A Review on Effect of Heat Treatment and Nano Additives on Wear Behaviour of Spheroidal Graphite Cast Iron

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Abstract - *SG iron or ductile iron is widely used for production of different machinery components and automobile parts. The use of SG iron has been increasing over the past 30 years, just because of it has a better combination of strength as well as toughness with good wear resistance property. The main reason of this high wear resistance property and toughness is presence of nodular structure of graphite in microstructure of SGI. Various heat treatment process can also improve mechanical as well as microstructure properties of SGI or ductile cast iron. The main aim of this paper is to understand the effect of microstructures and various heat treatment process on mechanical property like wear resistance and hardness.*

***Key Words*: Austempered, Heat treatment, Mechanical properties, Microstructure, Nano additives, Process Parameters, SG Iron, Wear behaviour.**

1. INTRODUCTION

Ductile iron or also known as spheroidal graphite cast irons, which use have been increasing over the past two decades, just because of it has a better combination of strength as well as toughness as compared with other types of cast irons. The graphite is existed in form of small spherical shape. Therefore, the concentration of inside stresses can be reduced, so its mechanical properties are very well and improved. Due to graphite spheroids can get mechanical properties like very high tensile strength, yield strength, better wear resistance and elongation. Hardness of SGI cast iron can be also control by change in chemical composition.

In microstructure of SG iron spheroids cause higher mechanical properties along with better wear resistance capacity. In addition of ductile and graphite cast iron carbon percentage present is also same. Due to addition of alloying elements like magnesium and cerium graphite spheroids generates in microstructure. These alloying elements can help to improve its dimensions in all the directions uniformly. When silicon is added above 2% it may cause graphitization rate increases. In SG iron microstructure graphitization rate is increases when silicon added more than 2%. The mechanical properties of SG cast iron can be improved by either changing the process parameters or using various heat treatment processes.[1]

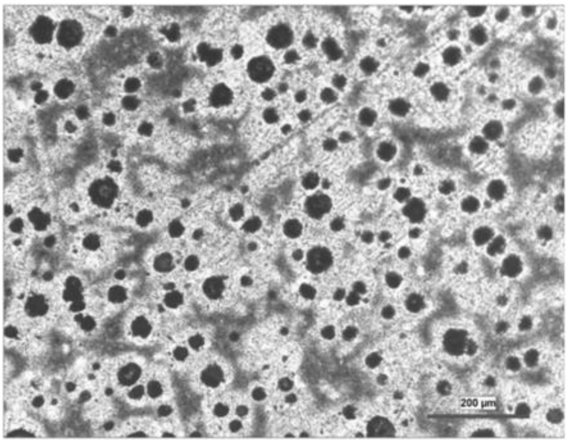

Fig-1: Graphite in form of spheroids or nodule shape in SGI

1.1 Wear resistance

Wear resistant cast irons are suitable for applications involving wear caused by minerals, for example in grinding tools, in reducing, mixing and conveying equipment and systems and in pumps. Others include mixer paddles, augurs and dies in the clay industry, liner plates for ball mills and coal chutes. Automotive and aerospace, quarries and mines, railways and rolling stock, mining, milling, earth-handling, and agricultural applications. Titanium nitride alloys were attempted for wear resistant alloys.

Wear resistance and impact a property of chilled ductile iron was also tried. Since the wear problems vary, the challenge was to identify the exact type of wear. In wear resisting cast iron, a certain amount of hardening phase distributes in the cast iron matrix makes it not easy to wear.

2. LITERATURE REVIEW

J. Kaleicheva, V. Mishev , Z. Karaguiozova , G. Nikolcheva, A. Miteva [2] Nanosized additives of TiCN + TiN in the spheroidal graphite cast irons have a modifying effect on the graphite phase. Without changing the graphite shape, they decrease the graphite spheres size and increase the graphite quantity in the irons' structure. The spheroidal graphite cast irons with nanosized particles have a higher abrasion wear resistance compered to this one of the irons without nano particles. It is specified that retained austenite in the structure of austempered ductile irons is partially transformed to a strain induced martensite in the wear testing as in a greatest extent, this conversion takes place in the cast irons with nano-sized additives of TiCN + TiN. These irons possess higher abrasion wear resistance compered to this one of the irons without nano additives. The increase of the wear resistance of the irons with nano additives is a result of the complex influence of the nanosized particles on the graphite phase characteristics, on the kinetics of the bainitic transformation under austempering and on the range of the metastable retained austenite conversion to a strain induced martensite in a wear testing.

