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Metallurgical Investigation and Analysis of Bevel Gear Failure

Vaibhav Gupta
M.Tech student
Dept. of Mechanical Engg.
NIT, Kurukshetra

Dr. Surjit Angra
Professor
Dept. of Mechanical Engg.
NIT, Kurukshetra

V.K. Mittal
Professor
Dept. of Mechanical Engg.
NIT, Kurukshetra

ABSTRACT

A bevel gear is used where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped.The various materials used for gears include a wide variety of cast irons, non ferrous material and non – metallic materials. Aim of current work is to analyze the bevel gear failure. The study applied the metallographic observation using SEM (Scanning Electron Microscopy) of fractured section. Based on the images produced in SEM analysis it was found that there were some impurities and casting defects like gas porosity seen in the images.

Keywords: Bevel gear, Metallurgical investigation, SEM, Porosity, Brittle fracture

I. INTRODUCTION

A bevel gear is shaped like a right circular cone with most of its tip cut off. When two bevel gears mesh, their imaginary vertices must occupy the same point. Their shaft axes also intersect at this point, forming an arbitrary non-straight angle between the shafts. The angle between the shafts can be anything except zero or 180 degrees. Bevel gears with equal numbers of teeth and shaft axes at 90 degrees are called mitregears.. A prime mover provides input and it is used to convert the input into an output with lower speed and higher torque. A noiseless operation is the most important thing in any machinery so well defined characteristics of the gear system has become necessary. In the automobile industry more number of gears is used as compared to other industries so higher reliability and lighter weight gears are necessary considering the demand of lighter automobiles. If it is possible to reduce engine noise then it promotes the production of quieter gear pairs so further noise reduction is done. It is used when power is to be transmitted between two intersecting shaft and teeth are formed on conical surfaces.

II. ANALYSIS

The fracture analysis of the bevel gear was done by visual inspection and SEM (Scanning Electron Microscope). The SEM observation has been taken using JEOL SEM Model JSM6100 Scanning Electron Microscope.

III.VISUAL ANALYSIS

The failed bevel gear of TATA INDICA is shown in Fig. It is found that the fracture had taken place on the surface and side surface of a bevel gear.

Figure- fractured bevel gear

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IV. SCANNING ELECTRON MICROSCOPE

SEM produces images of sample by scanning it with the help of beam of focused electrons. After that electron interacts with atom in sample which produces various signals that can be detected and which contains information about sample`s surface topography and composition. And SEM can achieve better resolution than 1 nanometer. The highly common SEM mode is detection of the secondary electrons which are emitted by atoms excited by the electron beam. The number of secondary electrons which are to be detected depends upon the angle at which beam meets surface of specimen, i.e. on specimen topography. By scanning the sample and collecting the secondary electrons with a special detector with an image displaying the topography of the surface is created. The Scanning Electron Microscope (SEM) consists of an energetically well-defined and highly focused beam of electrons scanned across a sample. The microscope also uses a LaB6 source and is pumped using turbo and ion pumps to maintain the highest possible vacuum. Images at various resolution are taken to study the defects properly.

Figure- JEOL SEM Model JSM6100

V. EXPERIMENTAL PROCEDURE

A failed piece of bevel gear has been from the workshop and a piece has been taken out from the failed area of bevel gear. After that this piece has been converted into specimen for undergoing SEM in the dimension of 12mm x 6mm. The operating environment of a standard scanning electron microscope dictates that specialist preparation techniques are used. Basically a specimen is chemically fixed, dehydrated through an acetone or ethanol series and after that dried at the critical point - a method used to minimize specimen distortion due to drying tensions.

VI. RESULT AND DISCUSSION

The images found through SEM in the present observation are shown next.

A. CASTING DEFECTS

Gas porosity is the formation of bubbles within the casting after it has cooled. This occurs because most liquid materials can hold a large amount of dissolved gas, but the solid form of the same material cannot, so the gas forms bubbles within the material as it cools. Gas porosity may present itself on the surface of the casting as porosity or the pore may be trapped inside the metal, which reduces strength in that vicinity. Nitrogen, oxygen and hydrogen are the most encountered gases in cases of gas porosity. Dendrite shrinkage is a distribution of very fine lines or small elongated cavities that may vary in density and are usually unconnected.

