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Processing of white cast iron powders to strengthen the iron composites

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Abstract:
To create metal matrix composites, this inquiry focused on the manufacturing of fast solidified white cast iron powders and iron powders. Here both the powders, after mixing in 50 is to 50 weight ratio, were consolidated in two different ways. The micro-structural analysis and property characterization of the processed materials were done. It was found that mixing iron and the quickly solidifying white cast iron might result in an extremely strong composite material.

Keywords: Rapidly solidified white cast iron; Compaction; Forging, Microstructure; Micro-hardness; Metal matrix composite

1. Introduction

Nowadays, composite materials have found widespread use. By adding reinforcements made of carbide materials like WC, SiC, and VC to soft matrices, high performance composites are created. Yilmaz[1] investigated the abrasive wear resistance of Fe-based metal matrix composites that were reinforced with FeCr-prepared powdered sand (PM). He noticed that the wear rate decreased as the volume percentage of FeCr Chrysanthousetal increased. [2] created metal matrix composites (MMC) based on ferrous materials with Ti and V reinforcement. They noticed that the composite's carbide sand ferrites' grain size decreased as the amount of vanadium increased. MMC's micro hardness grew as a result. The same year, Shamsuddin et al. [3] synthesized Fe based MMC using 5, 10, and 25 weight percent Alumina (Al_2O_3) particles in a PM method. Cr has been added for better corrosion resistance. Here MMC prepared with 20 wt% Al_2O_3 reinforcement showed highest hardness. Wangetal.[4] developed different samples of iron-matrix composites taking SiC particles of 3, 13, 21 and 45µm sizes as reinforcement. They adopted hot pressing sintering method and found that composite with SiC particles of size 13µm exhibited best tensile strength & elongation. In the recent years Kim et al. [5] fabricated iron based MMC reinforcing TiC particles. They used Planetary milling in argon atmosphere followed by hot pressing method. Here the compression yield strength of the composite increased with increase in TiC content. Das et al. [6] Synthesized ZrC reinforced iron composite by the process of reduction of Fe_2O_3 and $ZrSiO_4$ in the presence of carbon. They found that the mechanical properties like hardness, wear resistance of the composite were very promising. Wang et al. [7] produced ferrous based VC reinforced composites through in situ synthesis method. On investigation they found that the composite exhibited good densification and possessed great wear resistance.

But these reinforcing materials are very expensive to extend the scope of application of composites. As a result the industries are in search of inexpensive reinforcing materials. O.D. Sherby et al. [8-13] revealed that rapidly solidified white cast iron as well as ultra high carbon steel, when consolidated under appropriate thermo mechanical conditions, could be made super plastic at warm temperature. Again these materials could exhibit, to a maximum, yield strength of 1000MPa and hardness of68HRC with 4300MPa compressive fracture strength by heat treatment. The most useful property of these materials are that they can make very good solid state bonding with other ferrous based materials even below the lower transformation temperature (727°C) which enables one to produce very high quality laminated composites.

Considering these properties, an attempt has been made in this investigation to produce new types of particulate reinforced composites by reinforcing white cast iron powders in iron matrix through two different methods and to study the micro-hardness of the processed materials for industrial applications.

1. Materials and experimentation

Two types of ferrous based materials i.e. white cast iron powders and iron powders were produced using water atomization technique. Coarse powders above 150μm size were sieved out. The rest fine powders were taken for the experiment in both cases. Then the iron powders were annealed at 1000°C for 1 hr and white cast iron powders were annealed at 700°C for 2 hrs. After annealing both white cast iron powders and iron powders were mixed in weight ratio of 50 is to 50.1% Zinc stearate was added to the mixture. The chemical and Physical characteristics of iron powders were studied and are presented in Table1 and Table2 respectively. The chemical and Physical characteristics of white cast iron powders are given in Table3 and Table4 respectively.

Table1: Chemical characteristics of annealed iron powders in wt. %

C	S	P	Fe
0.045	0.014	0.025	Balance

Table2: Physical characteristics of annealed iron powders

Characteristics	value
Apparent Density, gm/cm^3	2.8
Flow rate, sec/50g	25
Approximate particle size range(μm)	10-150

Table3: Chemical analysis of annealed white cast iron powders in wt.%

C	Cr	Si	S	P	Fe
3.51	2	1.42	0.014	0.022	Balance

Table4: Physical characteristics of annealed white cast iron powders

Characteristics	value
Apparent Density, gm/cm^3	2.65
Flow rate, sec/50g	24
Approximate particle size range(μm)	10-150

In order to make composites, the consolidation of the said mixed powders was done in two different ways as discussed below.

