FORMING BEHAVIOUR STUDIES ON INFLUENCE of Fe-Mo-Cr ALLOY IN MECHANICAL ENGINEERING WORKING AREA PRODUCED BY POWDER METALLURGY METHOD

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ABSTRACT: Purpose:The purpose of this work is to investigate the forming behaviour studies on Fe-Mo-Cr alloy produced by powder metallurgy method.
Design/Methodology /Approach:In this study , Ferrous alloy Mo powders and Cr powders were accurately weighed and blended in ball mill to yield the different compositions namely(Fe,2%Mo and 2%Cr).The blending was carried out in ball mill with the 18mm diameter stainless steel balls.The balls and powders weight ratio is 5:1 and the speed of the drum was 150rpm.The milling was carried out for a period of 3 hours .Blended powders were pressed in dies under high pressure to form them into the required shape.The work part after compaction is called a green compact .In powder compaction process the powders were compacted under high pressure by various methods to pack the powders and reduce the porosity.The Fe,Mo and Cr powders were sintered in an electric muffle furnace in the temperature 1200^{0}C for a period of 1 hour and cooled to room temperature in the furnace itself.The sintered preforms were characterized by SEM analyses and it revealed that the uniform distribution of reinforcements (Mo&Cr).The true axial stress (σ_z),true hoop stress (σ_θ)and true hydrostatic stress (σ_m) increased with the addition of M_O and Cr particles in pure steel matrix during cold upsetting .The formability stress index (β)increased with the addition of 2 weight percentage of Mo Cr reinforcements in pure steel matrix during cold upsetting.
Findings: The powder metallurgy process is replacing traditional metal forming operations because of its low relative energy consumption ,high material utilization,and low capital cost.Also the uniformity in reinforcement distribution can be achieved by the powder metallurgy process to produce porous structures and this improves structural properties and also reproducibility .
Originality/Value:This paper explains the effect of Fe-Mo-Cr alloy produced by powder metallurgy method.

Key words: Powder metallurgy ,Ferrous alloy,Molybdenum ,chromium,Forming behavior.
Paper Type:Research paper

INTRODUCTION

AMCs are synthesized with various reinforcements such as graphite,SiC,Al_2O_3,TiC,VC,AlN,B_4C,Si_3N_4,TiB_2 and MgB_2.Eventhough Titanium dioxide(TiO_2) possesses high hardness and modulus with superior corrosion resistance and wear resistance ,it is not concentrated much by the recent researchers.It is proved that the addition of hard ceramic reinforcement particles increases wear resistance and hardness .However ,the composites containing hard ceramic particles lack a solid lubricant ,such as graphite .In particulate composites exhibit improvement in mechanical properties ,low friction and wear,reduced reduced temperature rise at the wearing contact surface ,excellent anti-seizure effects,improved machinability,low thermal expansion and high damping capacity because of graphite reinforcement .Hybrid matrix composites are produced with the addition of solid lubricant particles such as graphite along with hard ceramic particles to improve the tribological and self lubricating properties of the composites.Dai-hong XIAO,et .al studied about the Ti-Al-Mo-V-Ag (α+β) alloys and processed by powder metallurgy (PM)using the blended elemental (BE)technique.The effects of Ag addition and sintering temperature on microstructure and properties of the Ti-5Al-4Mo-4V alloys were investigated using X-ray diffraction ,optical microscope,scanning electron microscope and mechanical properties tests.A.R.Farkoosh et .al investigated the influence of Mo addition on the microstructure and mechanical properties of an Al-7Si-0.5Cu-0.3Mg alloy (wt%).The Mo-containing alloy exhibited significant improvement in creep resistance over the base alloy.BhargaviRebba et.al reported the results of an experimental investigation on the mechanical properties of molybdenum disulphide (MOS_2,also called molydisulphide) powders reinforced in aluminium alloy (Al-2024)composite samples reported in this paper.Hitesh D.Vora et.al assessed the amultiphysics based computational model was developed to predict the dilution of molybdenum (Mo)on an aluminium (Al)substrate during the laser surface alloying process.QunjiXue et .al researched over composite specimens of 2024 aluminium alloy reinforced with 15 vol.%SiC whiskers and 15 vol.%molybdenum powder were fabricated using powder metallurgy(PM).R.Maiti M.Chakraborty et.al researched over aluminium matrix composites reinforced with molybdenum aluminide nanoparticles were synthesized by ball milling and reactive sintering of the mixture of aluminium and 10wt%hydrated molybdenum oxide powders .A.A.Khan et.al assessed pure aluminium nitride can be hot pressesd with an addition of molybdenum powder.R.Figueroa et.al researched over the aim of the present work is to study the effect of nitrogen and molybdenum implantation in the tribological behaviour of the AA7075 alloy subjected to different structural hardening treatments (T6 and T73).
M.Metikos-Hukovicet et.al assessed pure aluminium corrodes readily in 1Ml HCl solution while its supersaturated alloys with Mo,explored in this work,exhibit excellent corrosion properties due to the oxide barrier film formation on the alloy surface.G.K.Dey et.al researched over a considerable improvement in the mechanical and chemical properties of the near surface regions of materials may be achieved by the use of high energy laser beams.I.Rosales et.al researched over several molybdenum silicates alloys with different aluminum additions were produced by the arc-cast method.A.K.Covington et.al researched over the rate of growth studied of the alloy layer formed on molybdenum when immersed in solutions of aluminium in the liquid metals ,bismuth,cadmium ,indium,lead,thallium or tin at 500^{0}C.Ravi shankerRajamure et.al researched over a continuous diode pumped ytterbium laser was used for alloying of molybdenum on Al1100 to

