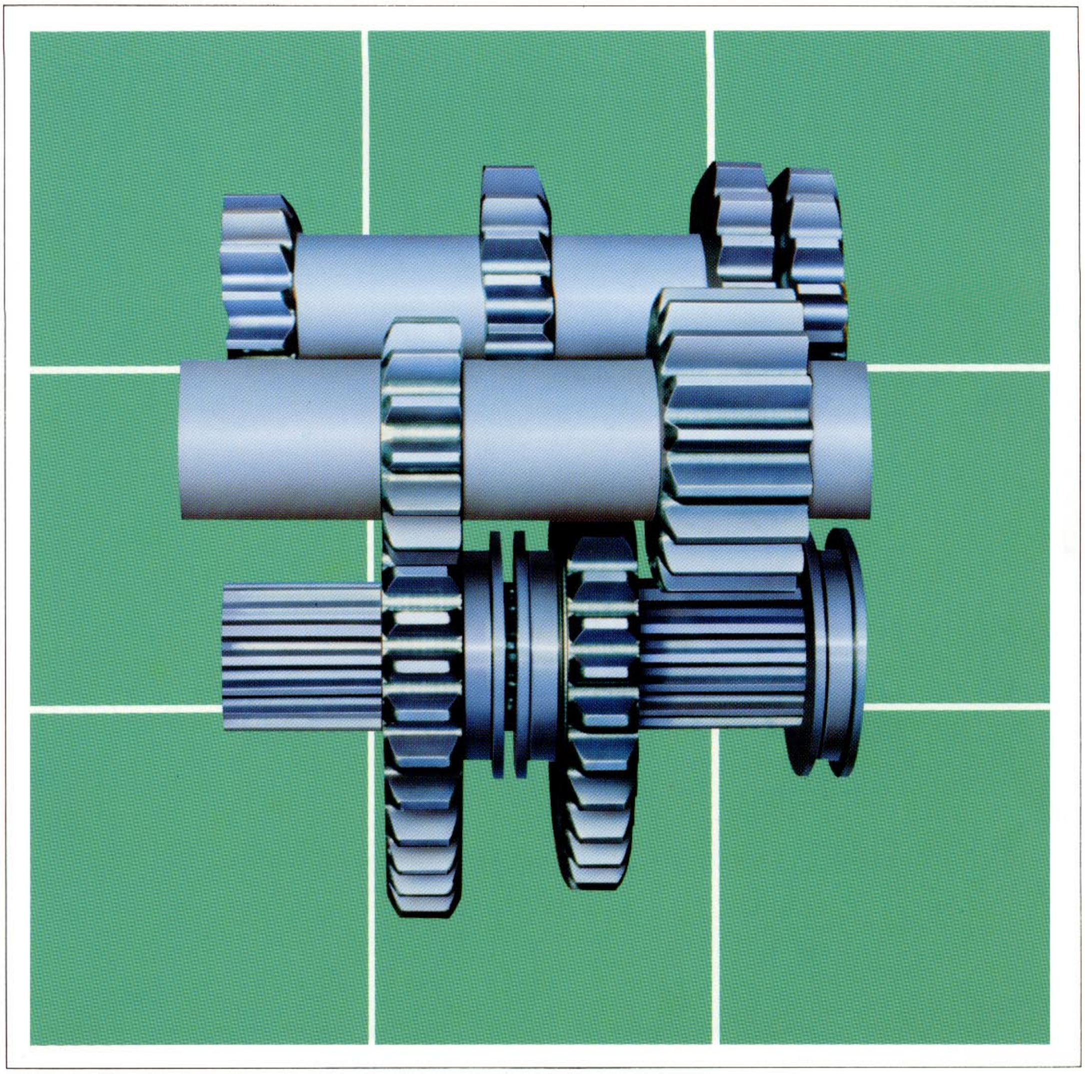
FORM NO. SEBG4050

SHOP MANUAL

GUIDANCE FOR REUSABLE PARTS

GEARS



GUIDANCE FOR REUSABLE PARTS

KOMATSU

INDEX

INTRODUCTION

This publication titled GEARS, contains photographs of typical cases of failure encountered in 'gears' at the time of disassembling and inspection of 'construction equipments' and is intended to provide guidelines for determing by visual inspection, whether the gear is fit to be reused or not prior to reassembly. This guide also contains basic information on 'gears' and 'gear trains', and gives explanations on the types of damage sustained and their causes.

Damage sustained by gears is usually the result of several combined causes. Particularly where work conditions are severe, several kinds of damage may combine to develop a complicated form of failure, resulting from multiple causes.

The writers will be gratified if, "lowering of repair costs" through appropriate reusage of parts, as well as, "prevention of reoccurance of failures" through correct diagnosis of their causes, is achieved.

GEAR FAILURE SIGNS, AND DIAGNOSIS FOR REUSAGE

In order to determine whether a gear can be reused or not, reference should be made to the typical failure photographs in this guide, according to the location and type of failure actually sustained. The degree of failure and whether the gear can be reused or not should then be determined by referring to the tabulated limits for reusage.

Standards for Reusage According to the Failure Signs

Failure signs	Standards for reusage	Remarks
• Gear hob marks • Gear shaving marks • Gear, shaper, and other cutting tool marks. • Ripping	These gear cutting-tool marks are harmless.	Gears can be used again.
• Spots and coloration caused by heat treatment.	Some differnce in color with other gears is harmless, and will not affect gear quality.	
• Initial contacting of gear teeth.	Horizontal line at mid-height of teeth contact surface, horizontal line appearing below the mid-height of the teeth surface and which is normal.	

Failure signs	Standards for reusage	Remarks
● Rippling	When ripples appear at addendum or dedendum of the gear teeth, gears can be used again. (When signs of pitting are observed standards for pitting should be applied.)	Important points to be considered at the final stage in determining whether to reuse or not. ● When the rank of failure signs in a meshing gear are of the same among different failure signs, the preceding standards will apply to the corresponding meshed gear. However, if the rank differs, the failure signs that are more serious should then be applied to both gears. ● The work-load conditions should be appropriate for the particular machine. (Reusage of parts may not be suitable for heavy loading conditions such as ripping, scraping, etc.) ●All the parts such as bearings and lubrication, etc. of the gear train containing device should be operating normally.
● Initial pitting	This is harmless until the tooth contacting surface extends as a smooth contact surface along the entire tooth height.	
● Abrasive wear	When flat surface wear is observed over the entire addendum, gears can be used again.	
● Scoring	When a shiny area appears on the teeth as though the oil-film has been damaged, gears can be used again but not under heavy loading conditions.	
● Interference wear	When a part of the tooth-tips shows signs of slight seizure or metal-to-metal contact, gears can be used again but not under heavy loading conditions.	
● Pitting	Refer to the color photograph contained in this guide.	
● Spalling	When slight peeling occurs at the mid-height part of the teeth, gears can be used again but not under heavy loading conditions.	
● Case crushing	This damage occurs through several combined causes and the standards that apply to each kind of failure for each cause should be considered. However, since the liability for the appearance of cracks is high, discarding and replacing with a new gear applies.	Gears cannot be used again.
● Breakage of theeth	Disregarding the degree of damage, whenever breaks or cracks appear in gears, the gears should be replaced with new ones.	

Standards for Failure Determination

The damage is ranked by three according to the failure degree.

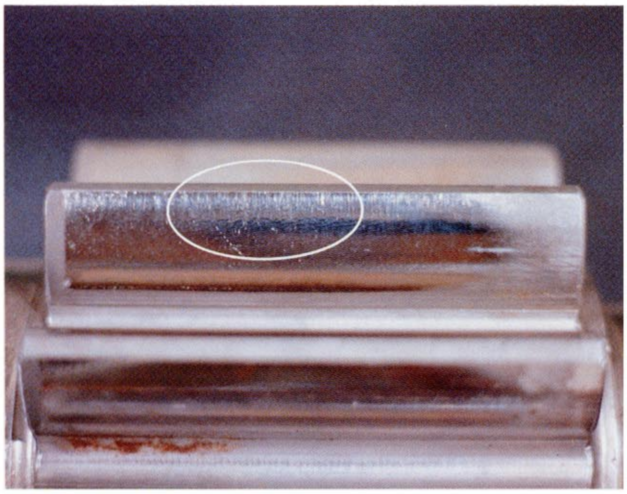
Rank	Failure degree
Use again	Slight to light failure that will not affect the machine's function and operation, and that is free from causing secondary damage.
Use again only under moderate loading condition	Medium degree of failure that will not have immediate effects on the machine's operation, but where there is concern about the developing of secondary damage effects. And when the gear is to be used under heavy loading conditions the gear should be replaced.
Do not use again.	Heavy degree of gear failure, that is liable to cause severe damage to the machine, and also gears that have reached the end of the their service life. Gears to which this rank applies should be discarded and replaced with new ones.

Since hazards resulting from gear damage differ with the type of damage sustained, hazards accompanying a certain rank of damage for a given type of damage and those accompanying the same rank for a different type of damage are not the same.

Therefore, determination of the bad effects and/or hazards accompanying gear failure must be based on experience, however, the photographs of typical cases of gear failure are presented in the following pages as reference material in determining whether the part can be reused or not.

When the degree of failure to be diagnosed lies between the same kind of failure ranked "Use again" and "Use again only under moderate loading condition" among the photographs, the latter rank, that is the more hazardous rank should de selectd to ensure safety.

