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Study of failure of gears and analysis through SEM of Fracture surface

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Introduction : Gears are the most common means of transmitting motion and power in the modern mechanical engineering world. A gear is a component within a transmission device that transmits rotational force to another gear or device. A gear is different from a pulley in that a gear is round wheel which has linkages ―teeth‖ that mesh with other gear teeth, allowing force to be fully transferred without slippage. A gear is a machine element designed to transmit force and motion from on mechanical unit to another. The design and function of gears are usually closely associated, various types of gears have been developed to perform different function, the most common of these being spur gears, helical gears, straight and spiral bevel gears, and hypoid gears.

The basic reasons of gear failure misalignment of gear, spalling, pitting etc, follow the reason of gear failure. Gears generally fail when the working stress exceeds the maximum permissible stress. Advances in engineering technology in recent years have brought demands for gear teeth, which can operate at ever increasing load capacities and speeds. The gears generally fail when tooth stress exceed the safe limit. In this study the technology of gears is presented along with the various types of failure that gears have. The causes of these failures are studied. The type of stress related failure due to (fatigue failure) of gear tooth because of stress concentration is detailed in this thesis. it focused on the different types methodology, that is used by the various researcher in the past recent year to find out causes of failure in gear and what is final result of that to reduce the failure in gear. Gears are commonly used for transmitting power.

Key Words : Gear, Failure, Teeth, gear failure misalignment of gear, spalling, pitting etc

Fracture surface analysis through SEM:

Fracture surface study for all the samples was done under SEM. A micrograph surface reveals dimple marks in Fig.4.27 (a). Moreover, river-like pattern which is a typical characteristics of cyclic brittle failure mode is visible in Fig.4.27 (a) and 4.28(a). However, striations, which is a typical characteristic of cyclic failure mode is embodied in the fracture surface.