improve its wear resistance.P.W.HeitmanL et.al studied brittle intermetallic compounds at the fiber –matrix interface on the deformation characteristics of molybdenum –aluminium fiber composites was investigated.P.Y.Li et.al analysed a series of Al-Fe-Mo-Si alloys with and without additions of Ti and Zr for elevated temperature applications produced by rapid solidification.Amir Azam Khan ,et.al produced aluminium nitride –molybdenum ceramic matrix composites by hot pressing a mixture of two powders without any sintering aids.Liujiexu,shizhong Wei,et.al researched over the conventional molybdenum alloys ,lacking of hard particles enhancing wear property ,relative poor wear resistance though they were widely used in wear parts.

2.MATERIALS AND METHODS

2.1.MATERIALS

Materials:Ferrous alloy,Mo,Cr.Ferrous metal alloy are selected as a base materials and the molybdenum powders and chromium powders are added to yield the different compositions.The ferrous materials,molybdenum powders and chromium powders are taken for research.

2.2.FORMULATION AND DESIGNATION OF THE MATERIALS.

The term "ferrous " is derived from the latin word meaning "containing iron".This can include pure iron such as wrought iron,or an alloy such as steel.The addition of silicon will produce cast irons ,while the addition of chromium ,nickel and molybdenum to carbon steels(more than 10%)results in stainless steels.Molybdenum metal is usually produced by powder metallurgy techniques in which Mo powder is hydrostatically compacted and sintered at about 2100^{0}C.Hot working is done in the 870-1260^{0}C range.Chromium metal and ferrochromium alloy are commercially produced from chromate by silicothermic or aluminothermy reactions,or by roasting and leaching processes.

2.3.DEVELOPMENT OF MATERIALS.

The methodology involved in the development of materials are given below in Table.1 .The green compact processes involved in blending ,mixing and compaction.The sintering process prepared in muffle furnace at 600^{0}C and cold upsetting in 100^{0}C.Forming behavior studies were carried out and microstructure analysis was done.