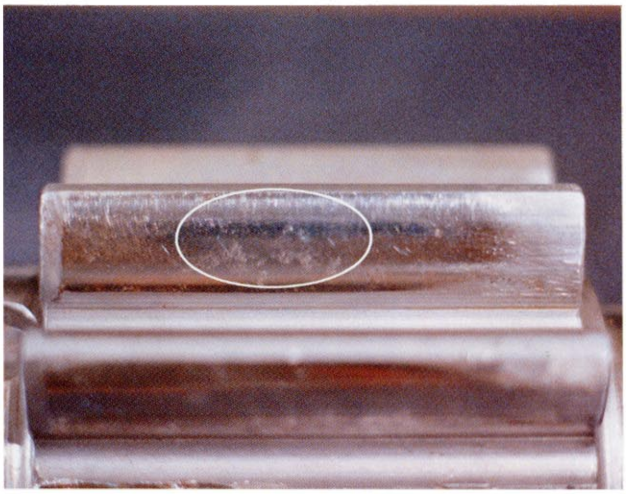
The diagnosis depends a great deal on the customer's requirement – of a long service life for the entire machine. Thus a generalized judgement cannot be made, and the diagnosis should include such factors as, what type of work operations at what rate of performance, and for how long.



USE AGAIN

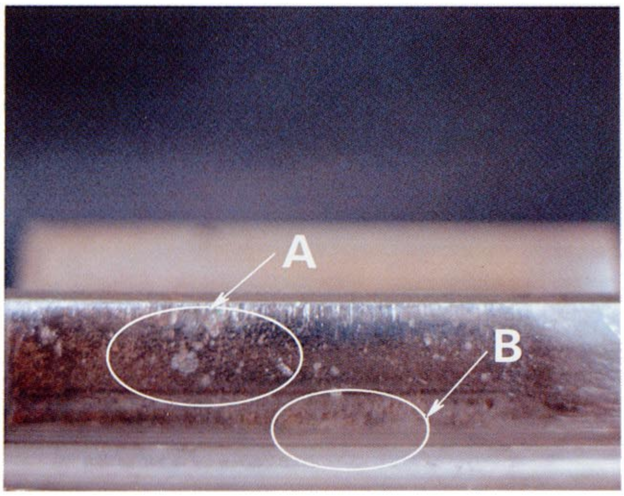
Failure Signs
- Rippling
- Slight ripples form on the addendum.

Causes
- Ripples develop through insufficient lubrication.



USE AGAIN ONLY UNDER MODERATE LOADING CONDITION

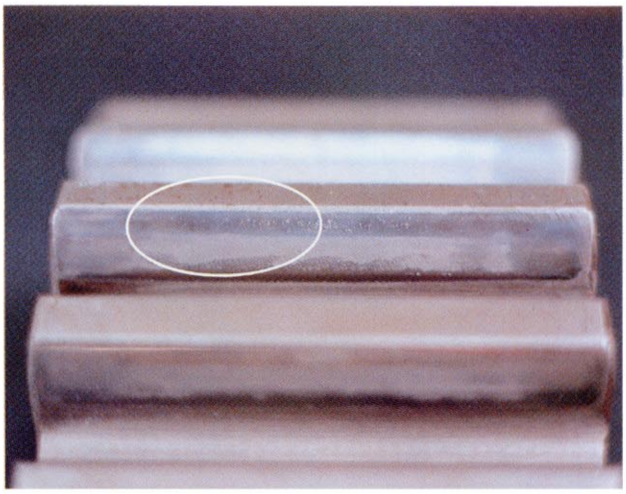
Failure Signs
- Rippling
- Ripples develop on both addendum and dedendum.
- The rippling described in the left has advanced.



DO NOT USE AGAIN

Failure Signs

- Ripples develop on both addendum and dedendum (A).
- In addition pitting occurs at the root of the tooth (B).
- Surface failure (fatigue) through wear over the entire surface can be seen.



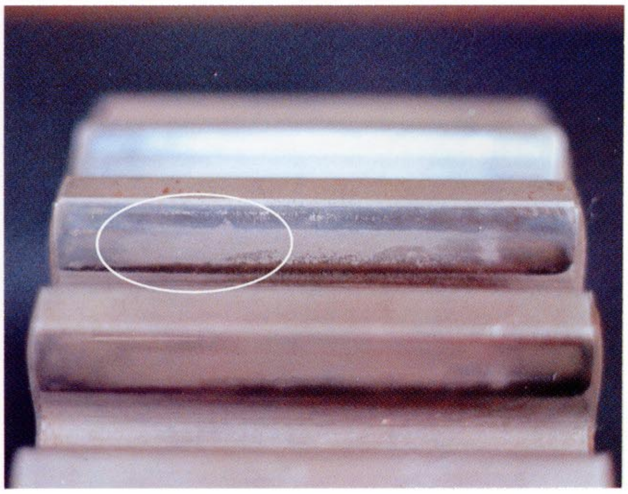
USE AGAIN

Failure Signs

- Abrasive wear
- Flat wear is seen over the entire addendum.

Causes and Necassary actions

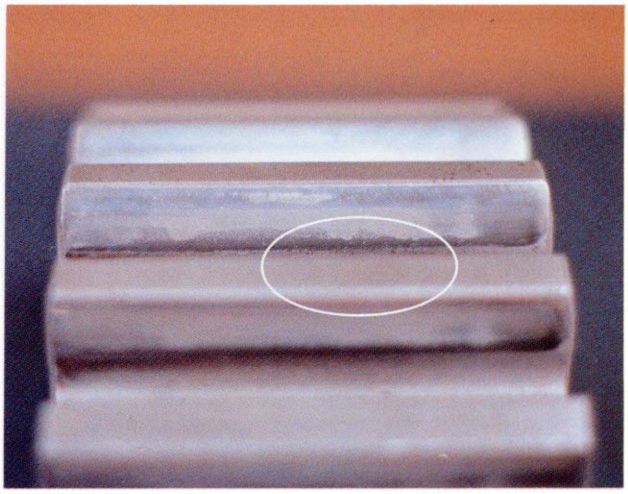
- Fine foreign matter mixed in the oil acts as a grinding agent.
- Change the oil filter element and reuse.



USE AGAIN ONLY UNDER MODERATE LOADING CONDITION

Failure Signs

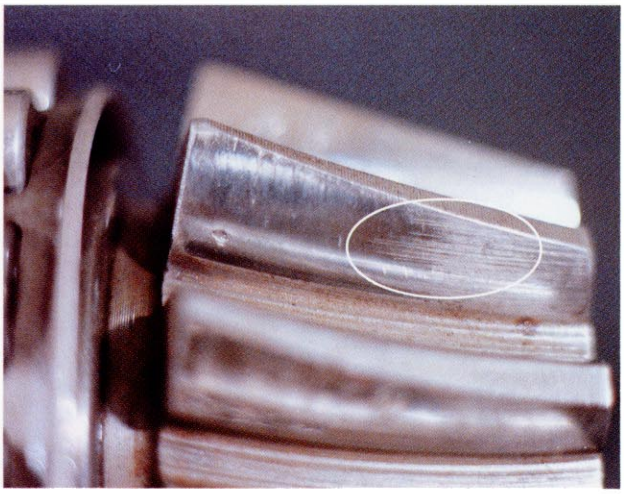
- Abrasive wear
- Flat wear extends over both addendum and dedendum.
- The abrasive wear described in the left has advanced, and loading of the wear ridges increases when the gear meshes.



DO NOT USE AGAIN

Failure Signs

- Abrasive wear
- Flat wear extends over the entire tooth mating surface and a wear ridge appears on the addendum.
- The load becomes concentrated towards the tip of the tooth where sliding rate is concentrated, to form a ridge.



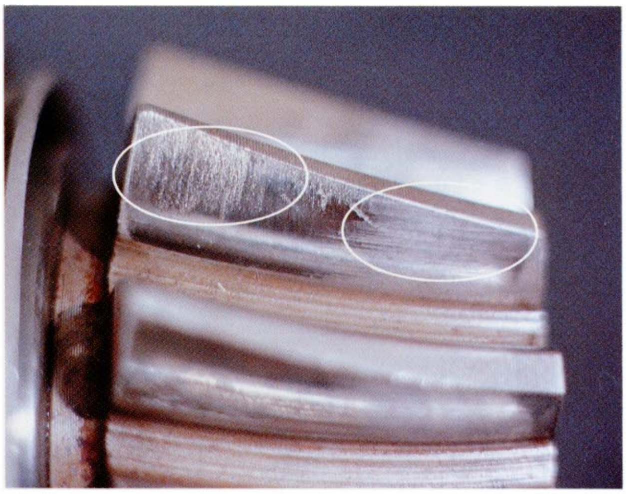
USE AGAIN ONLY UNDER MODERATE LOADING CONDITION

Failure Signs

- Scoring
- Scratch like damage is seen in the sliding direction of the tooth.