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For Sample 1

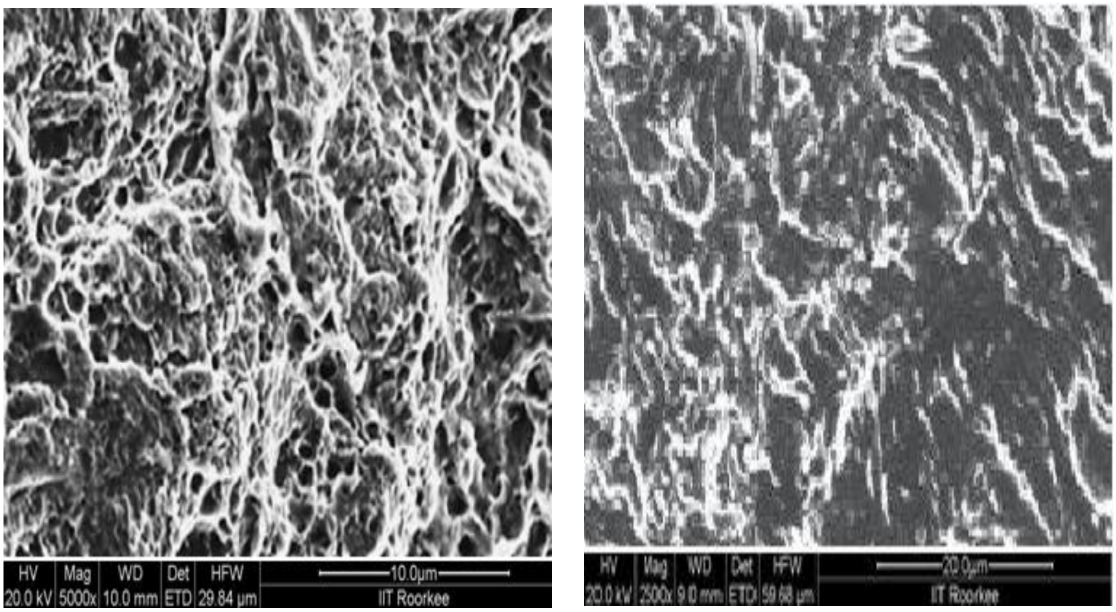

Fig Fractograph of etched sample 1 (a) at 5000X (b) at 2500X

For Sample 2

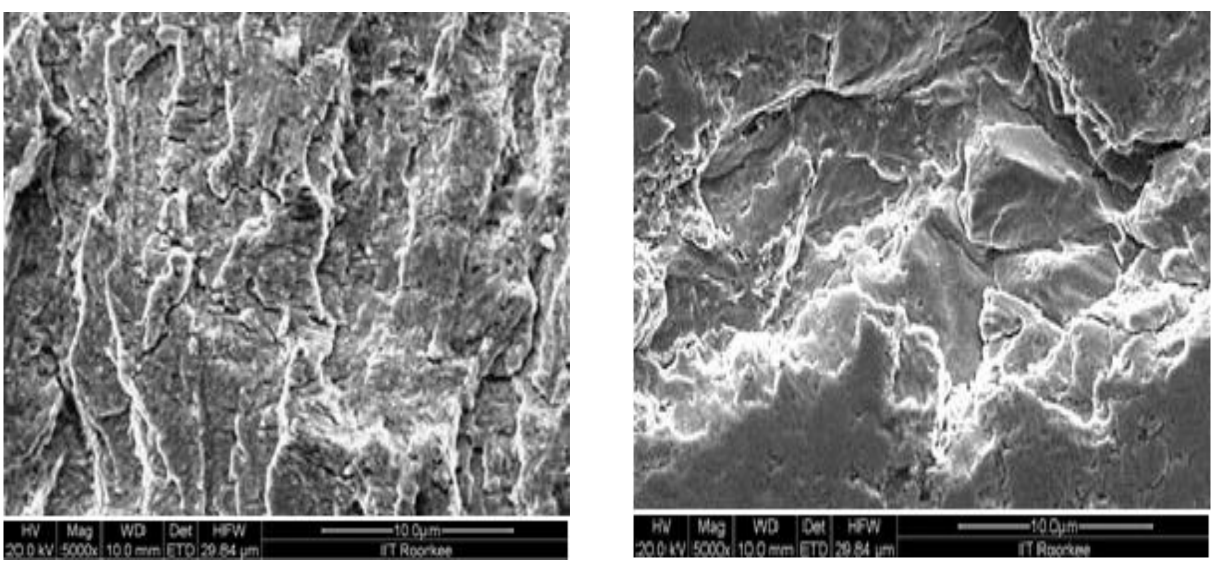

Fig Fractograph of etched sample 2 (a) at 5000X (b) at 2500X

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The carbide precipitation along the grain boundary has lead to the failure of this material. Fig. 4.28(b) shows the typical micrograph containing carbides particles sample 2.

For Sample 3

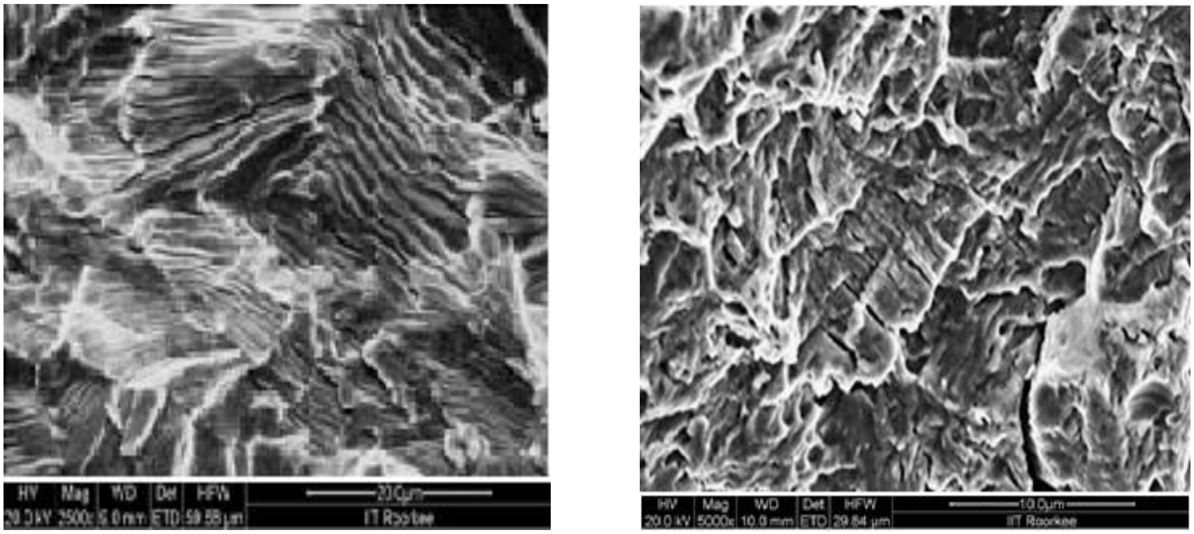

Fig Fractograph of etched sample 3 (a) at 2500X (b) 5000X

In case of sample 4, fatigue failure mode can be observed. Since the fatigue striation are oriented in same direction. The crack has propagated along grain boundaries. Carbides are visible in Fig

