REVIEW ON MICROSTRUCTURE ANALYSIS OF METALS AND ALLOYS USING IMAGE ANALYSIS TECHNIQUES

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Abstract: The metals and alloys find vast application in engineering and domestic sectors. The mechanical properties of the metals and alloys are influenced by their microstructure. Hence the microstructural investigation is very critical. Traditionally the microstructure is studied using optical microscope with suitable metallurgical preparation. The past few decades the computers are applied in the capture and analysis of the optical micrographs. The advent of computer softwares like digital image processing and computer vision technologies are a boon to the analysis of the microstructure. In this paper the literature study of the various developments in the microstructural analysis, is done. The conventional optical microscope is complemented by the use of Scanning Electron Microscope (SEM) and other high end equipments.

Keywords: Microstructure, image processing, mechanical properties, SEM.

1. INTRODUCTION

Many of the manufacturing industries have a constant pressure to manufacture a high quality product with a less cost. Thus they required a new technologies in increasing the production with a high quality. Hence they prefers to change their machining tools and manufacturing materials so that they can increase their efficiency in their manufacturing. The replacement among the tools will progressively reducing the tool wear. Reduction of tool wear is placing a major significance in tool designing industries. Wherever the aluminium alloys placing a better shaping and cutting process over the metals. These effect can be found by analysing the difference of metals and alloys [1].

Hard materials were commonly utilized for its wear application and the machining process. Due to the various reasons the material were tested to highly fatigue metals. Among the past years they have developed to improve hardness, bending strength and the fracture toughness. In order to design fatigue proof tools or structural components made of hard metals, mechanical and design engineers require material data like yield strength or fatigue strength [4].

Cast Al alloys are important structural materials for the light weighting of cars and, consequently, reduction of greenhouse gases emission and pollution. The microstructure and properties of cast Al
alloys could be further improved by means of grain refinement, practise which cannot efficiently be performed with common Ale TiE grain refiners used for wrought Al alloys [2].

The intelligent atomization processing is the on-line in situ sensing of powder size and velocity. The principles of operation and current analogous applications of several sensors make them potential candidates for consideration. In addition to meeting the specific measuring requirements, viable sensors must be non-intrusive, and must work reliably in high ambient temperature, high ambient light intensity, and high dust particle density environments. Usually non-intrusive sensors are based on electric, electromagnetic or optical principles, the latter being most developed in fields obviously related to atomization. Optical methods for particle sizing can be divided into imaging and non-imaging techniques. The imaging techniques include microphotography, holography and cinematography; non-imaging techniques can be further divided into ensemble or multi-particle techniques and single particle counting techniques [3].

L. Bolzoni has studied where a commercial Ale12Si alloy was inoculated with different level of NbþB addition to assess the grain refining potency of NbþB inoculation it can be concluded that insitute formed Nb-based intermetallics compounds are potent heterogeneous nucleation substrates with high potency for the refinement of AleSi cast alloys [2].

2. STUDIES ON MICROSTRUCTURE ANALYSIS

Microstructure analysis is used among the various industries to find the structure of the material at various stages of testing. Thus the analysis explains about the structure of the materials. Generally microstructure analysis is done by using the optical microscope but now a days there is development done with a digital analysis using Image progression methods. By using this analysis we can find the yield strength and ultimate tensile or compressive strength are not as well established in the literature mainly due to the high hardness and the low ductility that makes the determination of reliable information of material as a challenging task. So the general values of ultimate tensile strength and yield strength are higher in bending than in uniaxial testing conditions due to the differences in tested effective volume [5] and due to the non-linear stress distribution in the bent specimens which are partially deformed plastically before fracture [6]. The cyclic behaviour of hard metals was investigated by several authors [7]. The results from literature on microstructure and properties can be summarized. Roebuck finds significant higher fatigue life in hard metals at 300°C testing temperature compared to room temperature tests [8]. Varying testing temperatures up to 700°C encounters lifetimes significantly below the values determined at room temperature. The behaviour of hard metals under cyclic loads cannot be deduced from their behaviour under static loading conditions [9]. Has studied the microstructure of friction welded cu/al joint and its weld interface characterization were identified and discussed and also the correlation between the microstructure and mechanical properties has been investigated[10]. The full advantage that these materials can provide is strongly dependent on composition and microstructure [11].