Causes

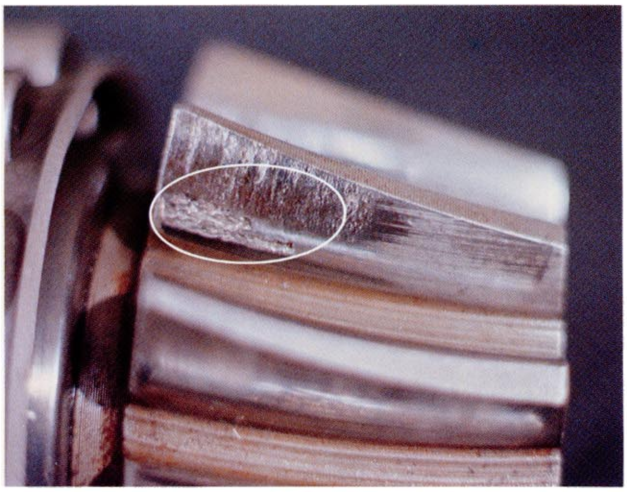
- Load is concentrated on a part of the contacting surface to breakdown the lubricating oil film.
- Caused by work overloading which results in deterioration of the lubricating oil. Or by insufficient backlash.



DO NOT USE AGAIN

Failure Signs

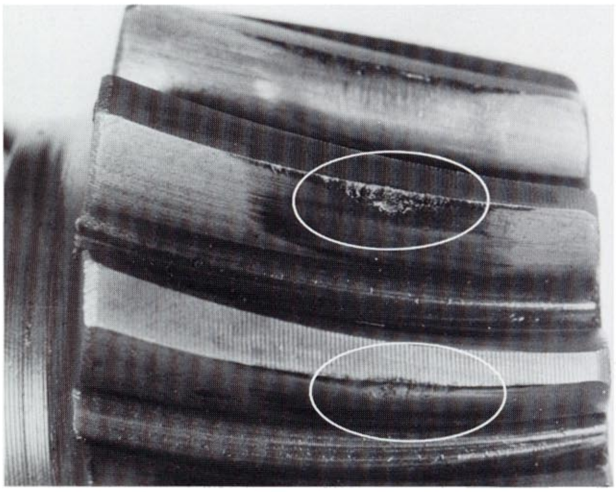
- Scoring
- The failure is spreading and other damage is about to develop.
- The described failure in the left has advanced and instead of the increased contact surface becoming smooth, loading is concentrated to certain areas and failure is spreading.



DO NOT USE AGAIN

Failure Signs

- Scoring
- Pitting is observed to have appeared rapidly as a complication to the described failure.



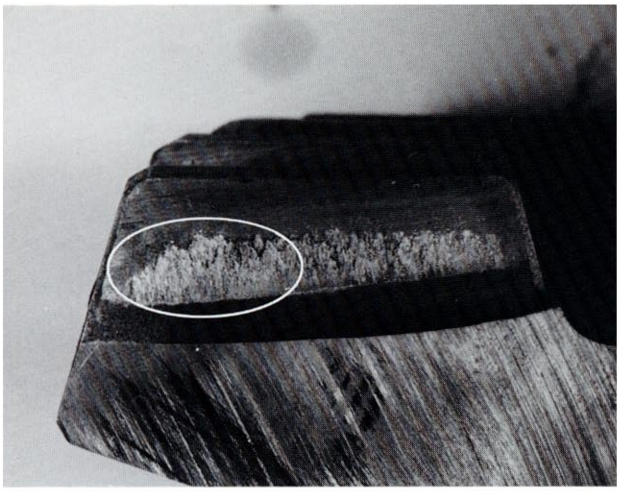
USE AGAIN ONLY UNDER MODERATE LOADING CONDITION

Failure Signs

- Interference wear
- Tooth tips are flattened through wear.

Causes

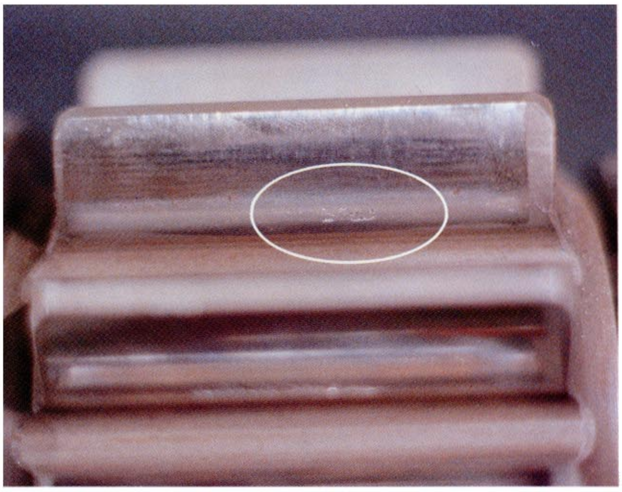
- This condition occurs due to slight misalignment, and gear noise when meshing increases.
- Insufficient backlash and poor gear alignment are causes.



DO NOT USE AGAIN

Failure Signs

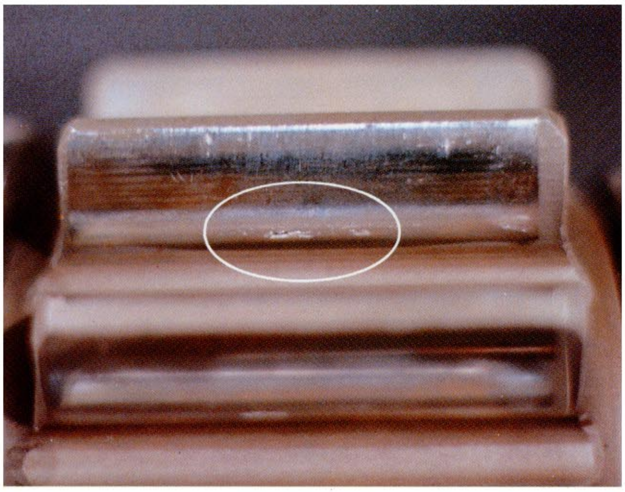
- Interference wear
- Tooth root surface is gouged.
- When the gear tooth ceases to contact, entire load is concentrated on the root of the tooth.



USE AGAIN

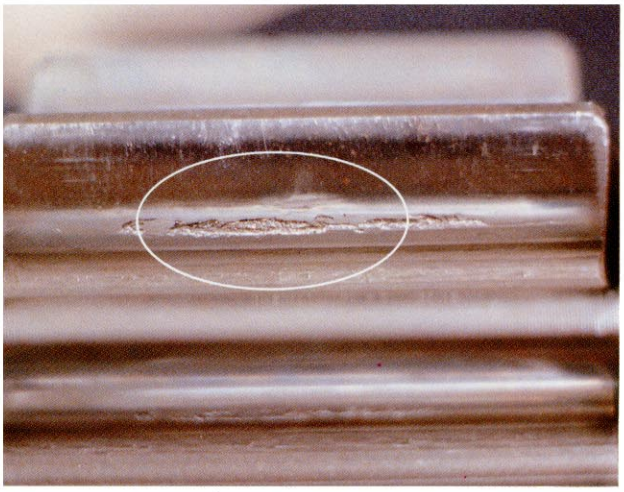
Failure Signs

- Pitting.
- Small pitting is seen at the root of the tooth.



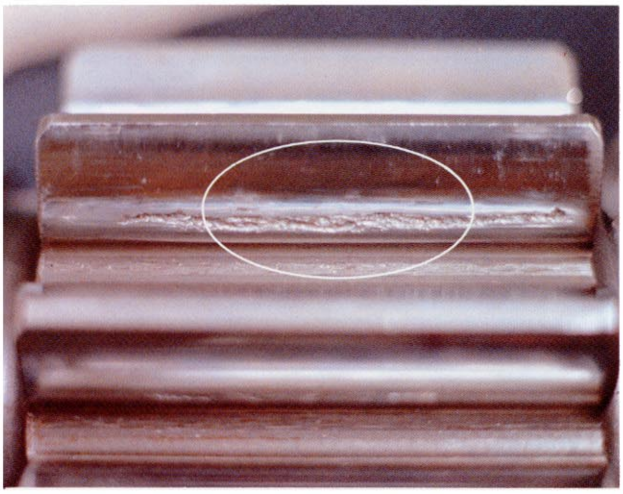
USE AGAIN ONLY UNDER MODERATE LOADING CONDITION

Failure Signs
- Pitting



DO NOT USE AGAIN

Failure Signs
- Pitting



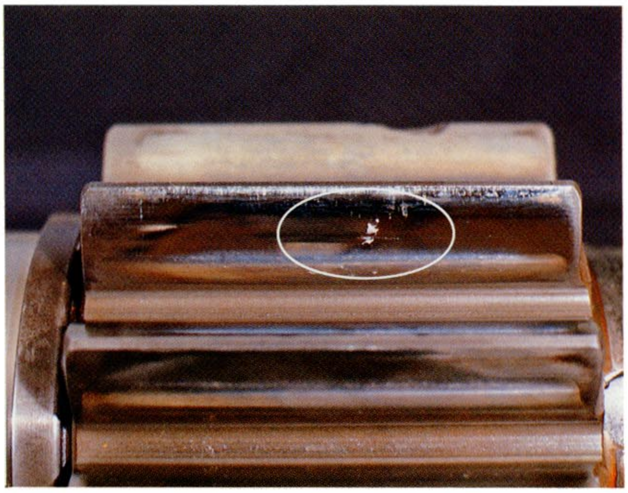
DO NOT USE AGAIN

Failure Signs

- Pitting

Note:

Spread of pitting is shown in the photographs from its early stage till bead damage. (shown from the previous page)



USE AGAIN ONLY UNDER MODERATE LOADING CONDITION

Failure Signs

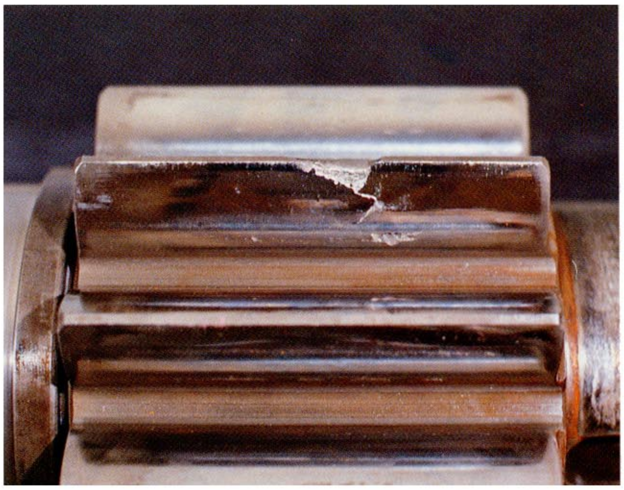
- Spalling
- A groove is formed along the pitch circle of the gear's teeth.