Julieta KALEICHEVA et al [3] The microstructure, tribological characteristics and hardness of Austempered ductile irons, containing nanosized particles of (TiN + TiCN), TiN and cBN are investigated. The wear resistance of the upper bainitic cast irons with nanoparticles increases from 5 to 23 % in comparison to the one of nanoparticles of free cast iron. The observed effect of the nano additives on the graphite phase characteristics and on the extent of the transformation of the austenite to bainite explains higher abrasion wear resistance of the tested Austempered ductile irons with nano additives compared to the same without nano additives. In Austempered ductile irons, as a result of friction in the wear test, partial transformation occurs of the metastable retained austenite to strain induced martensite. This transformation influences increase of wear resistance of cast irons.

Baradeswaran & A. Elaya Perumal [4] The dry sliding wear rate of the AA7075/Gr composite decreases with an increment in graphite content. The minimum wear rate is reached at 5 wt% graphite content. The coefficient of friction of AA7075/Gr composites reduces with the addition of graphite flexes or particles and reaches a value that is 2.5 times lower than that of the base alloy at 5 wt% of graphite. Under dry sliding conditions, the rate of wear for the composite with graphite particles is found to decrease with an increment in sliding speed. The dry sliding wear of the composite increases as the sliding distance increases, and it is found to be lower than that of the base alloy. Also, from this paper can conclude that tribological behaviour of the aluminum alloy 7075 can be improve by addition of the graphite flex or particles, which act like solid lubricant for aluminum alloy 7075. The AA7075 alloy exhibits the potential to be used as a self-lubricating material and causes an appreciable reduction in the wear rate and has a minimum friction coefficient at 5 wt% graphite. The hardness and tensile strength decrease with an increase in graphite content up to 5 wt%.

M. SALIM et al. [5] In this presented paper, the wear properties of as-cast pearlitic or ferritic ductile iron were compared with upper bainitic Austempered and normalized pearlitic /ferritic test samples. After referring this literature got concluded that:

1. At higher temperature in austempering pearlitic or ferritic matrix structure changes form into coarse upper bainitic matrix and this causes reduction in the hardness.
2. higher amount of pearlite causes specimen extra hard with good wear resistance properties.
3. For 20N loaded austempered specimen gain in weight was observed and for the normalized specimen there were no increment or decrement found in weight.
4. Micro cracks were also observed along the wear direction in each specimen and crack length was observed to be decreasing with increase in applied load.
5. For 10KN and 20KN there was no markable improvement observed in Wear surface morphology of as-cast and heat-treated specimens.

Muchammad et al. [6] In the present study, the effect of sliding distance and material hardness on wear depth, wear width and wear volume were analysed. The experimental method based on a pin disk tribotester was used. A few summaries can be made in this study. First, hardness of the material greatly affects wear volume; for FCD 40 the wear volume was higher and for FCD 60 the wear volume was lower as compare to FCD 40. Second, increasing sliding distance increases the wear volume, wear depth and wear width.

R.Arabi Jeshvaghani et al. [7] focused about the alloying elements at surface on the microstructure and also the wear phenomena of SG iron in his work study. He said that SG iron specimens were covered by single- and two-fold pass welds of a nickel-based electrode 15 utilizing shielded metal arc welding process then he investigated the effect on wear system and hardness of coated layer on the basis of number of passes. Finally, he concluded that the hardness of coated layer was high due to presence of full of austenite phase with little amount of carbides.