3. STUDY ON IMAGE ANALYSIS

The solidification process itself is analysed using the UMSA device by appliance of the Derivative Thermo Analysis. The influence of the cooling rate on the alloy microstructure was investigated using computer aided image analysis, in this work also the content of particular phases was analysed, as well the percentage of pinholes compared to the chosen cooling rate [12]. The aluminum images have inconsistent distribution of illumination due to light concentration from the metallograph image acquisition system. This is particularly apparent in the corners of the image. Since the main objective was to isolate the dark and gray blobs based on their intensity levels, a background correction
algorithm was performed to compensate for the inconsistent pixel intensity of the background. This minimized the possibility of dark and gray blobs being misidentified [4]. The microstructure of an engineering material depends on its properties. For the reason of the dependence settlement between the microstructure and properties there should be performed an image analysis. The process of image analysis can be defined as a image investigation for object identification and its contribution valuation on the properties. This process consist of data accusation from the image as well the analysis through: identification, classification, measurement and valuation of the physical state of the sample, analysis of the pattern observed in the image as well the spatial relation between the features of a given sample. In case of data acquisition about metal microstructure, the manual, stereological or conventional image analysis methods are often time-consuming and not always user friendly. As a solution for this problem there are applied computer aided qualitative and quantitative metal microstructure analysis [13]. The alloy precipitates present in the image are represented by the blobs which are fairly distinctly distinguished into two shades of gray – the white blobs which are the lighter ones and the darker or grey blobs. The objective is to identify the two types of blobs and statistically characterize them for comparison purposes [4].

4. STUDY ON METALS

All Metallic materials are broadly of two kinds – ferrous and non-ferrous materials. This classification is primarily based on tonnage of materials used all around the world. Ferrous materials are those in which iron (Fe) is the principle constituent. All other materials are categorized as non-ferrous materials. Another classification is made based on their formability. If materials are hard to form, components with these materials are fabricated by casting, thus they are called cast alloys. B.K Prasad has investigated on the observations pertaining to the effects of specimen and slurry compositions as well as traversal distance on the slurry wear response of a zinc-based alloy [14]. among the different kinds of alloys the zinc alloy has a better coating and it scarifying to protect steel structures against the corrosion taken place in the environment. Zinc-based alloys have been shown to be more effective as protective coatings and sacrificial anodes than pure zinc in more corrosive environments [15]. It has been observed that the corrosion resistance of zinc-based alloys increases with Al content [16] while addition of Si to the alloy system has been proved to be still more beneficial in this context [17]. Studies suggest that Zn-Al alloys behave in a manner similar to that of pure Zn from corrosion resistance standpoint since AI remains practically unaffected [18]. Steels are alloys of iron and carbon plus other alloying elements. In steels, carbon present in atomic form, and occupies interstitial sites of Fe microstructure. Alloying additions are necessary for many reasons including: improving properties, improving corrosion resistance, etc. Arguably steels are well known and most used materials than any other materials. Low carbon steels: These are arguably produced in the greatest quantities than other alloys [19]. Carbon present in these alloys is limited, and is not enough to strengthen these materials by heat treatment; hence these alloys are strengthened by cold work. Their microstructure consists of ferrite and pearlite, and these alloys are thus relatively soft, ductile combined with high toughness. Hence these materials are easily machinable and weldable. Typical applications of these alloys include: structural shapes, tin cans, automobile body components, buildings, etc [20]

Magnesium alloys: The most sticking property of Mg is its low density among all structural metals. Mg has HCP structure, thus Mg alloys are difficult to form at room temperatures. Hence Mg alloys are usually fabricated by casting or hot working. As in case of Al, alloys are cast or wrought type, and some of them are heat treatable. Major alloying additions are: Al, Zn, Mn and rare earths. Common applications of Mg alloys include: hand-held devices like saws, tools, automotive parts like steering wheels, seat frames, electronics like casing for laptops, camcoders, cell phones etc.

Titanium alloys: Ti and its alloys are of relatively low density, high strength and have very high melting point. At the same time they are easy to machine and forge. However the major limitation is Ti’s chemical reactivity at high temperatures, which necessitated special techniques to extract. Thus these alloys are expensive. They also possess excellent corrosion resistance in diverse atmospheres,
and wear properties. Common applications include: space vehicles, airplane structures, surgical implants, and petroleum & chemical industries [20].

5. CONCLUSION

The implementation over the microstructural analysis is explained for the testing of different metals and alloys. We also gathered the information of analyzing the microstructures of metals and alloys. Thus the structure explains about the various strength of the materials. The different kinds of alloys were discussed in this paper.