Note:

Failure occurs when gear meshing becomes irregular, check and readjust the critical parts of the gear-train.

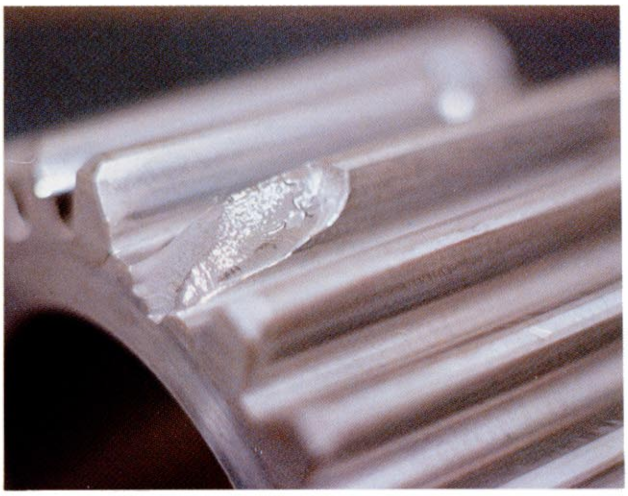
USE AGAIN ONLY UNDER MODERATE LOADING CONDITION

Failures Signs
- Spalling
- Photo shows enlargening of the groove.



DO NOT USE AGAIN

Failure Signs
- Spalling
- A groove develops at the tooth tip surface.



DO NOT USE AGAIN

Failures Signs
- Static fracture
- Concentrated loading on one end of the teeth caused this fracture.

DO NOT USE AGAIN

Failure Signs
- Fatigue fracture
- Cracks have developed through fatigue, and the tooth has broken-off at its root.

DO NOT USE AGAIN

Failure Signs

- Multi-stage fracture
- Chamfered part of the teeth becomes fractured due to continuous uneven shock loading.

ANALYZING GEAR FAILURES

Causes Underlying to Gear Failures

Gear failures result from a compounding of various forms of different causes, however the following causes are the most common.

Backlash:

Even if gear trains were accurately aligned according to theory, thickness of the oil film between the meshing teeth, expansion of the gears through heat, bending of the teeth and gear shafts, etc.; during actual running, are bound to cause slight changes in; teeth contact points, teeth contact surfaces, and amount of backlash etc. As a result, gear teeth may clash together and cause a complete breakdown in work operations.

To prevent such occurrences proper backlash that matches actual meshing conditions determined from the shape, size and type of gear-train must be provided.

Lubrication:

Most failures are caused by; insufficient lubricating oil, mixing of abrasive particles in the oil, improper type of and insufficient lubrication.

Gear loading conditions:

Excessive loading, and shock loads, develop concentrated loads between the inner and outer gear wheels and the pinion gear, resulting in gear failures.

The analysis of gear failure causes is not an easy task. Not only should the actual failure such as the fractured tooth be investigated, but investigations of conditions such as; the gear train, the gear meshing with the failed gear, gear shaft bearings, lubricating oil, and – operating conditions etc. should also be conducted.

Gear Failure Signs and their Causes

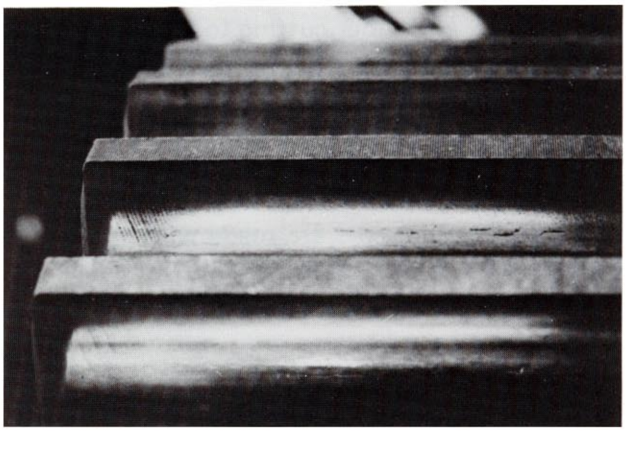
To correctly diagnose a gear failure, as to whether the gear can be processed and reused, or whether it should be discarded and replaced, is important for the customer, in order to lower repair costs and to obtain maximum effective use of the machine.

Failures that are harmless such as gear marks remaining on its teeth from the gear cutting and finishing works, slight flow of metal at the point of contact, and also failures that are not harmless such as; abrasive wear, metal fatigue, and fractures, and their causes are given hereunder.

Harmless Marks Developed During the Gear-Making Process

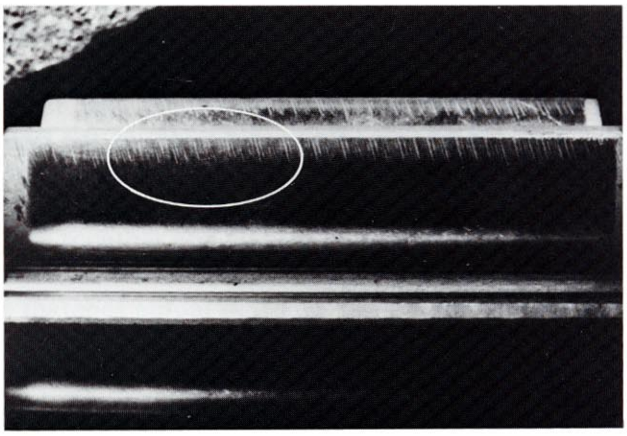
Hob marks:

The hobbing operation produces longitudinal cutting marks along the root area. Normally these marks are nearly all removed by the shaving operation, however, if the amount removed is small, longitudinal hob marks with widths of from 2 to 4 mm may still be remaining. These marks are harmless.



Shaving marks:

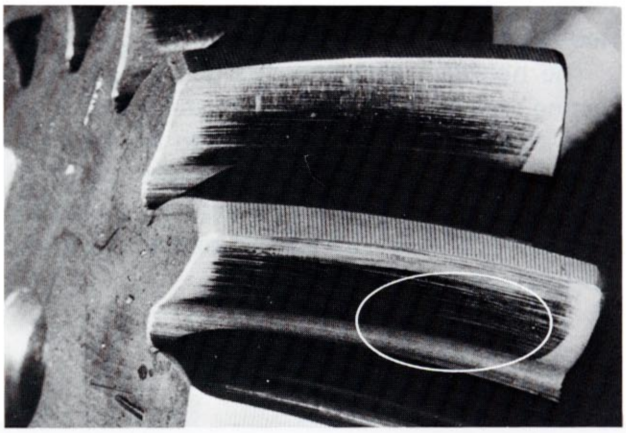
These remain as distinct slanting lines on the tooth face. Sometimes; depending on the shaving operation, deep shaving marks can be seen extending up to the tip of the tooth, which are harmless.



Gear shaper, and other cutting tool marks:

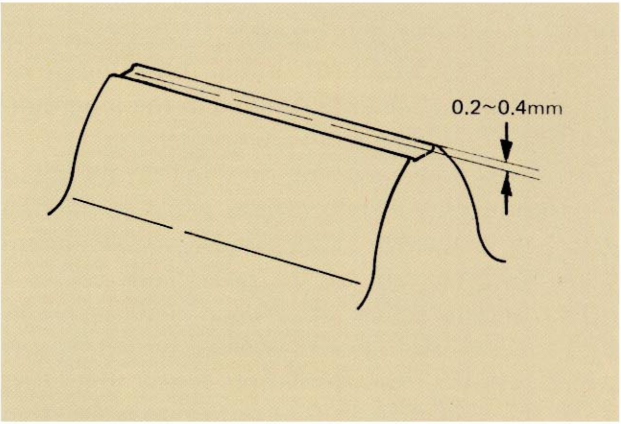
The tooth surface of bevel gears and pinion gears, teeth face of internal gears of ring gears, and in the case of some gears; finishing cutting marks of bevel gear cutters, and cutting marks of gear shapers.

When finishing cuts are made with these machine tools, several tens of fine lines can be observed, however these are harmless.



Lipping:

Lips are sometimes formed at the tip of the tooth during the shaving operation for finishing the gears. A lip of approximately the same height over the entire width of the gear at its tooth tip develops for both sides of the tooth, which is harmless.



