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O T T A W A April 26th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1393.

Examination of Failed Differential Gears from a Snowmobile.

(Copy No. 4.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Examination of Failed Differential Gears from a Snowmobile.

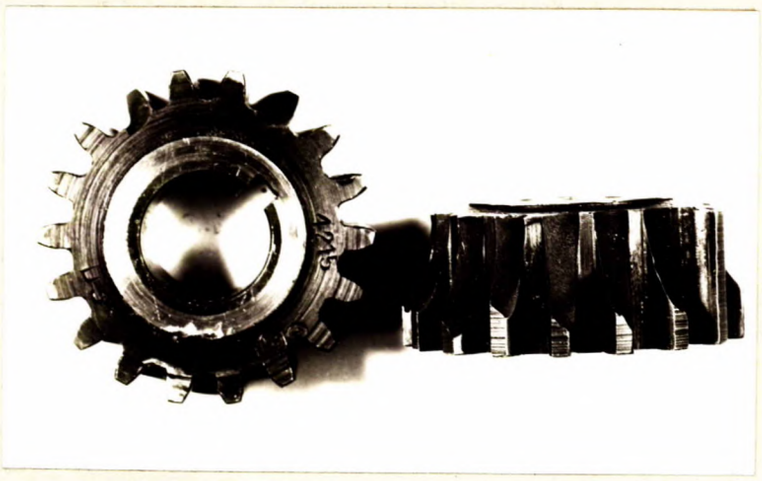
Origin of Request:

On April 19th, 1943, two small differential gears from a bombardier-type, full-track Snowmobile were submitted for examination. The request originated from Mr. W. J. Washburn, staff engineer of the Mechanical Transport Vehicle Chassis Section, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario.

Description of Gears:

Figure 1 shows the gears as received. They are about 2¼ inches in diameter and about 7/8 inch thick. A considerable number of teeth are broken away.

Figure 1.

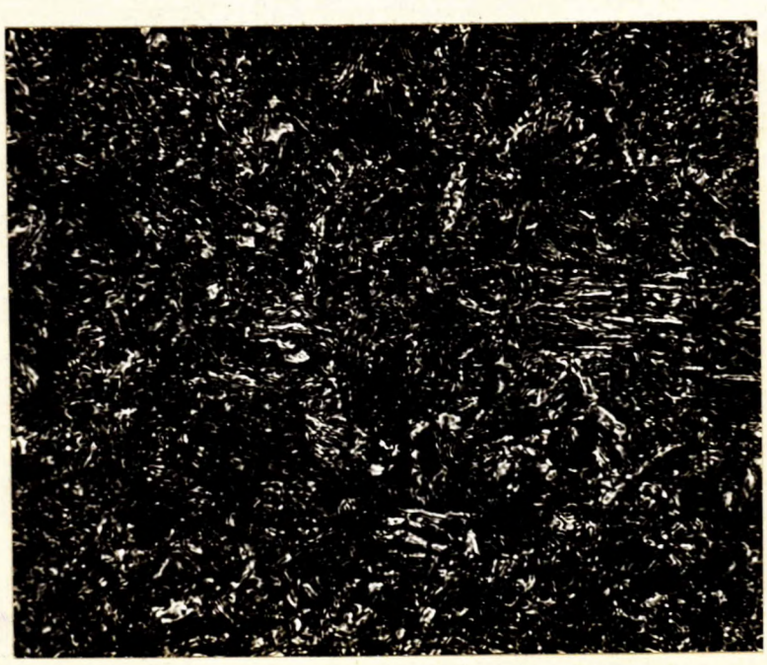


SPUR GEARS AS RECEIVED.
#1 is vertical;
#2 is horizontal.

Microstructure:

Figure 2 shows the structure typical of both gears. This structure is usually produced by quenching and drawing and is called "sorbitic". There are traces of free ferrite (white patches), indicating that quenching was not quite rapid enough. Free ferrite lowers fatigue and impact strength.

Figure 2.



X1000, nital etch.
SORBITIC STRUCTURE OF SPUR GEARS.

Hardness Tests:

		Rockwell "C"
Gear #1	=	42
Gear #2	=	46

Chemical Analysis:

		Gear #1 = Per cent =	Gear #2
Carbon	=	0.47	0.47
Manganese	=	0.76	0.78
Nickel	=	0.10	0.11
Chromium	=	0.81	0.81
Molybdenum	=	0.02	0.02

Conclusions:

These gears are typical of normal industrial practice. They are homogenoously hardened.

No metallurgical reason for failure was found. A slight increase in life would be expected if more drastic quenching could be applied without warping the gears.

DISCUSSION:

The failure of gears in service is usually due to mechanical factors.(1)(2) The major factors to be considered in gear life are: design, machining, fitting, material, and operation.

(1) REAR-AXLE GEARS--FACTORS WHICH INFLUENCE THEIR LIFE, Almen and Boegehold, A.S.T.M. Proc., Vol. 35, Part 2, 1935.

(2) FATIGUE OF METALS AS INFLUENCED BY DESIGN AND INTERNAL STRESSES, J. O. Almen. A.S.M. Publication (1943).

(Continued on next page)

(Discussion, cont'd) -

Design -

If the design has not allowed sufficient cross-section in the tooth to withstand the normal running loads, failure will occur in a short time. After a few trials the size of the gear can thus be specified. Breakages that occur after a period of a few weeks to a year of operation are generally fatigue failures and their cause may be one of the following:

Machining -

It has been proven that heavy cuts in machining distort a layer of metal at the surface. This distorted metal has strains set up in it which make it weaker than if lightly machined. Grinding generates strains in the metal; these strains are often sufficient to pull the metal apart at the surface. Even when grinding cracks are not produced, there are tension strains in the metal which reduce its strength. Unless machining operations are carefully controlled, strains may be set up in a part which will lead to early failure.

Fitting -

Few gears mate perfectly. If bearing alignment is "out" a fraction of a thousandth, uneven tooth loading will result. If the gear warps slightly in heat treatment the load may be thrown on one end of the tooth. Improper fitting can thus lead to early failure. Gear life can be greatly extended by lapping, provided bearing alignment is perfect. Prussian blue can be used to check load-bearing areas on gear teeth.

Material -

If a gear tooth is bent more than only very slightly it becomes useless. A stiff "springy" tooth is required for

(Discussion, cont'd) -

good service. This condition is obtained at Rockwell "C" 55 to 50. Increase in hardness increases wear resistance but lowers impact strength. Many gears are surface-hardened in order to obtain maximum wear resistance.

The life of a gear may be reduced by the presence of free ferrite, decarburization, inclusions, or carbides These lower the fatigue strength of the metal. The gears examined had traces of free ferrite, which could have been avoided by a more drastic quench.

Steels which warp on heat treatment should not be used for gears.

Operation -

As the stress in the gear is increased, its life is shortened. Overloading is obviously a cause of early failure.

SHOTBLASTING:

The life of gears has been materially extended by shot blasting.* This removes the strains set up by machining and strengthens the metal.

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* See footnote 2 on Page 3.