2.4.CHARACTERIZATIONS

Metals were prepared as a cast into a finished part or cast into intermediate form such as ingot,then worked ,wrought by rolling ,or processed by forging ,extruding or another deformation process.Molybdenum formed a volatile oxide when heated in air above about 600^{0}C and mechanical stability at high temperatures (upto 1900^{0}C).Molybdenum was reacted with hydrochloric acid,sulfuric acid only at a temperature 80-100^{0}C.Nitric acid,aqua regain dissolved molybdenum only temperature 100^{0}C.Molybdenum heat shields compared with tungsten easier almost doubled,so molybdenum products had high specific strength (at a temperature of not more than 1370^{0}C).Chromium application,along with chrome plating (electro plating with chromium)currently comprised 85%of the commercial use for the element,chromium was the only elemental solid which shows antiferromagnetic ordering at room temperature(and below).Above 38^{0}C,it transformed into a paramagnetic state.Powder metallurgy involved making,characterizing,and treating the powder which have a strong influence on the quality of the end product.In atomizing process,the molten metal was forced through an orifice into a stream of high velocity air,steam or inert gas.This caused rapid cooling and disintegration into very fine powder particles and the use of this process was limited to metals with relatively low melting point.In gaseous reduction process,It consisted of grinding the metallic oxsides to a fine state and subsequently,reducing it by hydrogen or carbon monoxide .This method was employed for metals such as iron,tungsten,copper etc.In electrolysis process,The conditions of electrode positions were controlled in such a way that a soft spongy deposit was formed ,which was subsequently pulverized to form the metallic powder.The particle size varied over a wide range by varying the electrolyte compositions and the electrical parameters.In carbonyl process,Based upon the fact that a number of metals reacted with carbon monoxide to form carbonyls such as iron carbonyl made by passing carbon monoxide over heated at 50-200bar pressure.The resulting carbonyl was then decomposed by heating it to a temperature of 200^{0}C-300^{0}C yielding powder of high purity.In granulation process,It consisted of in the formation of an oxide film in individual particles when a bath of metal was stirred in contact with air.powders of two or more pure metals were mixed in a ball mill.Under the impact of the hard balls,the powders were repeatedly fractured and welded together by forming alloy under diffusion.In powder blending,A single powder might not fulfill all the requisite properties and hence ,powders of different materials with wide range of mechanical properties are blended to form a final part.In powder compaction,The principle goal of the compaction process was to apply pressurize and bond the particles to form a cohesion among the powder particles.This was usually termed as the green strength.Compaction was carried out by pouring a measured amount of metallic powder into the die cavity and applying pressureby means of one or more plungers.Sintering refered to the heating of the compacted powder perform to a specific temperature(below the melting temperature of the principle powder particles while well above the temperature that would allow diffusion between the neighboring particles).Prior to the sintering process ,the compacted powder perform was brittle and confirm to very low green strength.Sintering process enhanced the density of the final part by filling up the incipient holes and increasing the area of contact among the powder particles in the compact perform.

3.RESULTS AND DISCUSSIONS

3.1.HARDENABILITY FACTORS

One of the main benefits that makes Mo a favourable element for use in water. Atomized powder metallurgy (PM)materials are a relatively minor effect on compressibility.Mo is widely used as a prealloyed element with high contribution to hardenability.Figure 1 shows a plot of hardenability factor as a function of percentage alloying content.Mo as a prealloyed element is that has an easily reducible oxide at conventional sintering temperatures such as 1120^{0}C.

3.2 .BALL MILLING

Ferrous alloy Mo powders and Cr powders are accurately weighed and blended in ball mill to yield the different compositions namely (Fe,2%Mo and 2%Cr).The blending is carried out in ball mill with the 18mm diameter stainless steel balls in figure 2. The balls and powders weight ratio is 5:1 and the speed of the drum is 150rpm.The milling is carried out for a period of 3 hours.Atomized ferrous powder of particle size less than 325µm and the purity 99.7% supplied by kemphasol,Mumbai ,india is used as matrix material.The rutile grade of molybdenum and chromium powder with an average particle size of 0.334mm and purity 99.0% and graphite powders of size less than 10mm supplied by the Acechemie (india)is used as reinforcements for the present work.The morphology of the as received powder particles are presented in figure 2.

