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"A REVIEW ON EFFECT OF EROSION ON TRIBOLOGICAL PROPERTIES OF DUCTILE IRON"

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ABSTRACT

The present paper deals with the review of the properties of ductile iron. Due to presence of graphite in compact nodular form it becomes easier to machine ductile iron. It also deals with A Brief Discussion about Ductile Iron, factors that affect properties of Ductile Iron, Mechanical Properties of Ductile iron. Different structures are discussed and effect of erosive wear on hardness is discussed.

Key Words: *Sand, Erosion, Wear, Hardness, Parameters, Particle, Pearlite, Austenite*.

I. INTRODUCTION

All ferrous materials other than those having an austenitic matrix may fail in a ductile or a brittle manner according to the method of testing and the geometry of the test piece, the temperature of testing, the structure and the composition of the material. The randomly oriented crystals or grains of metal undergo plastic deformation by a process of slip which is due to a shear stress caused by the lamellae of the crystal sliding over one another. Failure by slip only occurs after a large amount of plastic deformation and will be accompanied by a considerable elongation of the test piece in a tensile test. Besides, crystals sometimes fail by cleavage due to separation on a plane known as a cleavage plane. Such failure is of a sudden brittle nature and occurs when the tensile stress, Normal to the cleavage plane, exceeds the cohesive strength of the material.

In a tensile test, when a crack is first initiated, there is a considerable amount of elastic energy stored in the specimen, as a large volume of material is stressed to the maximum stress level. This energy is released when failure starts and serves to propagate the crack. The release of elastic energy speeds up crack propagation, and depending on the chemical composition, a certain speed may be exceeded causing the fracture to change from ductile state to brittle state. The first commercial applications of Austempered Ductile Iron (ADI) occurred in 1972. But, the history of the development of ADI spans from the 1930's to the present. Revolutionary heat treatment work with steel (1930's) and the discovery of ductile cast iron (1940's) are included among the important events which lead to the development of ADI.

In the 1930's, work was conducted by Bain et al on the isothermal transformation of steel. A new micro constituent was discovered that was described as "an acicular, dark etching aggregate." This new microstructure exhibited promising properties as it was found to be tougher, for the same hardness, than tempered martensite. In the 1940's Keith Millis was assigned the task of examining elements to additional for chromium in the production of Ni Hard cast iron at the International Nickel Company (INCO). This study eventually leads to the treatment of gray cast iron with magnesium. On examination, spheroidal shaped graphite was found in this cast iron. The first magnesium treated ductile iron had been produced.

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II. LITERATURE REVIEW

Ductile iron is defined as a high carbon containing, iron based alloy in which the graphite exists in compact, spherical shapes rather than in the shape of flakes, the latter being typical of gray cast iron. As ductile iron, occasionally referred to as nodular or spheroidal graphite cast iron, constitutes a family of cast irons in which the graphite is present in a nodular or spheroidal form. The graphite nodules are small and constitute only small areas of weakness in a steel-like matrix. Because of this the mechanical properties of ductile irons associated directly to the strength and ductility of the matrix present—as is the case of steels.

The graphite occupies about 10-15% of the total material volume and because graphite has small tensile strength, the main effect of its presence is to reduce the effective cross-sectional area, which means that ductile iron has tensile strength, modulus of elasticity and impact strength proportionally lower than that of a carbon steel of otherwise alike matrix structure.

The matrix of ductile irons can be varied from a soft and ductile ferritic structure, through harder and higher strength pearlitic structures to a hard, higher and comparatively tough tempered martensitic or bainitic structure. Thus, a wide range of combinations of strength and ductility can be achieved. General engineering grades of ductile iron commonly have the structures which are ferritic or ferrito-pearlitic. Well-ordered processing of the molten iron precipitates graphite as spheroids rather than flakes. The round shape of the graphite eliminates the material's tendency to crack and helps prevent cracks from spreading.

Chemical Composition: Chemically this material is same as grey iron and is Fe-C-Si alloy. It is one of the more recent developments in cast iron technology has been around since 1948. As the name suggests, it was established to overcome the brittle nature of grey and white irons. It is also quite ductile in as cast form. The main trace elements present in ductile iron can have a noticeable influence on the structure and hence the properties of the iron. With the exception of silicon, all elements encourage pearlite and all elements with the exception of silicon, nickel and copper also encourages carbides. The strength properties of ferritic ductile iron are generally increased by the elements, which go in to the solution. With the exception of carbon, all the elements increase tensile strength and hardness. An example of the extent to which ferrite is affected by solid solution strengthening is demonstrated for the elements silicon and nickel. 1% addition of silicon raises the proof and tensile strength of a ferritic iron by approximately 82 N/mm2 whereas 1% of nickel increases these properties by 46 N/mm2. In the ferritic irons increase in tensile strength and proof strength are obtained at the expense of ductility and in such case the iron can become embrittled

Structure: The main difference between ductile iron and grey iron is the morphology of graphite particles which take on a nodular or almost spherical form after appropriate treatments are made to the melt. The chief microstructural constituents of ductile iron are: the chemical and morphological forms taken by carbon, and the continuous metal matrix in which the carbon and/or carbide are dispersed. The following significant microstructural components are found in ductile iron.

Graphite: This is the stable form of pure carbon in cast iron. Its important physical properties are low density, low hardness and high thermal conductivity and lubricity. Graphite shape, which can range from flake to spherical, plays an important role in determining the mechanical properties of ductile irons. Ductile iron is categorized by having all of its graphite occurs in microscopic spheroids. Even though this graphite constitutes about 10% by volume of ductile iron, its compact spherical shape minimizes the effect on mechanical properties. The graphite in commercially produced ductile iron is not always in perfect spheres.

