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Major Failures in Automobile Components

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Abstract: Microscopic and Macroscopic Fracture Analysis Techniques have been used to find out causes of failure of automotive parts. This paper is a combination of research as well as a case study of nearly all types of failures which will help to optimize life and reliability of automotive parts .Aim of this paper is to make clear the differences among various modes of failures and their causes so that one can proceed for their failure analysis and take necessary actions.
Keywords: Beach marks, Fatigue striations, Ratchet Marks, fatigue, Brinelling, Chevron Wear Pattern, Crystalline Wear Pattern, Etching, Fretting, Galling, Frosting, Pitting, Shock Load, Hot Spotting, Heat Checking

I. INTRODUCTION

Failure Analysis is a systematic, science-based method employed for investigations of failures occurring during test or in service.
For this analysis, we generally consider a broad spectrum of possibilities or reasons for the occurrence of failure. Like the great detective, we must carefully examine and evaluate all evidence available, then prepare a hypothesis—or possible chain of events—that could have caused the "crime". We may compare ourselves to a coroner performing an autopsy on a person who suffered an unnatural death, except that the failure analyst works on parts or assemblies that have had an unnatural or premature demise

II. HOW THIS ANALYSIS CAN BE DONE

There are several ways to do this. Some of these are:
Visual examination
Nondestructive testing
Mechanical testing
Microscopic examination
Surface examination
Chemical analysis
In this paper, we will be presenting our analysis done through microscopic and Surface examinations.

III. TYPES OF WEAR

This publication provides a parts analysis process to help you determine how parts failed during operation,

A. Normal Wear

Components that are operated correctly, and inspected and maintained at recommended intervals, will eventually wear under normal operating conditions. This is called "normal" wear.

B. Premature Wear

Components can wear prematurely and fail when a vehicle is not Operated Correctly, or is Operated Abusively.

IV. VARIOUS FAILURES

A. Beach Marks

Beach marks are macroscopic progression marks on a fatigue fracture or stress-corrosion cracking (SCC) surface that indicate successive positions of the advancing crack front. They take the form of crescent-shaped macroscopic marks on fatigue fractures representing positions of the crack propagation, radiating outward from one or more origins.
Beach marks are also known as clamshell marks, arrest marks or growth rings.

B. Fatigue Striations

Fatigue striations are microscopic features on a fatigue fracture surface that identify one propagation cycle of a fatigue crack. They are not always present and can only be seen under a scanning electron microscope shown in figure 6. In figure 1, **Ratchet Marks** can also be seen, which are actually traces of vertical planes separating fatigue fractures originating from multiple initiation points.

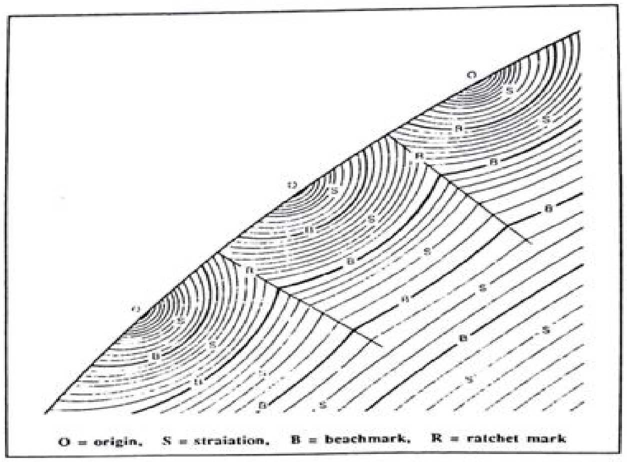

Figure 1: various features seen on given sample

Figure 2**:** beach marks on gear

C. *Bending Fatigue (Fatigue Fracture)*

Bending is a type of fatigue fracture that occurs when a shaft is subjected to both torsional and bending fatigue at the same time. Beach marks form and usually point toward the origin of the fracture, which represents fatigue fracture cycles that occurred before the component failed completely. Figure 2 shows beach marks on an axle shaft that indicate it fractured as a result of bending fatigue.

D. *Brinelling (Surface Fatigue)*

Brinelling is a process of wear in which similar marks are pressed into the surface of a moving part, such as bearings or hydraulic pistons. Brinelling is a material surface failure caused by Hertz contact stress that exceeds the material limit. It usually occurs in situations where a significant load force is distributed over a relatively small surface area (ref to fig 3).