For sample 4

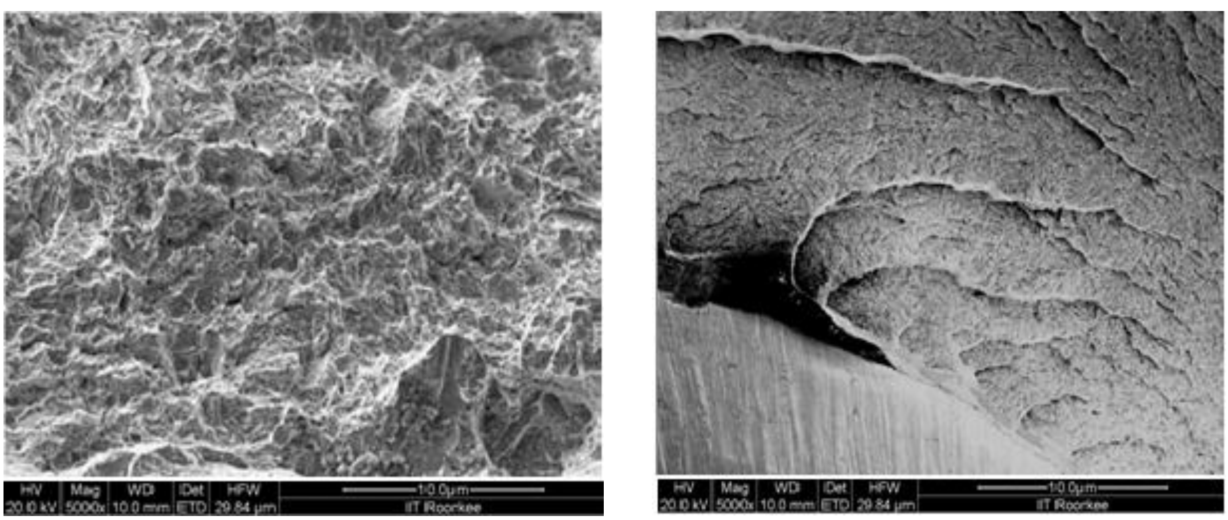

Fig Fractograph of etched sample 4 (a) at 2500X (b) 5000X

The fatigue failure is not observed to be dominant cause of fracture as depicted by Fig. of sample 4. The fracture surface exhibits typical characteristics where ductile and brittle both characters are present. However in certain area river like pattern is also visible.

For Sample 5

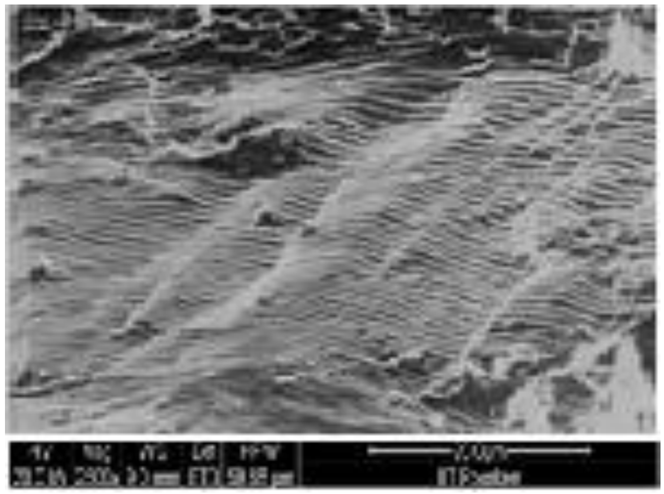

Fig Fractograph of etched sample 5 at 2500X

Fig. of sample 5 exhibit a cyclic failure as evident from presence of striations. The fracture surface was characterized to be a brittle type failure with signs of fatigue striations.