3.3.COMPACTION

Blended powders are pressed in dies under high pressure to form them into required shape .The work part after compaction is called a green compact.In powder compaction process the powders are compacted under high pressure by various methods to pack the powders and reduce the porosity .Also particle deformation also enhances in compaction techniques due to the high applied pressure .Many compaction methods are used ,but the most established method for powder metallurgy parts production is uniaxial compaction in a rigid die.This method is cost effective with relatively conventional tooling.The powder mixtures are compacted into cylindrical billets of diameter 24mm and height 12mm by making use of high carbon die steel set as shown in figure 3.The required pressure is applied using hydraulic press of 400KN capacities.The biggest problem in pressing particulate mixtures composed mostly of aluminium powder is the fact that ,at compaction process ,aluminium particles adhering to the walls. The required compacting load is calculated using the corresponding compressibility data to prepare the compact with required initial perform relative density and aspect ratio .After compaction ,ejection of the compact is done by removing the butt and placing the die on two parallel blocks of same height leaving the hole right in the centre of the free space between the two blocks and then applying pressure by means of hydraulic press.The fall of the compact is cushioned bymeans of cotton.The conventional die compaction process are used to produce parts from most frequently used engineering materials such as iron ,steel,stainless steel ,brass,bronze ,copper,and aluminium .It is the most applicable to medium to high production volume ,small to medium size parts such as gears,sprockets,pulleys,cams,levers,pressure plates,automotive,appliances ,power tools,sporting equipment,office machines,and garden tractors.

3.4.SINTERING

The Fe,Mo and Cr powders are sintered in an electric muffle furnace in the temperature 1200^0C for a period of 1hour and cooled to room temperature in the furnace itself.During sintering ,compacted metal particles are bonded or sintered by heating in a furnace to a temperature that is usually below the melting point of the major constituent .Sintering occurs in a series of overlapping but balanced phases ,all of which depend on temperature ,time ,and atmospheric composition .Initial particle bonding ,neck growth ,pore channel closure ,pore rounding ,densification or pore shrinkage and pore coarsening are the various stages of the sintering process in figure 4, and 5

Characteistic structural constituents of investigated steels after sintering at 1120 and 1250^0C.F-ferrite ,P-Pearlite ,B-bainite ,M-martensite of investigated steels after sintering at 1120 and 1250^0C are presented .The microstructure of investigated steels containing sintered at 1120^0C consists of ferrite +pearlite (2%Mo and 2% Cr),ferrite +pearlite +bainite (2%Mo and 2%Cr),bainite +pearlite +martensite (2%Mo and 2%Cr)and bainite +martensite(2%Mo and 2%Cr) in figure .The microstructure of investigated steels containing sintered at 1250^0C consists of ferrite +pearlite (2%Mo and 2%Cr),ferrite +pearlite +bainite (2%Mo and 2%Cr),bainite +pearlite +martensite (2%Mo and 2%Cr) and bainite +martensite (2%Mo and 2%Cr) in figure 6.

A high carbon content results in the complex and high strength sintered microstructure containing martensite and bainite (2%Mo and 2%Cr).For Fe with addition of 2% Mo and 2%Cr (after sintering at 1120^0C and 1250^0C respectively)is observed .The fracture surface morphology after tensile tests (figure 7)are strongly dependent on the type of microstructure ,which is controlled by carbon content and sintering temperature.For alloys based on both Fe powders with 2%Mo and 2%Cr ,it is dominated by inter particle failure with shallow dimples ,some small cleavage facets and inter granular decohesion.In some areas of ductile dimple surface ,particularly for high temperature sintering ,local plastic deformation occurred ,which corresponds with achieved values of plasticity ,expressed by tensile strains of more than 5%.The failure is controlled by quality of interface areas ,particularly of bainite packet surfaces and by cleavage in martensite.The result is a mixed character of the fracture surface ,which consists of shallow dimples and cleavage facets.Both lower sintering temperature and lower chromium content lead to higher amount of inter granular decohesion ,which is connected with the formation of carbide phases at grain boundaries.It is shown through by figure 8.