Spotting and coloration resulting from heat-treatment:

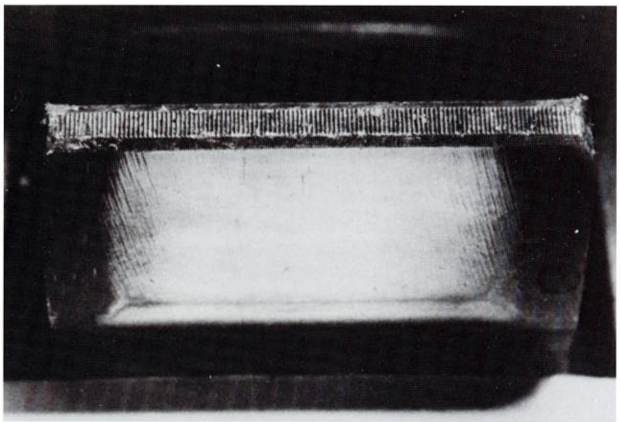
Case hardened gears sometimes have spots in some areas of their surfaces that develop as a result of the formation of oxides on the surfaces during the heat treatment. Nitriding sometimes produces brownish or bluish coloring to some areas. Spotting and coloration are harmless and do not contribute to gear failure.

Minor Metallic Flow from the Meshing of Gears

Initial contacting of the teeth:

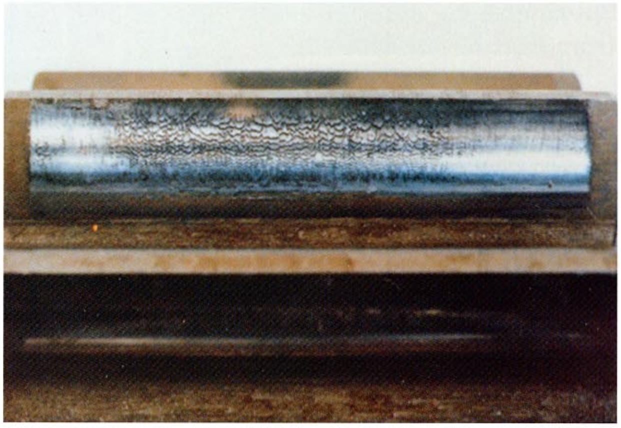
As an indication of initial breaking-in of meshed gears, fine lines running in the longitudinal direction of the teeth are normal.

In a gear drive system, meshing on the pitch line produces a rolling action, while contacting above or below the pitch line i.e. in the addendum or dedendum of the gear teeth causes a rolling sliding action to develop. This action in turn causes strong and weak contact forces which results in the formation of the fine lines. Thus the fine lines caused by initial contacting of the teeth is a normal condition which is harmless.



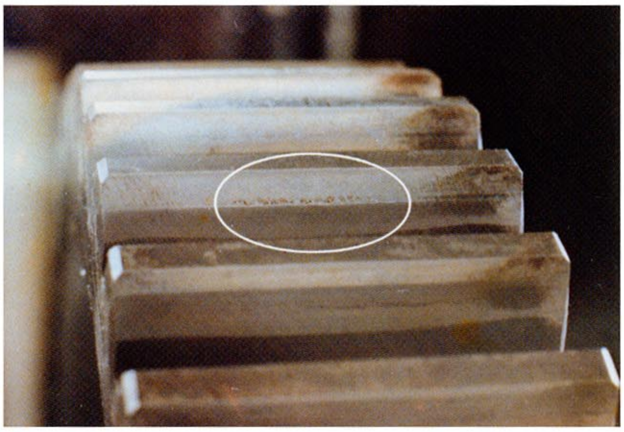
Rippling:

Ripples are formed on the surface of the teeth in a direction perpendicular to the sliding action. Sticking and sliding friction caused by insufficient lubrication, excessively heavy loading, vibration causes the rippling through 'yielding' of the tooth surface.



Initial pitting:

In the initial running-in period, a large number of very small pits develop as a narrow band above and below the pitch line. These marks disappear when local wear smooths the teeth surface.



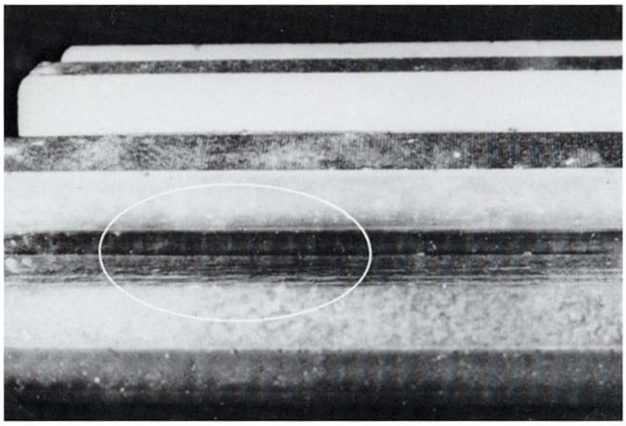
Harmful Gear Failures

Abrasive wear:

The teeth contacting areas become highly polished through initial wear. The entire curved surface of the teeth is polished flat or in a concave manner, over the whole width of the gear. This wear develops mostly at the points where the load is heavy, and the ratio of sliding action is high.

More specifically, near the pitch circle, and between the borderline of single and double tooth meshing.

This failure spreads rapidly when fine sandy dust gets mixed in the lubricating oil.

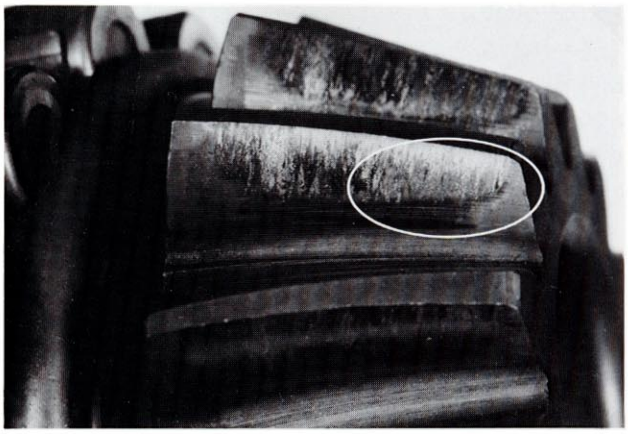


Scoring (wear):

Direct metal-to-metal contact between metal surfaces, softens the metal surface through the very high temperatures that develop, and scoring through the yielding of the metal surface and sudden ripping of minute fused metal particles from the surfaces results.

Normally, scoring develops when the tooth load becomes concentrated in a certain area of the contact surface, causing rupture of the oil film.

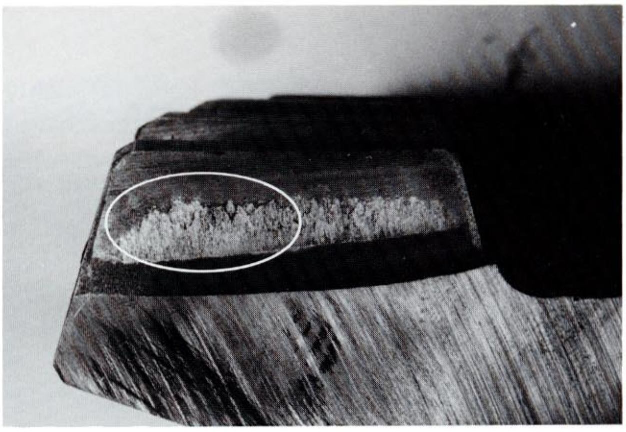
Scoring occurs when the initial 'running-in' period is too short, or work-operations over-load the gear trains, or when deterioration of the lubricant develops.



Interference wear:

If the driving gear is misaligned with the driven gear, the root of the driving gear's tooth may contact the tip of the driven gear's tooth, or the opposite condition may prevail.

In this event most of the load is concentrated on the tip and root of the meshing gear teeth; when parting contact, to cause severe wear or fracture of the teeth. For bevel gears, not only misalignment, but insufficient backlash and improper adjustment may become the cause of the above type of failure.



Pitting (fatigue):

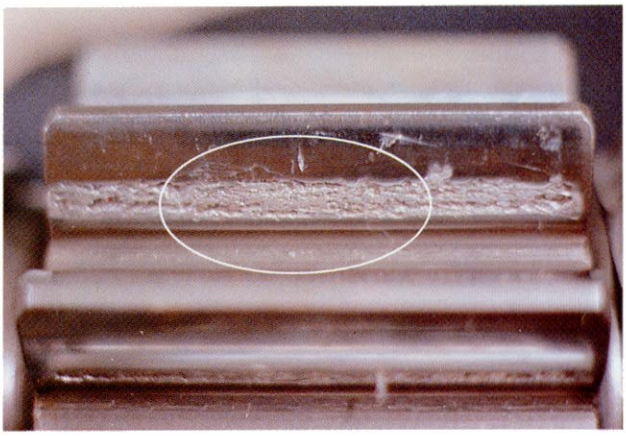
This failure is caused by the combined action of rolling and sliding of the contacting teeth.

For pure rolling contact, maximum shear stress develops slightly below the tooth's contact surface.

In actual gear teeth, frictional forces and sliding forces are exerted on the tooth's contact surface so that the maximum shear stress on the tooth shifts towards the contact surface area, and when the stress becomes excessive cracks develop from the surface of this area.

The fine cracks develop into fine pit-like holes, and spread into pitting.