Ferrite: This is the purest iron phase in a cast iron. In conventional Ductile Iron ferrite produces lower strength and hardness, but high ductility and toughness. In Austempered Ductile Iron (ADI), enormously fine grained acicular ferrite provides an excellent combination of high strength with good ductility and toughness. The strength properties of ferritic ductile iron are generally increased by the elements, which go in to the solution.

Pearlite: Pearlite, produced by a eutectoid reaction, is a close mixture of lamellar cementite in a matrix of ferrite. It is common constituent of cast irons; pearlite gives a mixture of higher strength and with a corresponding reduction in ductility which meets the requirements of many engineering applications.

Martensite: Martensite is a supersaturated solid solution of carbon in iron formed by rapid quenching. Due to very high lattice distortion it is very brittle and hard. Martensite is produce by shear deformation process.

Austenite: Normally a high temperature phase containing of carbon dissolved in iron, it can be present at room

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temperature in austenitic and austempered cast iron. In austenitic irons, austenite is stabilized by nickel in the range of 18-36% **[34].**It is also known as gamma iron, it is produced by a combination of rapid cooling which suppress the formation of pearlite and the supersaturation of carbon during austempering process, which reduce the start of the austenite-to-martensite transformation far below room temperature.

In austenitic irons, the austenite matrix offers ductility and toughness at all temperatures, corrosion resistance and good high temperature properties, especially under thermal cycling conditions. In austempered ductile iron stabilized austenite, in volume fractions up to 40% in lesser strength grades, advances toughness and ductility and response to surface treatments such as fillet rolling.

Family of Ductile Iron

Through a high percentage of graphite nodules present in the structure, mechanical properties are determined by the ductile iron matrix. The importance of matrix in controlling mechanical properties is give importance to by the use of matrix names to designate the following types of Ductile Iron.

Ferritic Ductile Iron: Graphite spheroids in a matrix of ferrite provide an iron with good ductility and impact resistance and with a tensile and yield strength same to low carbon steel.

Ferrito- Pearlitic Ductile Iron: These are the most common rating of ductile iron and are normally produced in the as-cast condition.

Pearlitic Ductile Iron: Graphite spheroids in a matrix of pearlite result in an iron with high strength, good wear resistance, and modest ductility and impact resistant. Machinability is also more to steels of equivalent physical properties. **Austempered Ductile iron (ADI):** ADI, the latest addition to the ductile iron family, is a sub-group of ductile iron produced by giving conventional ductile iron a special austempering heat treatment. Closely twice as strong as pearlitic ductile iron, ADI still retains high elongation and toughness. This combination delivers a material with more wear resistance and fatigue strength.

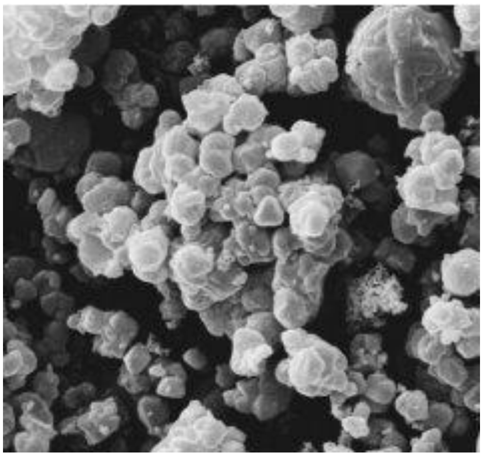

Fig.1 *SEM image ofADI*

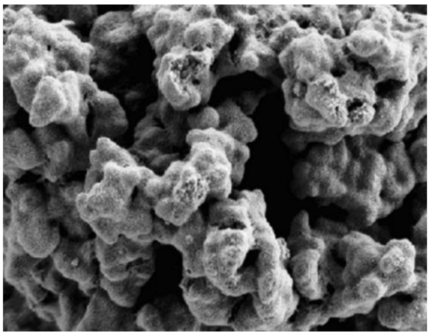

Fig.2 *SEM image of Pearlitic Ductile Irin*

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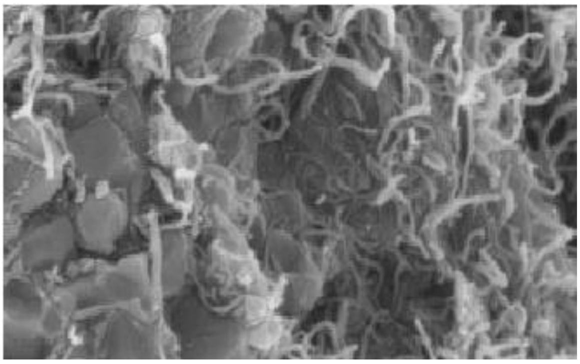

Fig.3 *SEM image ofMartensite*

III. CONCLUSION

In most erosion processes, target material removal typically happens as the result of a large number of impacts of irregular angular particles, usually carried in pressurized fluid streams. The fundamental mechanisms of material removal, however, are more easily understood by analysis of the impact of single particles of a known geometry. Such fundamental studies can then be used to guide development of erosion theories involving particle streams, in which a surface is impacted repeatedly. Single particle impact studies can also reveal the rebound kinematics of particles, which are very significant for models which take into account the change in erosive potential due to collisions between incident and rebounding particles.

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