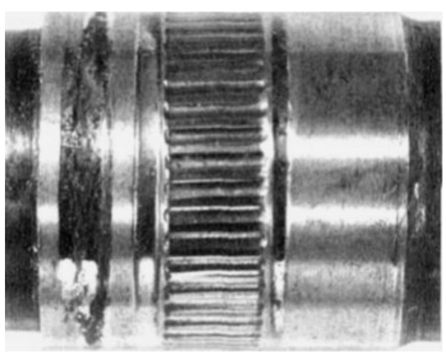

Fig3: Brinell wear

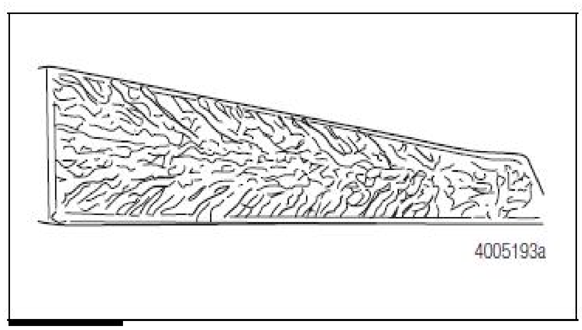

fig 4: Chevron

E. *Chevron Wear Pattern*

A **chevron** is an inverted V-shaped mark on a brittle fracture surface, usually on parts whose widths are considerably greater than their thickness. Also called a herringbone pattern(ref to fig 4).

F. *Crystalline Wear Pattern*

When a sudden, severe impact load occurs, the wear pattern that forms on the surface of the part resembles crystal facets (ref to fig 5).

G. *Etching (Surface Fatigue)*

Etching is a type of surface fatigue that corrodes metal and leaves a dull stain on a part’s surface, because the lubricant was contaminated with water. Water can enter the carrier through breathers, or a damaged or worn seal, or as condensation from humid weather. Water in lubricant damages bearing races and cups, and causes the hypoid gear set to wear prematurely. Figure 6 shows corrosion on the spigot bearing roller ends.

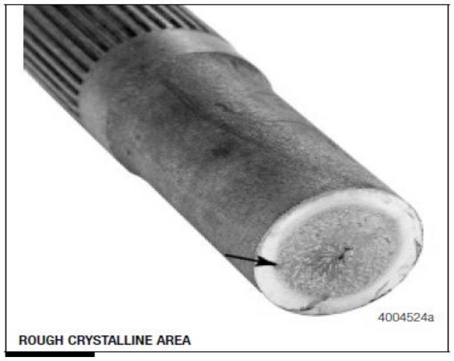

Fig 5: Crystalline Wear Pattern

fig 6: Etching on roller bearing

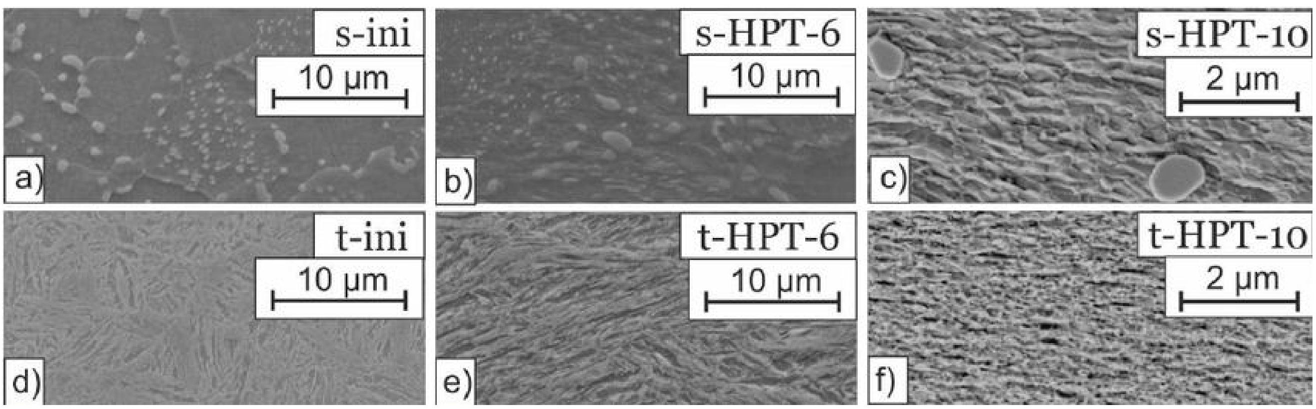

fig 7: Etching Observed microscopically

H. Fretting

Fretting refers to wear and sometimes corrosion damage at the asperities of contact surfaces. This damage is induced under load and in the presence of repeated relative surface motion, as induced for example by vibration (ref to fig 8).