In the first case, the mixed powders were compacted in a double action die set at 500MPa. Cold compacts of 12mm diameter were prepared. Then the cold compacts were heat treated in the furnace at 720°C for one hour in presence of Nitrogen. Then those were forged by a 0.5 ton capacity air hammer. In the second case, the powders were properly blended using a blender. The blended loose powders were put inside a mild steel can, which was kept in thefurnaceandheatedat720°Ctemperatureforonehourinhydrogenatmosphere. After this, the mild steel can, which had been filled with mixed powders, was rolled by using a rolling mill. A 5mm thick sheet was obtained.

2. Micro-structural Analysis

The materials processed in both the ways were put to grinding and polishing followed by etching with 5% nital. Then micrographs were taken by scanning electron micro-scope. These are shown in Figure 1 and Figure 2.

2.1 Micro-hardness study of the processed materials

The micro-hardness study was conducted by a micro-hardness tester and the average value sat different regions are presented in Figure 3 and Figure 4.

3. Results and discussions

From Table1, it is found that Sulphur and Phosphorous content in iron powders are0.014% and 0.025% respectively. Though these are undesirable, these are quite low in weight percent. From the Physical analysis of iron powders, the apparent density i.e.2.8gm/cm^3 and flow rate i.e. 25sec/50gm found are good for manufacturing high density machine parts. From Table 3, it is observed that 2wt% Cr and 1.42wt% Si are present in white cast iron powders. Addition of2% of Cr acted as carbide stabilizer, 1.42wt % Si enhanced the A1 transformation temperature up to 1000ºC in the powders. From Table4, it is found that flow rate is 24

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sec/50gm and apparent density is 2.65gm/cm^3, which are comparable with any quality powder of such kind.

3.1 Micro-structural Analysis

From Figure 1, it is interesting to note that both the iron powders and white cast iron powders adjusted nicely in the processed material through the process of forging. This led to filling of pores present after compaction stage. No crack is marked on white cast iron powders inspite of heavy strokes of the hammer. Again it is noticed that a specific area inside it is unaffected from forging operation.

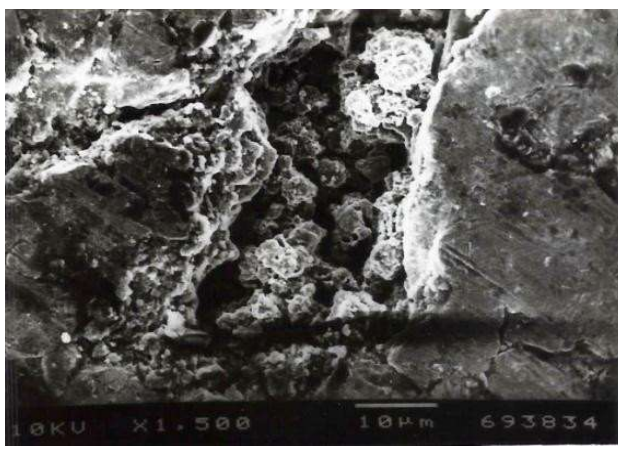

Figure1: SEM micro graph of the compacted, 700°C heat treated and forged material

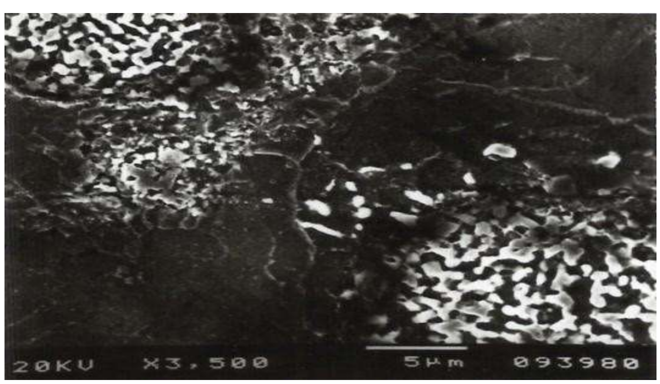

Figure2:SEM micro graph of the700°C heat treated, forged and rolled materi

From Figure2, it is found that very fine (<2µm) equiaxed cementite and ferrite grains are well distributed inside the castiron particles surrounded by iron matrix. The bonds among cast iron and iron powders are very good. The composite material is good for manufacturing high performance structural components.

3.2 Micro-hardness studies of processed materials

Figure 3 presents the micro-hardness values of the 720ºC heat treated, compacted and forged material. An average micro-hardness value of 202HV is observed in ferrite rich area. In carbide rich area, the average micro-hardness value is calculated to be505HV.