3.5.COLD UPSETTING

The sintered performs are cleaned and measurements such as initial height (H_o),diameter (D_o)and mass (m) are taken.The cold upsetting is carried out between two flat high speed steel dies with graphite lubricant at both of die contact surfaces ,to ensure minimum friction .The incremental compressive load is applied on the cold upset specimen in steps of 10KN ,until fine cracks appeared on its free surface.In figure 9 . shows the performs befor and after deformation .After each interval of loading dimensional changes in the specimen such as height after deformation (H_D),top contact diameter (D_{TC}),bottom contact diameter (D_{BC}),bulged diameter (D_B) and density of the perform (ρ_f) are measured .Archimedes principle is used to find the actual densities of the performs after each step of deformation .

The measured values are used to calculate the true axial stresses (σ_Z),true hoop stress (σ_Θ),true hydrostatic stress (σ_m),true effective stress (σ_{eff}),formability stress index(β)and true axial strain(ε_Z).These workability parameters under triaxial stress state conditions are calculated by using following expressions.

The true hoop strain (ε_Θ) can be determined by the following expression ,

$\varepsilon_\Theta=(2D_B^2+D_C^2/3D_O^2)$ Where D_o initial dia;D_B,bulge dia ;D_C ,average surface contact dia

The true hydrostatic stress (σ_m)is given by

$\sigma_m=((2\sigma_\Theta+\sigma_Z)/3)$

The true hoop stress (σ_Θ) can be expressed by

$\sigma\Theta=((1+2\alpha)/(2+\alpha))\sigma_Z$ Where α is poisson’s ratio

The true effective stress(σ_{eff})is calculated by

$\sigma_{eff}=((\sigma_z^2+2\sigma_\Theta^2-R^2(\sigma_z\sigma_\Theta+\sigma_\Theta^2+\sigma_z\sigma_\Theta))/(2R^2-1))\sigma_z$

Where R is relative density of the performs

The formability index(β) is given by

$\beta=(3\sigma_m/\sigma_{eff})$

3.6.HARDNESS TEST

The Vickers hardness of the different samples are shown in figure 10.The highest hardness values (around 1340 HV 30)are found in samples with P/M steels which is achieved due to a combination of factors.During sintering ,a higher liquid phase content in the metallic matrix is formed leading to the formation of a more homogeneous microstructure ,containing carbide of precipitates as an interphase between the metallic matrix and the ceramic Mo and Cr particles ,here by improving the bonding between the phases.The formation of MC type carbides with Cr and Mo predicted by the presence of retained austenite as was observed by SEM analysis.Despite the low relative density values obtained for samples sintered by P/M steel,they exhibit a higher hardness compared to base samples for the compositions with no Mo and Cr addition and 2%of each powder .However the maximum hardness achieved in P/M steel samples is lower than the maximum values in base samples ,suggesting a more favourable microstructure in case of P/M steel.The fact that a liquid phase is needed for full densification of these composite grades ,resulting in concomitant more elevated harness values .The pore closing mechanism and presence of hard phase in the composite contributed to the increase in hardness after cold upsetting.

CONCLUSION

The Fe-Mo-Cr alloys were developed by powder metallurgy method.Based on the test results the following inferences were drawn:

- The significance of the development of sinter hardened PM Mo-Cr binate steel was summarized as follows :
  (a)good combination of strength and toughness.
  (b)Self hardening with high binate harden ability by convective cooling from the sintering temperature without additional quenching /tempering treatment.
  (c).reducing costs of both raw meterials and production .
  (d)Savings in energy resources .
- It was possible to sinter the Fe-Cr-Mo steels in other than a hydrogen –rich atmosphere without decreasing their mechanical properties.The mechanical properties were satisfactory ,in contrast to those achieved after sintering in hydrogen rich atmospheres.
- Investigated steels belong to the medium to high strength sintered steels.
- The optimized chemical composition ,alloying technique and processing of investigated PM steels result in high mechanical properties of the material,which improved by increasing sintering temperature and /or applying sinter hardening .The need for a secondary quench hardening treatment was eliminated.
- Using P/M process as a sintering atmosphere increased surface hardness of Fe –Mo-Cr steels.
- Alloying elements improved the hardness of steel and decreased the temperature of binate and martensite transformations.
- Sintered steels based on Cr-Mo prealloyed powder was called self hardened steels because of the low cooling rate necessary to obtain biotitic/martensitic structure.
- The investigated steels correspond to medium steel s which were used for structural parts in ferrous powder metallurgy and with success substituted traditional ,expensive PM steels.
- Higher temperature resulted in a significant increased in mechanical and plastic properties for all alloy variants.
- Sintered steels based on iron powder showed the best mechanical properties ,independently of carbon concentration in the steels .
- The hybrid composite was synthesized through powder metallurgy technique and its workability behavior was studied during cold upsetting test.
- The sintered preforms were characterized by SEM analyses and it revealed that the uniform distribution of reinforcements (Mo & Cr).The true axial stress (σ_z),true hoop stress (σ_Θ) and true hydrostatic stress(σ_m)increased with the addition of Mo and Cr particles in pure steel matrix during cold upsetting.
- The formability stress index (β) increased with the addition of 2 weight percentage of Mo and Cr reinforcements in pure steel matrix during cold upsetting.

  Thus,Among all composite materials ,metal matrix materials are widely used in various applications in which aluminium based metal matrix composites (MMCs)are widely used in structural applications in the aero space and automotive industries due to their high strength to weight ratio.

REFERENCES

[1].B.A .Behrens(2014),"Development of a powder metallurgical self cooling forging die with inner cavities",Science direct ,vol.15,pp.456-464.

[2].Sudema and jianjum zhang (2016),"Wear resistant high boron cast alloy –A Review ",Rev,Adv.Mater.sci.vol.44,pp.54-62.

[3].S.Natarajan (2015),"Determination of transformation induced heat transfer co-efficients in mechanical properties of powder metallurgy sheets",American –Eurasian journal of scientific research,vol.10,pp.27-33.

[4].Alexandre Nogueira ottoboni dias(2017),"Effect of high energy milling time of the aluminium bronze alloy obtained by powder metallurgy with niobium carbide addition ",Materials Research ,vol.20,pp.747-754.

[5].C.okechukwu(2017),"Review on hardfacing as method of improving the service life of critical components subjected to wear in service ",Nigerian journal of technology,vol.36,pp.1095-1103.

[6].Paula Rojas(2016),"Effect of the powder metallurgy manufacture process on the electro chemical behavior of copper ,Nickel & copper nickel alloys in hydrochloric acid",Int.J.Electrochem.sci,vol.11,pp.4701-4711.

[7].Bhairav patel(2010),"A novel route for processing cobalt chromium molybdenum orthopaedic alloys",JR soc interface,vol.07,pp.1641-1645.

[8].Yao Qiu(2017),"Corrosion of high entropy alloys",npj-materials degradation,vol.15.

[9].Siddhartha Tiwari(2012),"Densification behavior in the fabrication of Al-Fe metal matrix composite using powder metallurgy route ",ISRN metallurgy ,vol.2012.

[10].Saidatulakmar Shamsuddin(2013),"Fabrication and characterisation of powder metallurgy Fe Cr matrix composites reinforced with Al_2o_3 ",Advanced materials research.

[11].M.S.Bakare(2012),"corrosion behavior of crystalline & Amorphous forms of the glass forming alloy $Fe_{43}Cr_{16}Mo_{16}C_{15}B_{10}$".

[12].Pavan prabhakar(2018),"Mechanical & Tribological characterization of sintered iron and aluminium based alloys",IRJET,vol.05,pp.2338-2342.

[13].Marcello vertamatti mergulhao(2018),"Characteristics of biometallic alloy to additive manufacturing using selective laser melting technology ",Journal of biometrials &nano biotechnology ,vol.09,pp.89-99.

[14].J.Arivudainambi(2011),"Densification & mechanical properties of sintered powder metallurgy AISI 4340 steel performs ",ARPN Journal of Engineering and applied sciences ,vol.06,pp.61-68.