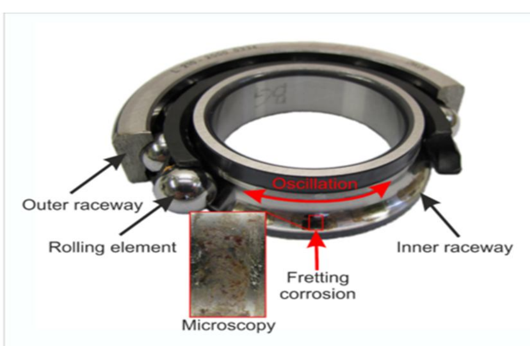

Fig 8: Fretting

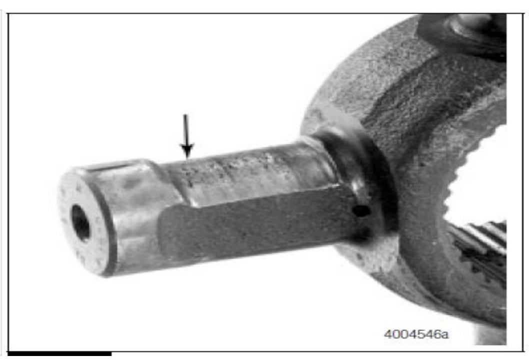

fig 9: Galling

I. Frosting

Frosting is a normal wear condition on spur gear tooth that doesn't affect performance or gear life. Differences in gear tooth manufacturing tolerances cause teeth in a gear set to have different profiles. During operation, gear teeth attempt to conform to a common gear tooth profile, and frosting wear occurs.

Frosting is a grayish or yellowish white color usually found at the center of the teeth at the mating gear contact position. Light pitting on the gear teeth also may accompany frosting. As the gear continues to operate, sliding friction eventually removes frosting.

J. Galling (Surface Fatigue)

Galling is a type of surface fatigue that occurs when two unlubricated metal surfaces rub against each other. Galling is also called "metal transfer" (ref to fig 9).

K. Heat Checking

Heat checking is fine lines or cracks on the surface of a brake drum or rotor. Even though heat checking is a normal condition that results when a friction surface continually heats and cools, it's important to recognize when cracks on the surface of the drum or rotor indicate damage has occurred. Under high temperatures or overload conditions, larger cracks can develop and extend below the surface. Several heat checks aligned across the braking surface require drum replacement. Cracks that align and approach the barrel area of the rotor, or lead to the vent area, require rotor replacement.

L. Hot Spotting (Black Spots)

Hot spotting (black spots) can appear on a brake drum's surface uniformly (over the entire surface), on only one side or in three equidistant areas. Hot spotting requires drum replacement

M. Pitting

Pitting corrosion, or pitting, is a form of extremely localized corrosion that leads to the creation of small holes in the metal. The driving power for pitting corrosion is the depassivation of a small area, which becomes anodic while an unknown but potentially vast area becomes cathodic, leading to very localized galvanic corrosion. The corrosion penetrates the mass of the metal, with a limited diffusion of ions.

Pitting is a type of surface fatigue that forms pits, or cavities, on metal surfaces. Initially, pits may be the size of a pinhead, or even smaller. If unchecked, pitting will progress until pieces of the surface metal break from a component ("spalling") and enter the axle lubrication system. Cyclic overloading and contaminated lubricant can damage bearing cups and rollers, and hypoid gearing. Localized pitting on drive pinion teeth can sometimes indicate that another axle component is operating out-of-position (ref to fig 10).

N. Shock Load (Impact Fracture)

Shock load, also called an "impact fracture," is a sudden and powerful force applied against a component. Shock load can destroy or damage a component immediately. Often, however, a component damaged by shock load will continue to operate, but it will wear prematurely or fail soon after the initial shock load has occurred. Shock load causes components to crack and separate from each other. We must look for a rough, crystalline finish on the separated parts.Torsional shock load results when a rapidly-applied twisting motion occurs; for example, when an excessive amount of torque is delivered to an axle shaft(ref to fig 11).

fig 10: pitting

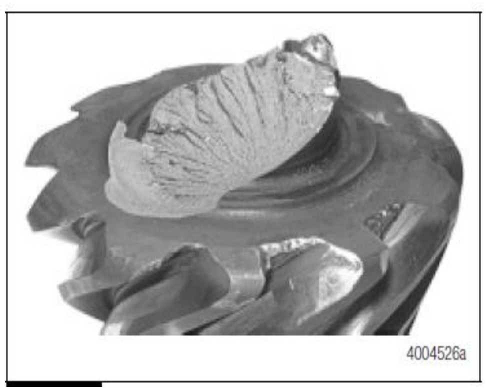

fig 11:Fracture due to shock load

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V. CONCLUSION

Hence it is a vital field of research to differentiate various failures that may occur in automotive parts and their causes of failure as well as mode of preventions. Automotive experts are working relentlessly on this field to come up with a product having more reliability than others. It's the common man who gets benefits from a reliable product.

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