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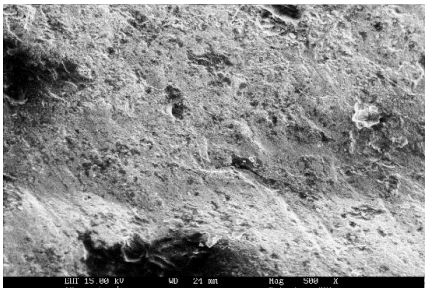

Figure- Image was taken at an manufacturing range of2500X

It is showing casting defects i.e. gas porosity, dendrite shrinkage and accumulated inclusion, together with initiated crack. The characteristics of this shows that fracture is a brittle fracture-granular fracture (also cleavage fracture).

B. DIFFERENT SURFACES

During casting some unwanted material had been also present Due to these impurities the bevel gear could not be able to withstand fatigue stresses and failure has taken place.

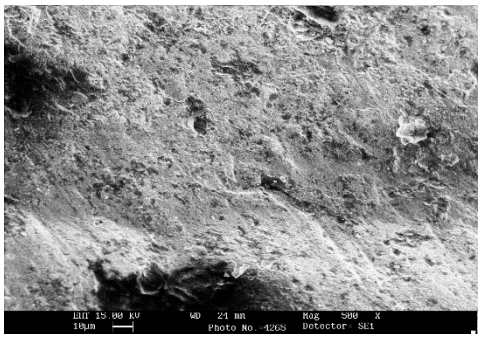

Figure- This image was take at a magnification of 500X from two different surfaces were seen.

C. FRACTURE

From various literature review it was seen that the fracture which usually occurs in bevel gear is the brittle fracture and in this case we also get an image at a magnification factor of 1000X. We get that fracture was a brittle fracture. As the loads come on the bevel gear are varying in nature these are heavy shear and bending forces .So the failure occurs in bevel gear is the fatigue failure or sudden failure.

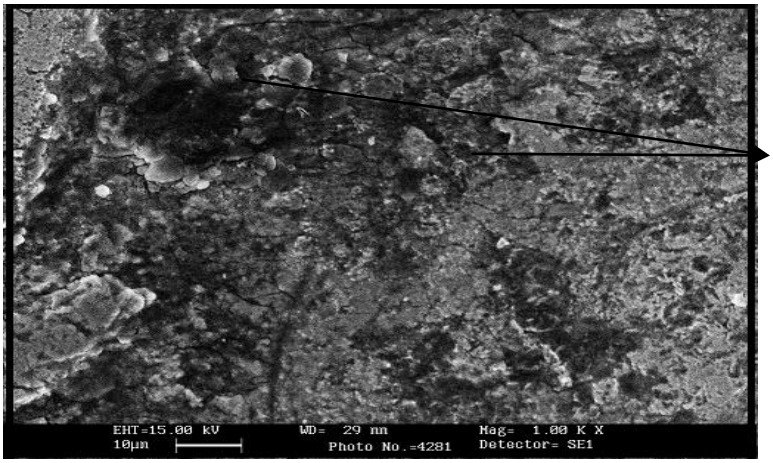

Figure A perfect brittle fracture surface could be seen at 1.00 KX

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D. IMPURITY AT HIGHERMAGNIFICATION

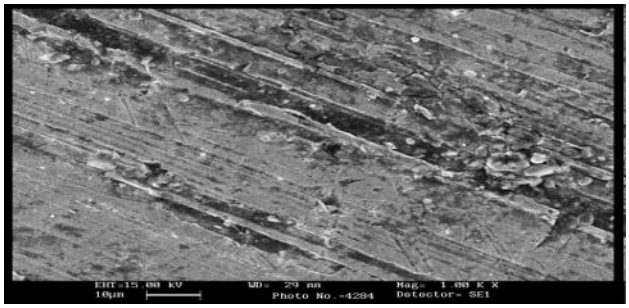

Figure The image was taken at a magnification of 1000X. to see the impure surface. White like crystals like material is impurity

VII. CONCLUSION

The main reason for the failure is casting defect, inclusion and crack propagation which decreased the lifecycle of bevel gear. Provision should be done for the removal of inclusion and shrinkage, avoidance of hard particle to enter. Some unwanted impurities have been also detected which allow cracks to pass straight through. Failure of bevel gearmay lead to failure of other components and can cause harm while in use. Finally bevel gearshould be designed with high reliability. It must be capable for sustaining heavy stresses caused by thrust and pull of the bevel gear. So the homogeneous and continuous structure is a desired factor for bevel gear.

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