Chapter 8 Gear damage

Table 1 shows causes for gear damage and its countermeasures.

Table 1. Causes of gear damage and its countermeasure

Technical Know How - Design for gear strength extracted from JSME (Japan Society of Mechanical Engineers), and others.

Damage	Details of damage	Condition of flank	Cause	Solution
1 Breakage	a. Overload breakage	Found crystallization on surface of breakage flank similar to surface of cast iron.	Overload. Poor tooth contact. Misusage.	Find the cause of overload. Comprehend usage conditions.
	b. Fatigue breakage	Flank breakage has discoloration but less damage than overload breakage.	Error in actual load calculation. Unsuitable shape of Dedendum.	Improve gear data for Tooth thickness. Exchange material and heat treatment.
	c. Shearing breakage	Found large plastic deformation at breakage surface.	Overload. Defective and unsuitable material.	Practice warm up and test run. Exchange material and heat treatment.
	d. Impact breakage	Found crystallization on the surface of breakage flank similar to surface of cast iron.	Oscillation of bearings from impulse load.	Improve axis and bearing stability to ease impulse load.
2 Wear	a. Abrasive wear	Found small scratches or grooves at sliding direction of flank.	Metallic dust from worn gear and bearing.	Purify lubricating oil. Exchange material and heat treatment
	b. Scratching	Found rough scratches at sliding direction. Scratches are larger and deeper than Abrasive wear.	Larger particles than 'a' and waste objects.	Countermeasure is the same as 'a'.
	c. Corrosive wear	Found rough pockmarks at flank.	Unsuitable lubricating oil. Oxidation of flank. Water contamination.	Exchange type of lubricating oil. Improve countermeasures for moisture and waterproof.
	d. Fretting	Found surface damaged with rust and oxidation by chemical change.	Relative reciprocation motion from minute oscillation at surface of contact.	Decrease oscillation. Improve surface hardening.
	e. Burning	Found discoloration and loss of hardness due to high temperature from excessive wear.	Inferior lubricating oil. Overload. Excessive speed. Increased temperature.	Exchange type of lubricating oil. Improve method of lubrication.
	f. Normal wear	This wear is within expectation of gear' s lifespan.	As expected and unavoidable.	
	g. Moderate wear	Found flank with over excessive mark cannot engage normally.	Unsuitable lubricating oil. Oxidation of flank. Water contamination.	Countermeasure is the same as 'a'. Practice warm up and test run.
3 Plastic deformation	a. Rippling	Found marks of corrugation or scale on contact area at flank.	Extreme sliding load. Deterioration of material or lubricating oil.	Improve gear strength and usage condition. Use extreme additive oil.
	b. Rolling	Found polish mark at flank and curled Tooth tip.	Heavy load. Insufficient robustness, or hardness of material.	Use shock absorber for design of driver side. Improve material and heat treatment.
	c. Peeling	Commonly, interpreted as rolling.	Commonly, interpreted as rolling.	Same as above. Practice warm up and test run. Improve assembly accuracy.
	d. Plastic flow	Same as above and usually found in soft materials.	Same as above. Insufficient robustness or hardness of material.	Improve strength of material. Practice warm up and test run.
	e. Collapsing tooth	All teeth collapsed.	Same as above. Dedendum stress exceeds elastic limit.	Same as above. Re-calculate conditions of load and gear data.
4 Fatigue of flank	a. Pitting	Found small pockmarks just under pitch line.	Metal fatigue from repeated stress.	Improve gear strength, material and heat treatment.
	b. Spalling	Detached large pieces of metal fragments from flank.	Metal fatigue under surface from repeated stress.	Same as above. Practice warm up and test run. Use extreme active oil.
	c. Case crush	Found extensive range of hardness layer detached from flank.	Same as above. Extreme residual stress of core.	Same as above. Improve flank and core hardness. Design radiator for gear.
5 Thermal damage	a. Scoring	Found many scratches and fusion marks at sliding direction of flank.	Extreme load. Metal contact from lack of oil film.	Emphasize on warm up and test run. Exchange the lubricating oil.
	b. Sand burning	Found extreme cohesion and fusion at final form of scoring.	Same as above. Inferior lubricating oil and accuracy. Increased temperature.	Same as above. Re-examine heat treatment. Improve gear accuracy.
6 Others	a. Damage and wear from interference	Found large scratches, exfoliation and falling apart at area of Tooth tip and Dedendum.	Inferiors design. Insufficient backlash.	Provide proper backlash to gears. Improve gear accuracy.
	b. Damage and wear from waste object	Found several detached tooth in various conditions.	Waste objects from inside and outside of equipment.	Improve assembly method. Remove waste objects. Seal for dust proof.
	c. Rust and corrosion	Found rust and corrosion on flank.	Chemical changes of lubricating oil, intrusion of impurities and water.	Add anti-corrosion agent to lubricating oil. Prevent intrusion of water and acids.