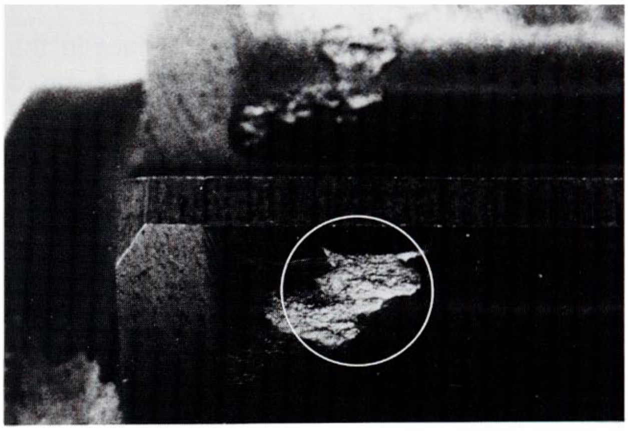
Pitting is mainly caused by gear overloading over a considerable length of time, deterioration of the lubricating oil, and tooth surface decarburization.



Spalling (fatigue):

This failure features larger pits than those observed in 'pitting'. In most cases it develops usually between the case hardened, and the untreated tooth surface areas.

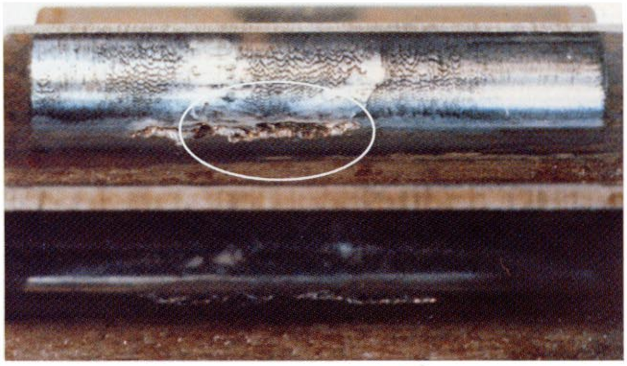
Spalling is caused when the shear stress below the tooth's surface exceeds the tooth's yield strength as a result of tooth overloading.



Case crushing (fatigue):

This failure originates in the area beneath the case hardened surface layer, between the surface layer and the supporting core material. The cracks that develop in the surface layer as a result of the fatigued core grow rapidly in length, and in many cases the top half of the tooth breaks off from the bottom half.

Case crushing is caused by abnormally high tooth surface pressures that cause shear stresses exceeding the yield strength of the boundary layer between the case hardened surface layer and the tooth's core material.

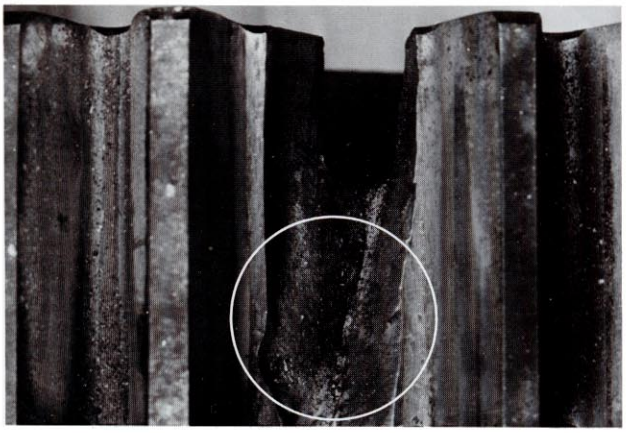


Static fracture:

This failure features a fiberlike surface in the area where the fracture originates, a rapid spreading out into a radial fracture area, and culminates in a shear-lip resulting from shear-stress breakdown.

Also, depending on the rapidness in which the failure developed, or on the coldness of the ambient temperature, the fiber-like surface and shear-lip area become smaller compared with the radial fracture area, and in this case, an inclined crack usually develops from the root of the tooth upward.

Static fracture is caused mostly by, shock loads resulting from inexperienced machine-operation.

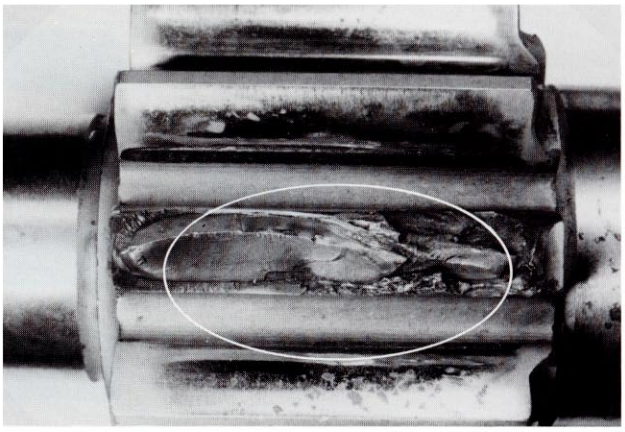


Fatigue fracture:

If an excessive bending stress is applied to a tooth, maximum tensile stress develops at one root of the tooth while compressive stress develops at its other root. Usually, a crack begins from the point where maximum tensile strength is exceeded and progresses slowly. From a certain point on, progress is rapid resulting in fracture of the whole tooth.

The fracture surface in this case is flat and features a sea-shell like pattern in the crack originating area, whereas in the final tooth break-off area larger surface undulations caused by rapid crack development are observed.

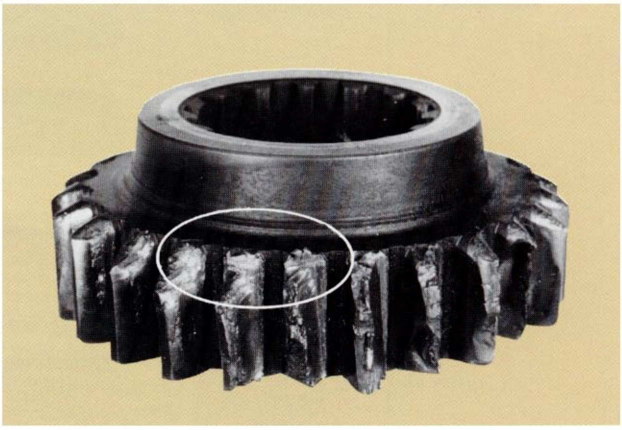
Concentrated strains developing in other parts of the tooth — than its roots, as a result of other damage may result in fractures.



Compound fractures:

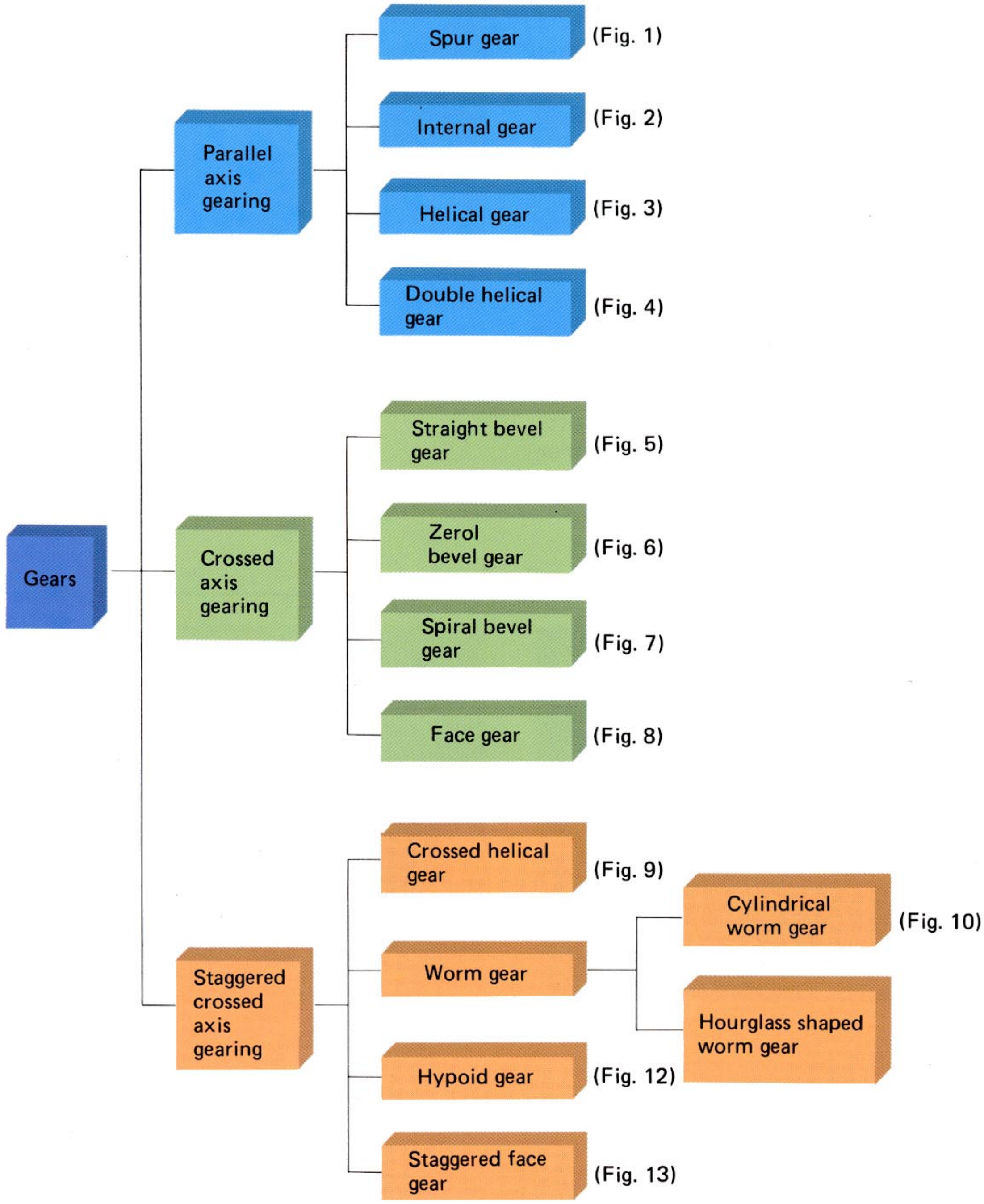
Shock type one sided loading if applied continually on the chamfered surface of the gear teeth, will cause fracture of the chamfered surface, and deformed gear teeth. If the gear is fully hardened a crack leading to fracture is liable to develop from the root inclining upward, when hardened to a lesser degree, plastic deformation of the core material may result.