Aravind Vadiraj et al. [8] investigated the hardness and wear resistance of specimens in different conditions like austempered, tempered and quenched conditions at different temperature. He made three groups of hypereutectic cast iron alloys with additives Cu, Ti, Nb, and Ni. Cast iron had good wear resistance in tempered and quenched condition, while at 400C, it had moderate hardness. So, that observation was helpful for the comparison of wear resistance of specimens in austempered condition. Further it was investigated that wear resistance of cast iron increased due to presence of Cu in higher extent, while wear resistance of cast iron decreased with the Ni content enhancement. In austempered condition, wear resistance enhanced by increase in Cu percentage and the deficient by increased in Ni content.

H.R. Abedi et al. [9] focused on the impact of characteristic of graphite nodule like nodule count, nodularity and nodule size.

In order to optimize the wear resistance capacity, he focused on the effect of nodule count of a ferritic–pearlitic ductile iron on its wear behaviour. In this presented work DCI test specimens, ranging from 10 to 50mm of thickness and with the range of 150 and 450nod/mm^2 nodule counts were taken. Prior to the wear test it was necessary to perform the heat treatment processes over the sample in order to investigate the microstructures. Wear tests were conducted on a pin-on-disk type machine under dry sliding conditions under the application of loads 1.5, 3.5 and 5.5kgf respectively. Oxidation wear was the main wear mechanism at lower load, while at the higher load adhesive wear was predominant. Meanwhile at the lower load conditions, the specimen had higher nodule count shows lower wear rate than that specimen having low nodule count. But when load was increased then it was found that wear resistance decreased with the increase in nodule count.

Aravind Vadiraj et.al. [10] Compared the properties of gray iron alloy in as-cast and austempered specimen at 360°C. It was observed that mechanical strength of austempered specimen had moderately increased than the as-cast Gray irons with pearlitic matrix. He also observed about wear behaviour and found that the wear rate of austempered specimen was lower by 7-14 times than pearlitic alloyed iron along with the decrement in friction coefficient. When Ni was added with the cast iron solution it was found that due to addition of it wear resistive capacity increased. It was also observed that tensile strength of cast iron increased, when carbon was added in lower extent. Finally, he concluded that presence of graphite nodules had tendency to improve the wear rate behaviour.

G. Straffelini et al. [11] focused on the dry sliding wear of two austempered SG irons, portrayed by distinctive hardness qualities, was researched. The tests were done utilizing plates with 40 mm breadth and 10 mm height. The connected load was in the extent somewhere around 50 and 500 N. Since the introductory Hertzian weights were expansive in light of the line contact, plasticity commanded wear with the arrangement of delamination was acquired. In this way, the treatment cycle of a few samples was directed with the point of acquiring a mild wear amid moving sliding through the development of a surface oxide layer. As an examination, the dry sliding wear of gas nitride steel was likewise researched. The outcomes demonstrate that the wear coefficients of the samples with the oxide layer on their surface were really mild. On the other hand, the samples created without such a layer showed even lower wear coefficients. Despite the fact that wear was by delamination, wear coefficients were still low in light of the activity of graphite, which had the capacity crush at first glance amid sliding, in this way decreasing adhesion powers. Furthermore, a mechanically blended layer shaped on the sliding surfaces, and this gave an extra increment in the wear resistance. Due to this, the material with lower matrix hardness showed a more noteworthy wear resistance. The wear resistance of the nitride steel was discovered to be dictated by the external piece of the compound layer, and it was obtained to be lower than that showed by the two ADI.

B. Podgornik et al. [12] suggested that SG iron should have more application because of its good properties like strength, toughness and fatigue endurance as well as its low cost. For this purpose, he performed the different heat treatment process for improving wear resistance of SG iron. He extracted a new method in order to improve local reinforcement of SG iron without bargaining other properties which was known as OPTICA.

3. CONCLUSION

From above literature survey concluded that for the wear properties of Spheroidal graphite iron casting can be improve and enhance by using various heat treatment methods like Austempering, normalizing and also by addition of nano particles like (TiN + TiCN), TiN and cBN. With help of nano particles, we can improve wear or tribological properties if SG iron and also can get good hardness and better microstructure with help of heat treatment process.

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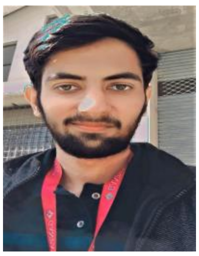

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