nor preventive measures for any condition described are discussed.

This International standard does not define “gear failure”. One observer's “failure” is another observer's “run-in”. There is no single definition of gear failure, since whether or not a gear has failed depends on the specific application.

NOTE The term “gear failure” is subjective and a source of considerable disagreement. For example, a person observing gear teeth that have a bright, mirrorlike appearance might believe that the gears have “run-in” properly. However, another observer might believe that the gears have failed by polishing wear. Whether the gears should be considered failed or not depends on how much change from original condition is tolerable.

Changes made to reduce the risk of one failure mode can sometimes worsen or create other failure modes or have other unintended consequences. Therefore, it is imperative that any remedy be evaluated prior to implementation and thoroughly tested and evaluated after implementation. See part 2 for additional discussion on the potential causes of the different failure modes and some suggestions to minimize the risk of them occurring.

NOTE “gear” throughout this standard means gear wheel or pinion unless the gear is specifically identified.

2 Normative references

The following documents contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions were valid. All publications are subject to revision, and the users of this standard are encouraged to investigate the possibility of applying the most recent editions of the publications listed:

ISO 701:1998 *International gear notation — Symbols for geometrical data*

ISO 1122-1******

ISO 14104, *Gears - Surface temper etch inspection after grinding*

3 Definitions

3.1 Definitions

The terms used in this standard, wherever applicable, conform to the definitions given in ISO 701 and ISO 1122-1.

NOTE Some of the symbols and terminology contained in this standard might differ from those used in other documents and International Standards.

3.2 Classes and modes of failure

Table 1 groups the common modes of gear failure into six general classes. For each class, the preferred terminology is listed, and older or other commonly used names are listed as non-preferred. Additional terms which can help to clarify the general mode are listed in Table 2.

Table 1 – Nomenclature of gear failure modes

General mode	Non-preferred terminology	Clause
Tribological damage (non-fatigue)		
Polishing (unintentional)	Burnishing	4.2
Scratches		4.3
Abrasive wear	Cutting, Scoring	4.4
Scuffing	Scoring, Welding, Microwelding, Galling, Seizing	4.5
Adhesive wear	Normal, running-in wear, Tearing, Plucking, Microwelding	4.6
Fretting corrosion		4.7
Interference wear		4.8
Fatigue damage		
Micropitting	Frosting, Gray staining, Peeling	5.2.2
Macropitting	Contact fatigue, Destructive, Arrowhead	5.2.3
Case crushing (subcase fatigue)	Internal rupture	5.2.4
White layer flaking		5.2.5
Tooth flank fracture (TFF) (Subsurface initiated fatigue)		5.2.6
Tooth interior fatigue fracture (TIFF)		5.2.7
Tooth root fatigue fracture		5.3.1
Rim, web, and hub cracks		5.3.2
Non-fatigue Fracture		
Tooth root rupture	Fast fracture	6.2
Tooth end rupture		6.3
Tooth shear fracture		6.4
Plastic deformation		
Indentation	Bruising, Peening	7.2
Brinelling	Denting	7.3
Cold Flow		7.4
Hot Flow		7.5
Root fillet yielding		7.6
Fracture after plastic deformation		7.7
Rolling		7.8
Tooth hammer		7.9
Rippling	Fish scaling, Scalloping	7.10
Ridging		7.11
Burr		7.12
Interference deformation		7.13

General mode	Non-preferred terminology	Clause
Manufacturing issues		
Forging cracks		8.1
Hardening cracks	Quenching cracks	8.2
Grinding cracks		8.3
Hydrogen and Internal Residual Stress		8.4
Grinding burn (temper due to grinding)		8.5
Grinding notch [not a failure mode]		8.6
Scaling		8.7
Case/core separation		8.8
Other surface damage		
Corrosion		9.1
Cavitation		9.2
Erosion		9.3
Electrical discharge	Arcing	9.4
Overheating		9.5

Table 2 – Additional terms

Additional terms	Mentioned in section on:	Clause
Point-Surface-Origin	Macropitting	5.2.3
Spall, Spalling	Macropitting	5.2.3
Root fillet cracks	Tooth root fatigue fracture	5.3.1
Non fatigue overload	Tooth root rupture	6.2
False brinelling	Fretting corrosion	4.7
Gross plastic deformation	Fracture after plastic deformation	7.7
Tight mesh	Interference wear, Interference deformation	4.8, 7.13

4 Tribological damages (non-fatigue)

4.1 General information on wear

Wear describes changes to a gear tooth flank surface involving the removal of material without any evidence of fatigue cracks. It may be accompanied by some displacement of material. See ISO 1122-1 for definition of flank.

Wear includes polishing, scratches, and abrasive wear. It can be categorized as mild, moderate or severe.

Figures 1 and 2 show moderate and severe wear. They are not intended to indicate the mode of wear.