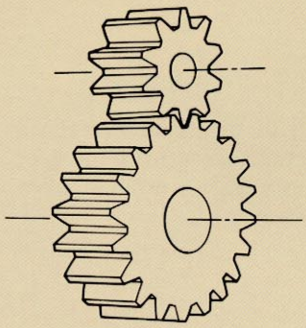
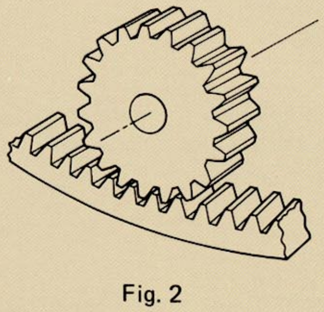
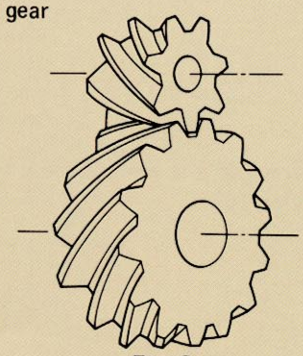
Compound fractures, are caused by improper gear-shifting operations etc.

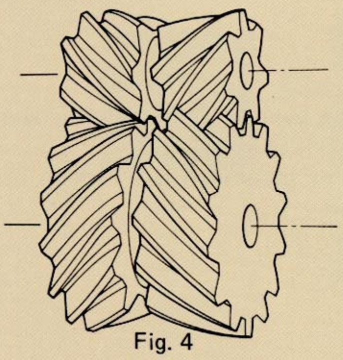
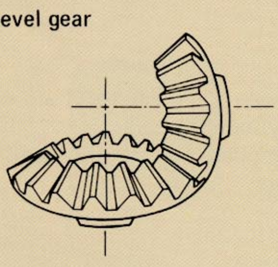
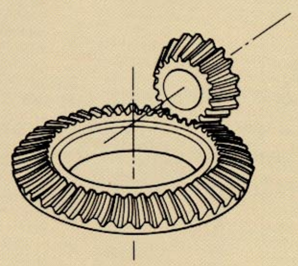


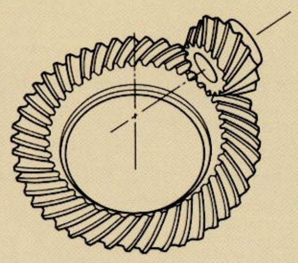
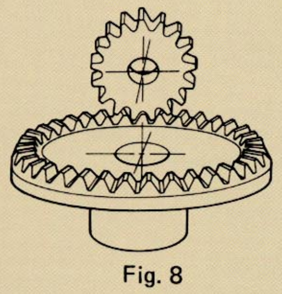
ESSENTIAL GEAR INFORMATION

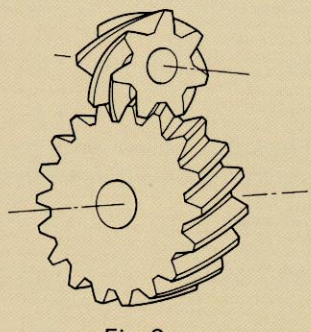
Different Types of Gears

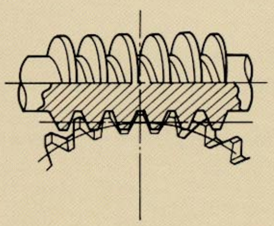
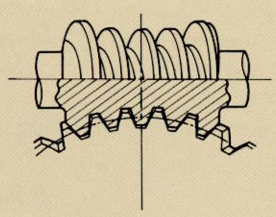
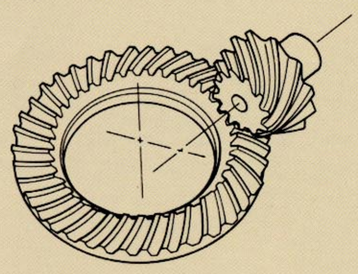


Parallel axis gearing	Description
Spur gear  Fig. 1	A spur gear is a cylindrical wheel with teeth cut parallel with the axis of rotation. Normally, used to transmit rotary motion between two parallel shafts.
Internal gear  Fig. 2	An internal gear is one in which teeth are cut on the inner surface of a cylinder or cone. Internal gearing implies an internal gear with its meshing external gear.
Helical gear  Fig. 3	A helical gear is one having teeth cut on a cylinder and at an angle as a spiral, with its axis of rotation. Normally helical gears are used to transmit rotation from one shaft parallel with another.

Parallel axis gearing	Description
Double helical gear  Fig. 4	Two helical gears of the same diameter of different hands, are joined together to form this gear. Normally used to transmit rotation from one shaft parallel with another.
Crossed axis gearing	**Description**
Straight bevel gear  Fig. 5	A bevel gear is one in which the teeth are cut so that they radiate from the apex of a cone and lie on the conical surface.
Zerol bevel gear  Fig. 6	A spiral bevel gear in which the teeth are cut with a zero degree spiral angle.

Crossed axis gearing	Description
Spiral bevel gear  Fig. 7	A bevel gear in which the teeth are cut as a helical spiral to mesh with those cut in a *crown wheel. *A bevel gear in which the pitch surface is a flat surface.
Face gear  Fig. 8	A pair of gears consisting of a spur or helical gear and a flat disc shaped gear meshing with it. Their two axes can cross, or can be staggered, normally they cross perpendicular to each other. Sometimes the flat disc-like gear is called a "face gear."

Staggered crossed axis gearing	Description
Crossed helical gear  Fig. 9	Cylindrical helical gears can be cut to transmit motion from one shaft at an angle with the other.

Staggered crossed axis gearing	Description
Cylindrical worm and worm gear  Fig. 10	*A cylindrical worm and a worm gear meshing with it and driven by it. *A cylindrical worm has teeth cut in the form of a screw with its axis coinciding with that of the cylinder.
Hourglass worm and worm gear  Fig. 11	An hourglass shaped worm wheel, and a helical worm gear that meshes and is driven by it.
Hypoid gear  Fig. 12	A combination of helical bevel gears with teeth cut so that the gear axles can cross on different planes.

Gear Nomenclature

Nomenclature of the gear and it's definition is shown in the diagram.

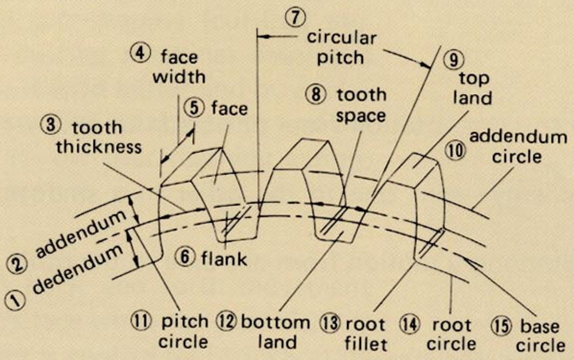


Fig. 13 Gear Nomenclature

Terminology	Definition
① Dedendum	The radial distance between the pitch circle and the root circle
② Addendum	The radial distance between the pitch circle and the addendum circle
③ Tooth thickness	Thickness of the tooth measured along the pitch circle.
④ Face width	Length of the tooth face along the axis of the gear
⑤ Face	The tooth surface outside the pitch circle.
⑥ Flank	The tooth surface between the pitch circle and the root circle.
⑦ Circular pitch	The distance from a point on one tooth to the corresponding point on the next, measured along the pitch circle.
⑧ Tooth space	Width of the groove on the pitch circle.
⑨ Top land	Top area of the tooth.
⑩ Addendum circle	As defined by the diagram.
⑪ Pitch circle	Intersection between the pitch cylinder and the gear's face.
⑫ Bottom land	Bottom. area of the tooth (space).
⑬ Root fillet	Fillet area of the tooth bottom.
⑭ Root circle	Circle containing the groove bottoms.
⑮ Base circle	The circle from which the involute curve of the teeth is derived.

Involute Gears

The involute curve derived from a circle is a typical tooth shape used in gear making and the gears are called involute gears.

Function of the involute gear:

The gear wheels serve to transfer rotation from one shaft to another. The involute gear has the following features.

- Involute gears transfer energy from one to the other in a smooth manner continuously and effectively.
- Involute gears transfer rotationary motion from one axle to the other at a constant angular speed ratio and as result –.

Involute gears have the following advantages:

- Gear making process is simple and economical.
- Interchangeability of the gears is excellent.
- Slight differences in the distance between centers of meshed gears do not affect the angular speed ratio.