References

[1] Mohammed E. Hoque, Ralph M. Ford, and John T. Roth Penn State Erie, Automated Image Analysis of Microstructure Changes in Metal Alloys, School of Engineering and Engineering Technology Erie, PA 16563-1701.
[2] L. Bolzoni, M. Nowak, N. Hari Babu, On the effect of Nb-based compounds on the microstructure of Ale12Si alloy (vol-162 (2015) 340e345), Brunel University London, Institute of Materials and Manufacturing, Uxbridge, Middlesex, UB8 3PH, UK.
[3] G. Jiang, H. Henein, and M. W. Siege, Intelligent Sensors for Atomization Processing of Molten Metals and Alloys, The Robotics Institute Carnegie-Mellon University Pittsburgh, PA 15213 June 1988.
[4] Thomas Klünsnera, Stefan Marsoner, Reinhold Ebnera, Reinhard Pippan, Johannes Glatzle, Arndt Puschel, Effect of microstructure on fatigue properties of WC-Co hard metals. Procedia Engineering 2 (2010) 2001–2010.
[5] Quinn GD. Weibull effective volumes and surfaces for cylindrical rods loaded in flexure. J Am Ceram Soc 2003; 86[3]:475–9.
[6] Lackner JM. Entwicklung eines Zugversuches für hochstfeste Werkzeugstähle. Leoben, Diploma Thesis, 2001.
[7] Kursawe S, Pott P, Sockel HG, Heinrich W, Wolf M. On the influence of binder content and binder composition on the mechanical properties of hardmetals. Int J Refract Met Hard Mater 2001;19:335-40.
[8] Roebuck B, Maderud CJ, Morrel R. Elevated temperature fatigue testing of HM using notched testpieces. Int J Refract Met Hard Mater 2008;26:19-27.
[9] Kindermann P, Schlund P, Sockel HG, Herr M, Heinrich W, Gorting K, et al. High-temperature fatigue of cemented carbides under cyclic loads. Int J Refract Met Hard Mater 1999;17:55-68.
[10] CH.Muralimohan, S.Haribabu, Y.Hariprasada Reddy, V.Muthupandi, K.Sivaprasad, Evaluation of microstructures and mechanical properties of two dissimilar materials by friction welding.
[11] Ulrike Taffner, Veronika Carle, and Ute Scha¨fer, Max-Planck-Institut fur Metallforschung, Stuttgart, Germany Michael J. Hoffmann, Institut fur Keramik im Maschinenbau, Universitat Karlsruhe, Germany Preparation and Microstructural Analysis of High-Performance Ceramics
[12] M. Krupiński, K. Labisz, L.A. Dobrzański, Z. Rdzawski, Image analysis used for aluminium alloy microstructure investigation, VOLUME 42 ISSUES 1-2 September-October 2010.
[13] J.P. Anson, J.E. Gruzleski, The quantitative discrimination between shrinkage and gas microporosity in cast aluminum alloys using spatial data analysis, Materials Characterization 43 (1999) 319-335.
[14] B.K. PRASAD, O.P. MODI, Slurry wear characteristics of zinc-based alloys: Effects of sand content of slurry, silicon addition to alloy system and traversal distance, Advanced Materials and Processes Research Institute (CSIR), Bhopal-462026, India Received 16 April 2008.
[15] KUBEL E J. Expanding horizons for ZA alloys [J]. Advanced Materials and Processes, 1987, 132: 51–57.
[16] DAFYDD H, WORSLEY D A, MCMURRAY H N. The kinetics and mechanism of cathodic oxygen reduction on zinc and zinc-aluminium alloy galvanized coatings [J]. Corrosion Science, 2005, 47: 3006–3018
[17] CHEN W, LIU Q, ZHU L, WANG L. A combinatorial study of the corrosion and mechanical properties of Zn-Al material library fabricated by ion beam sputtering [J]. Journal of Alloys and Compounds, 2008, 459: 261−266.

[18] G. E. Dieter, Mechanical Metallurgy, Third Edition, McGraw-Hill, New York, 1986.
[19] William D. Callister, Jr, Materials Science and Engineering – An introduction, sixth edition, John Wiley & Sons, Inc. 2004.

[20] ASM Handbook, Heat treating, Vol. 4, ASM International, Materials Park, OH, 1991.