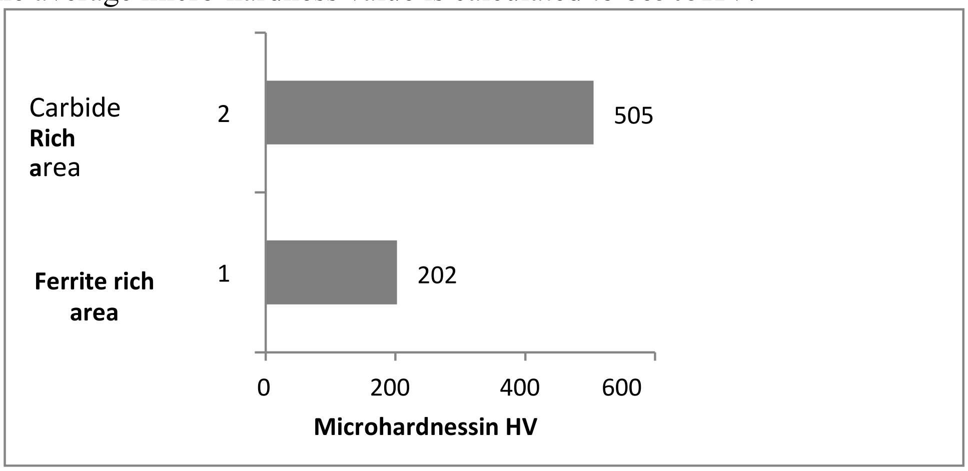

Figure 3: Microhardness values of the compacted, 720°C heat treated and forgedmaterial

Figure 4 presents the micro-hardness values of the 720ºC heat treated and rolled materialat different regions.In ferrite rich area micro-hardness values range from 190HV to220HV giving an average value of 207HV.High carbon content ferrous regions, richwith carbides, show hardness values in between 600HV to 640 HV and the averagevalueis estimated to be615HV. The carbide rich area shows higher hardness andferriterichareashowslowerhardness.Suchkindofstructureintheprocessedmaterial makes it a suitable dual phase composite material. This can be effectivelyutilizedformanufacturingdifferentkindsof componentsfor variousapplications.

Figure4: Microhardnessvaluesofthe 720°Cheattreatedandrolledmaterial

4. Conclusions

The conclusions are as follows.

- White cast iron and iron powders that have swiftly solidified can be used to create good composite materials that have a very fine microstructure and strong bonding.
- The hardness values achieved are excellent for using the materials in the fabrication of structural components in many sectors.

References

[1] Yilmaz,O. Abrasive wear of FeCr(M7C3-M23C6) reinforced iron based metal matrix composites. Materials Science and Technology 2001,17(10),1285-1292.

[2] Chrysanthou,A.; Modi,O.P.; Han,L.; Ramakrishnan,N.; Sullivan,J.M.O.Formation and micro structure of (Ti,V) C-reinforced iron –matrix composites using self-propagating high-temperature synthesis. International Journal of Materials Research 2008,99(3),281-286.

[3] Shamsuddin,S.; Jamaludin,S.B.; Hussain,Z.; Ahmad,Z.A. Characterization of Fe-Cr-Al2O3 Composites Fabricated by Powder Metallurgy Method with Varying Weight Percentage of Alumina. Journal of Physical Science 2008,19(1),89-95.

[4] Wang,Y.M.; Zhang,C.H.; Zong,Y.P.; Yang,H.P. Experimental and simulation studies of particle size effects on tensile deformation behavior of iron matrix composites. Advanced Composite Materials 2013,22(5),299-310.

[5] Kim,J.M.; Park,J.S.; Yun,H.S. Microstructure and Mechanical Properties of TiC Nano particle- Reinforced Iron-Matrix Composites. Strength of Materials2014, 46(2),177-182.

[6] Das,K.; Bandyopadhyay,T.K. Synthesis and characterization of zirconium carbide-reinforced iron-based composite. Materials Science and Engineering; A2004,379(1-2), 83-91.

[7] Wang,J.; Fu,S. Production of in situ Vanadium Carbide Particulate Reinforced Iron Matrix Composite 2014,20(4),409-413.

[8] Sherby,O.D. Ultra High Carbon Steels, Damascus Steels and Ancient Black smiths. Iron and Steel Institute of Japan International 1999, 39(7),637-648.

[9] Sherby,O.D.etal.SuperplasticUltraHighCarbonSteels.ScriptaMetallurgica1975, 9, 569-574.

[10] Mordike,B.L.; Kainer,K.U. Consolidation of Rapidly Solidified Powders. Solid State Phenomena1989,8& 9,135-148.

[11] Lesuer,D.R.; Syn,C.K.; Goldberg,A.; Wardsworth,J.; Sherby,O.D. The case for Ultra High Carbon Steels as Structural Materials.JOM1993,40-46.

[12] Walser,B.; Kayali,E.S.; Sherby,O.D. Warm Working and Super plasticity in Plain Ultra High Carbon Steels. Proceedings of 4th International Conference of Strength of Metals and alloys 1976,1(8),266-270.

[13] Sherby,O.D.etal. Super plastic Bonding of Ferrous Laminates. Scripta Metallurgia1979,13(10),941-946.