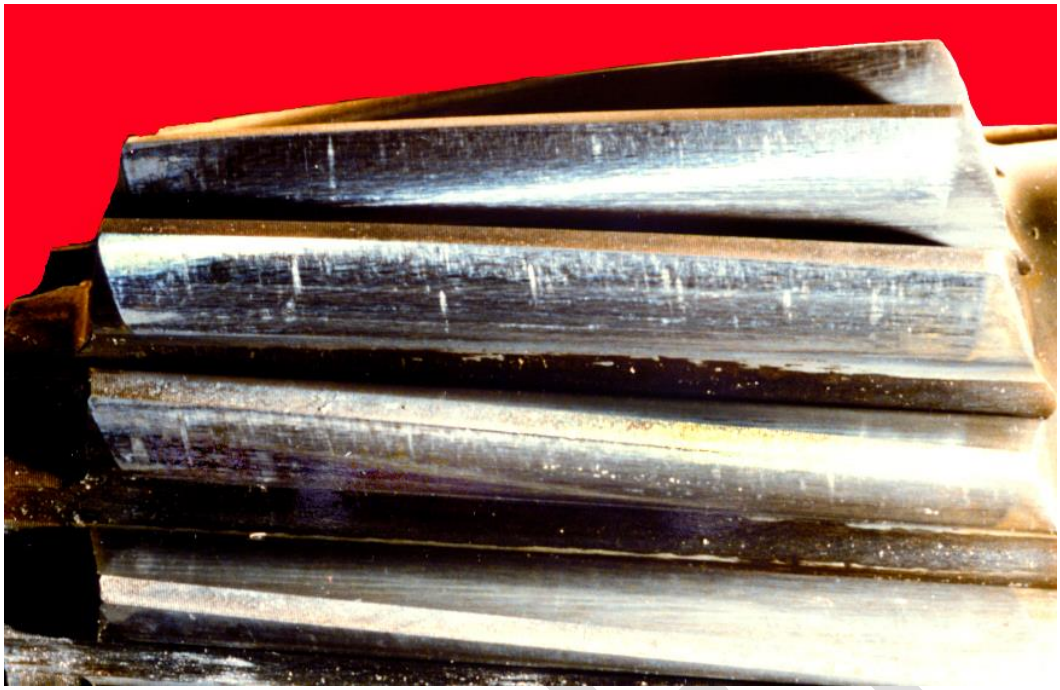


Figure 1 – Moderate wear

Figure 2 – Severe wear

4.2 Polishing

Polishing is a very slow wearing-in process in which the irregularities of the contacting surfaces are gradually worn until mirror-like, smooth surfaces develop. The gear tooth flank might be smooth or wavy with local bumps. Under sufficient magnification, the surface appears to be covered by fine scratches that are oriented in the direction of sliding.

NOTE Intentional polishing may occur during the manufacturing process or during running in.

4.2.1 Mild polishing

Polishing is classified as mild if it is confined to the peaks of the surface asperities. Mild polishing typically occurs during running-in and ceases before the original machining marks are removed from the tooth surface.

4.2.2 Moderate polishing

Polishing is classified as moderate if remnants of the original machining marks are visible on the tooth surface.

4.2.3 Severe polishing

Severe polishing removes all of the original machining marks from the active flank of the tooth. The polished surface might be wavy and there might be wear steps at the ends of the active face and in the dedendum. If extreme, polishing can reduce tooth thickness to where the topland is a knife-edge. See Figures 3 and 4.