The failure mode was found to be low cycle, high stress fatigue from the morphology of the fracture surface. Due to the extreme forces applied to the gear, fracture propagated to the complete failure in very few cycles. The presence of fatigue crack in most of the spline roots of the gear needs special attention. It may be recalled that in the earlier failure, excessive stresses on the splines of the gear were found to be responsible for the fatigue crack initiation. Also, there were severe deformation and wear on the flank of the gear splines.

Table: Mahindra and Mahindra specifications for material grade 20MnCr5 showing chemical compositions of elements.

Material Grade	C%	Mn%	Si%	S%	P%	Cr%	Ni%	Mo%
20MnCr5	0.17-0.22	1.10-1.40	0.15-0.40	0.035	0.035	0.60-0.90	NIL	NIL

The chemical composition of the elements present in gear materials was determined by energy dispersive analysis through x-ray analysis (EDAX). For material grade 20MnCr5, carbon percentage should be 0.17 to 0.22% and phosphorus percentage should be 0.035% as shown in

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table 4.12. EDAX analysis shows that the percentage of carbon and phosphorus is more than the specifications mentioned in Mahindra and Mahindra standards for given material grade. During heat treatment carburizing has done to increase surface hardness.

Prolong carburizing condition led to high carbon percentage in this gear. Although tempering has done to optimize the hardness still carbon percentage is not being controlled, which becomes prominent factor for failure to occur. There can be other reasons of failure such as (a) the component/system is subjected to an environment beyond its design envelope, (b) the choice of material and its condition is inappropriate for the design and operating conditions, (c) the material of construction is defective, or (d) the design itself is wrong. It is often seen that there is no single cause or no single train of events leading to the failure. Generally, several factors combine at a particular time and place to cause a failure to occur. When a failure occurs, an understanding of the failure process is required so that attempts can be made to determine how and why a component/system failed. The root cause analysis provides this understanding of these conditions. The critical analysis of Microstructural features and EDAX analysis led to conclude that higher case depth than specified, high hardness in the core region of gear, defective microstructure (containing several inclusions, pits, fatigue striations), high cyclic loading and high percentage of alloying elements all these factors equally contribute for the failure to occur.