The involute curve:

As shown in Fig. 14, if a string attached to and wrapped around the perifery of a fixed cylinder with center 'O' were kept taut and a pencil attached to the string's end was arranged to trace its path as the pencil was moved to unwrap the string from around the cylinder, the curve traced by the pencil is the involute curve of circle "O', and this circle is called the 'base circle'.

This vurve can be extended inderfinitely by lengthening the wrapped string, but, the part of the curve this is used for shaping gear teeth is only the part starting from the base circle and rising a small distance.

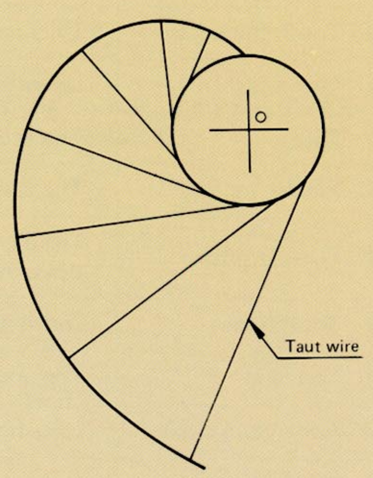


Fig. 14 Involute curve

Cutting Gear Teeth

Methods used in forming spur gear teeth are: Die-stamping, die-forming, and gear-shaping (cutting) etc. To day most modern gear-cutting machines employ a rack-shaped cutter or a gear-shaped cutter and by applying a relative motion between the cutting teeth and the gear blank corresponding to the gear meshing action, perform the gear cutting operation.

Rack cutter:

The rack-cutter is given back and forth movement parallel to the gear blank's face while the gear blank is rotated and cutting action is applied by reciprocating the cutter.

Pinion cutter:

The pinion-cutter is given rotary movement while the gear blank is rotated and cutting action is applied by reciprocating the cutter.

Gear hob:

A hob (shaped like a worm wheel with radial slots to provide cutting action) is rotated and the table with the work mounted is also made to rotate to provide even cutting action.

The hob is set at a slight angle with the work to offset the lead angle of the hob's screw, when cutting a spur gear.

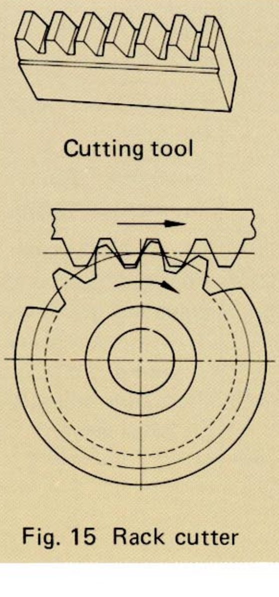


Fig. 15 Rack cutter

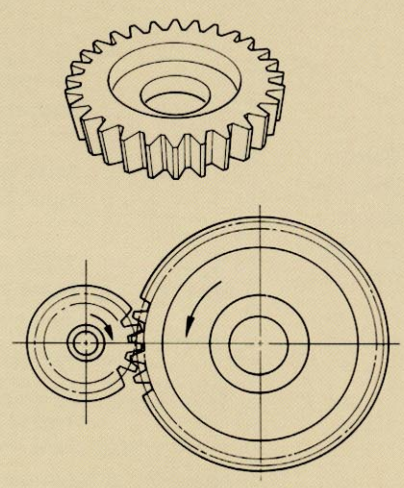


Fig. 16 Pinion cutter

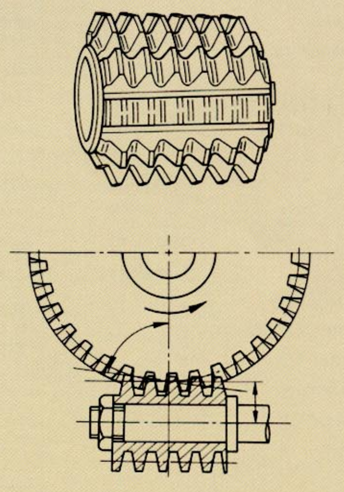


Fig. 17 Gear hob

Gear Blank Material

Type	Code	Heat treatment	Hardness after annealing	Gear usage
Carbon steel for machine structural use	S43C	temper & anneal on blank material	Up to 1/4 R from surface HB201 – 255 HB229 – 277 HB248 – 298 HB201 – 277	Timing gears for engines
		temper & anneal high frequency wave	HRC52 – 60	Main pinion gear (mechanical press)
		temper & anneal on finished product	HRC30 – 36	Drive gear train for low pressure pump (bulldozer)
	S45C-V	temper & anneal on blank material (gas elimination)	HB207 or over	Final drive gear (small machine)
	S48C-V	temper & anneal on blank material (gas elimination)	HB212 or over	Final drive gear (large machine)
	S53C	temper & anneal on finished product	HRC30 – 36	Drive gear train for low pressure pump (bulldozer)
Chrome molybdenum steel forgings	SCM3H	temper & anneal on blank material	HB262 – 311 HB277 – 331 HB262 – 311	Drive gear (mech. press) Drive gear & main pinion
		high frequency wave temper & anneal	HRC52 – 60	Gears for planetary reduction gear transmission (dump truck)
	SCM4H	temper & anneal on finished product	HRC39 – 45	Final drive gear (motor grader)
	SCM5H	nitriding		Torqueflow ring gear (bulldozer)
Chrome molybdenum steel for machine structural use	SCM21H SCM22H	case hardening temper & anneal	HRC58 – 63	Small bevel gears (mechanical press)
		gas carburizing temper & anneal	Gear blank (m = 6, d = 100) SCM21H HB235 – 311 SCM22H HB248 – 375 Surface HRC58 – 63	Engine PTO gears Reduction gears (dump trucks) Planetary gears Transmission gears (bulldozers. dump trucks. Press slide adjuster (mech. press bevel gears) Differential gears

Type	Code	Heat treatment	Hardness after annealing	Gear usage
Nickel chrome molybdenum steel	SNCM21H SNCM23H SNCM23H-K	gas carburizing temper & anneal	Gear blank (m = 6, d = 100) SNCM21H H_B217 – 302 SNCM23H H_B285 – 331 SNCM23H-K H_B269 – 388 Surface H_RC58 – 63	Spiral bevel gear (dump truck) Hindley worm
			Gear blank same as above Surface H_RC60 – 64	Final drive pinion Transmission gear (bulldozer) Gear for R.P.C.U.
Silicon manganese steel forgings	SCSiMn2A SCSiMn2B	high frequency wave temper & anneal	H_RC52 – 60	Main gear (mechanical press)
		temper & anneal on blank material	H_B201 – 255	Main gear (maypres)
		temper & anneal on blank material	H_B229 – 277	Main gear (maypres)
		high frequency wave temper & anneal	H_RC52 – 60	Main gear (maypres)
Nickel chrome steel forgings	SNC3 SNC22	temper & air quench on finished product	H_B360 and over	Worm wheel for reduction gearing (mechanical press) Gears for transmission (snow mobile, dump truck) Differential gearing (dump truck)
Phosphor bronze castings	PBC2A		H_B60 and over	Worm wheel for reduction gearing (mechanical press)

Gear Lubrication

Function of the lubricating oil

The lubricating oil forms an oil film on the tooth surface. The thickness of this film increases with rise in the oil's viscosity, this absorbs the pressure exerted on the tooth surface and reduces wear between the meshing teeth.

Also, maintaining the thickness of the oil film serves to prevent tooth surface failures such as; pitting and scoring etc.

This oil film also serves as a boundary lubricating agent, so that when relative motion occurs between the two surfaces of the meshing teeth, heat generates as a result of the wearing friction in the oil film. The temperature of the oil film rises and the viscosity of the oil changes significantly to increase the fluidity of the oil and form a fluid lubricating film that dissipates the generated heat, and at the same time carries away the worn metallic particles.

Gears operated under high loads develop elastic deformation of their rolling surfaces, so that the formation of a fluid lubricating film is highly effective in the prevention of failures.

Lubricating systems

Various systems exist depending on the type of gearing and operational conditions, however, the 'oil bath' and 'circulated oil' systems are most commonly employed.

Oil baths . . .

The gears are partly submerged in a bath of oil. This method is effective for periferal speeds up to 15 meters per second. The gears should not be submerged to over three times the tooth height. If the amount submerged is excessive frictional loss will increase while if it is too little insufficient lubrication will result.

Oil circulated by pumps . . .

The pressurized oil is sprayed on to the meshing part of the gears by suitable nozzles. Oil pressures ranging from 0.6 to 0.7 kg per cm^2 are sufficient.

This type of lubricating system permits including an oil cooler, and oil filter in the oil circuit, so that control of oil temperature and removal of dust and abrasive particles is facilitated.

PREVENTIVE MAINTENANCE

To prevent the occurrence of failures beforehand, always keep track of the customers machine's condition, pay attention to oil temperature, oil consumption, and abnormal noises in particular. In this manner you will be able to keep the machines running in top condition.

The maintenance procedures outlined in the ''operation and maintenance manual'' will prevent most of the usually encountered failures, however, the customer is requested to pay particular attention to the following items.

- Use Komatsu specified lubricating oil, follow the instructions for periodic col changing, and use the proper lubricating oil that matches the ambient temperature.
- Thoroughly warm-up the engine before starting regulat work-operation, refrain from sudden accelerating, or sudden starts and stops when running the machine.
- If any abnormal signs are perceived, stop machine operation immediately and search for the cause.

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