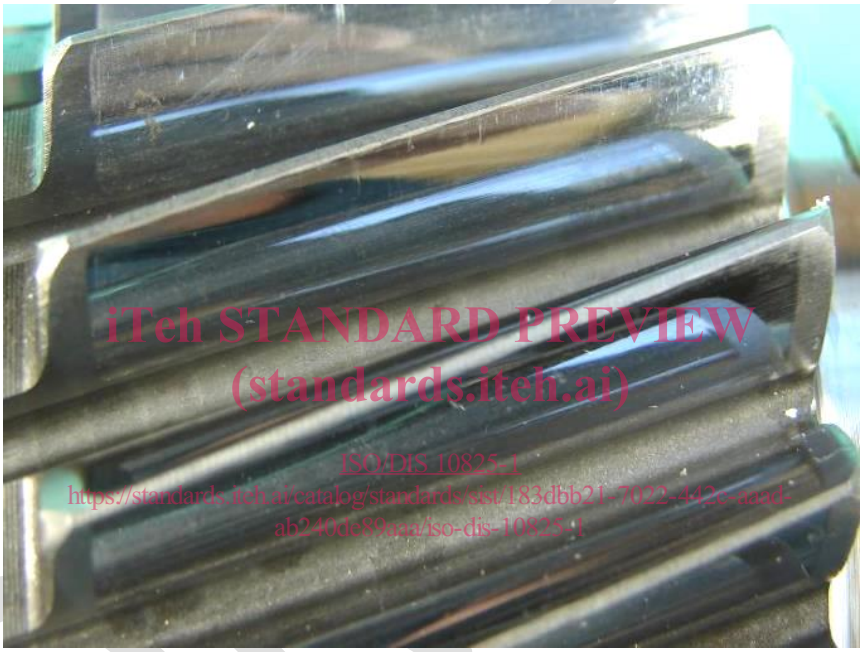


Figure 3 – Severe polishing on both flanks

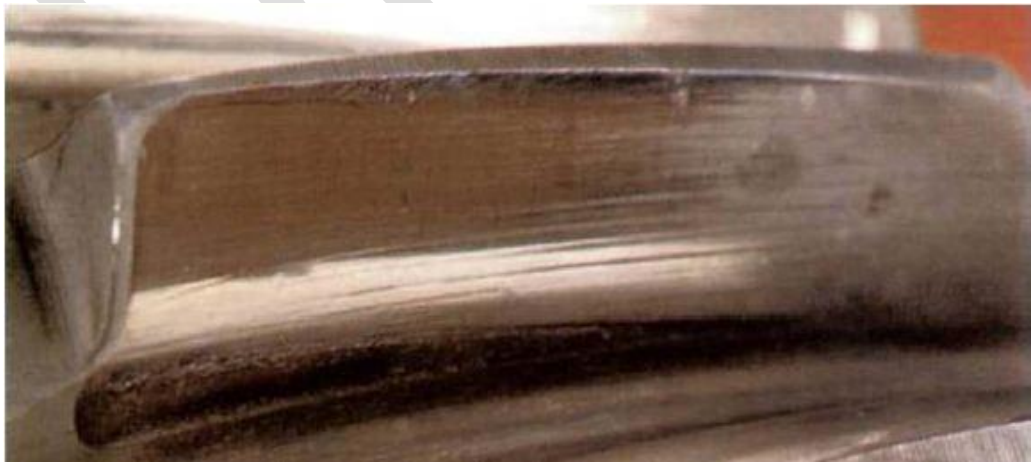


Figure 4 – Severe polishing on a misaligned gear

4.3 Scratches

Scratches are narrow and shallow grooves or furrows in the surface. They are usually oriented in the sliding direction. This is a specific type of abrasive wear. See Figure 5.

Note: The term “scoring” that was incorrectly used in earlier gear nomenclature for scuffing, is in reality scratching and is now classified as a form of abrasive wear.

Scratches can also occur during the manufacturing or assembly process, and such scratches can be in any direction.

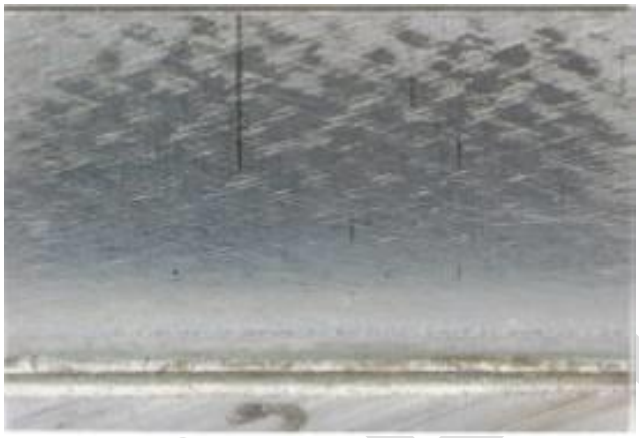


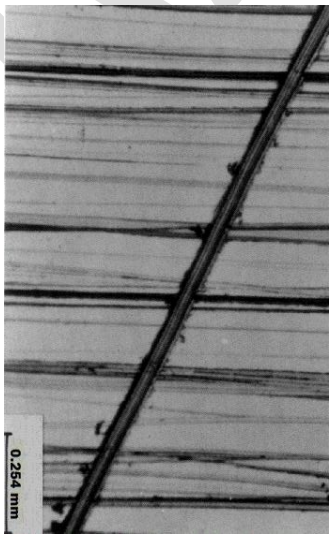
Figure 5 – Scratches in sliding direction.

4.4 Abrasive wear

4.4.1 General

Abrasive wear, also known as abrasion, is the removal or displacement of material due to the presence of hard particles: for example, metallic debris, scale, rust, sand, or abrasive powder, suspended in the lubricant or embedded in the flanks of the mating teeth.

Abrasive wear causes scratches or gouges on the tooth surface that are oriented in the direction of sliding. Under magnification, the scratches appear as parallel furrows that are smooth and clean. See Figure 6.



Note: The diagonal line is a scratch, an **abrasive wear** furrow cut by a hard particle showing smooth, clean appearance. The horizontal lines are the original grind marks.

Figure 6 – A scratch due to abrasive wear, SEM image

Abrasive wear due to loose contaminants is called three-body abrasion. The three bodies are the two gear elements and the loose contaminant. Three-body abrasive wear appears as small, usually square, randomly distributed areas that are scuffed or scored. See Figures 7 and 8. Two-body abrasive wear occurs when embedded particles or asperities on one gear tooth abrade the opposing tooth surface, leaving long scratches that often form a repeating pattern.

Based on the severity, abrasive wear can be categorized as mild, moderate, or severe.

Figure 7 – Three body abrasive wear

Figure 8 – Three body abrasive wear

4.4.2 Mild abrasive wear

Abrasive wear is classified as mild if it consists of fine scratches that are not so numerous or deep enough to remove significant amounts of material from the tooth flank surface and some machining marks are visible on the tooth surface. See Figure 9.