Results from XRD Analysis

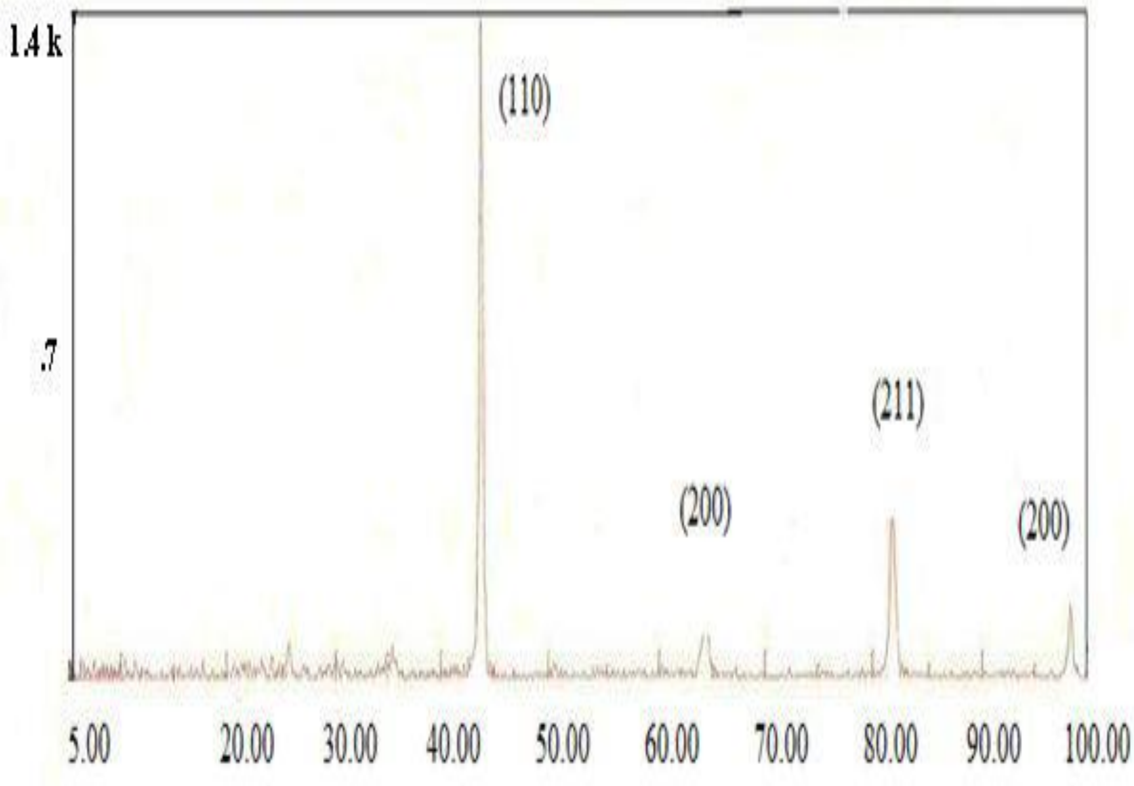

Fig. XRD pattern of 1st gear specimen

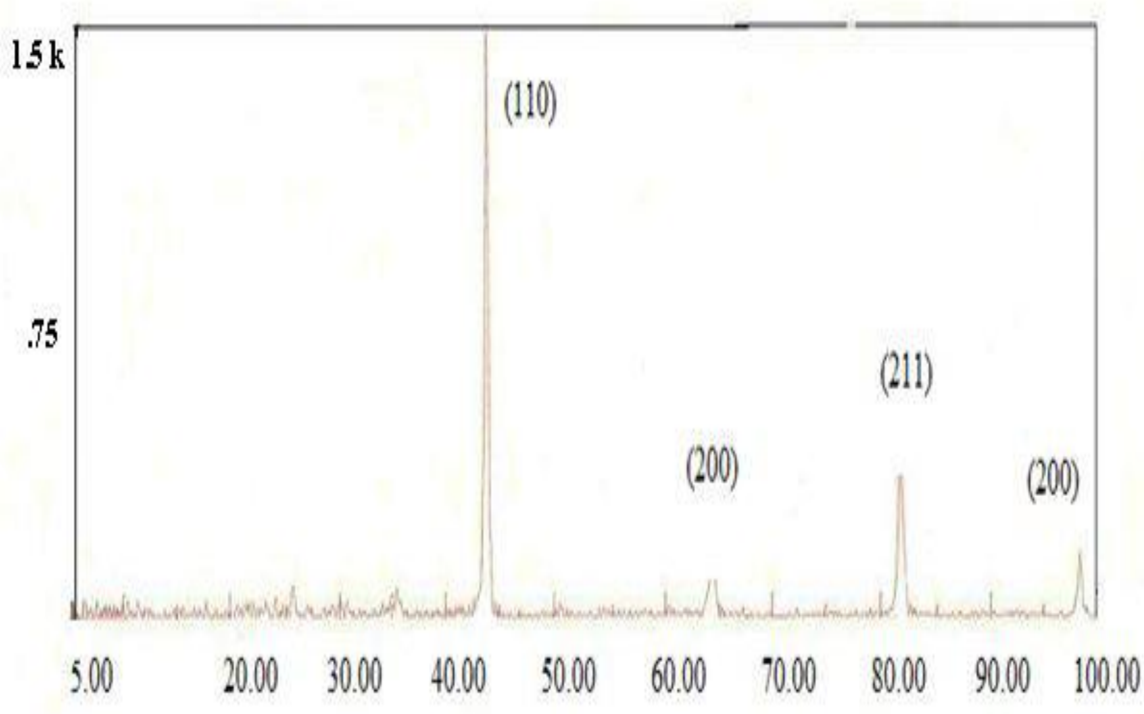

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Fig. XRD pattern of 2nd gear specimen

From x-ray diffractogram pattern, it was observed that highest intensity of peaks belonging to pure iron phase (JCPDF card no. 60696) is present. The planes of diffraction are indicated above their respective peaks in the graph as shown in Figs. . Some other peaks having lower intensity are also found but are not clearly visible. So we can't compare them with any data file because these peaks are mostly due to impurities or mixture of phases. X ray diffractogram shows only some variations in peak intensities in first and second gear specimen. However only pure iron phase have been detected in both of them.

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