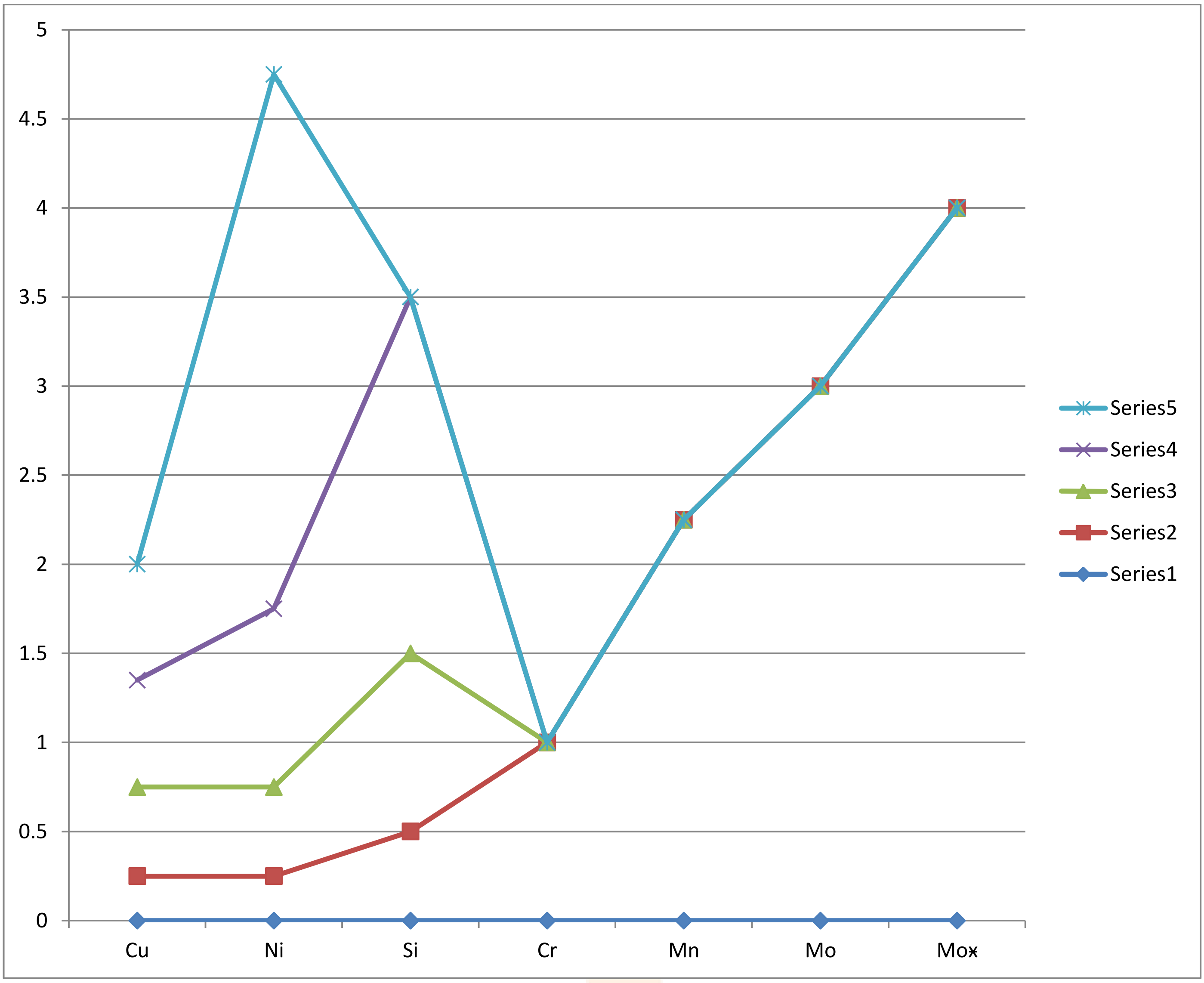

Figure 1.Hardenability factors for various prealloyed elements

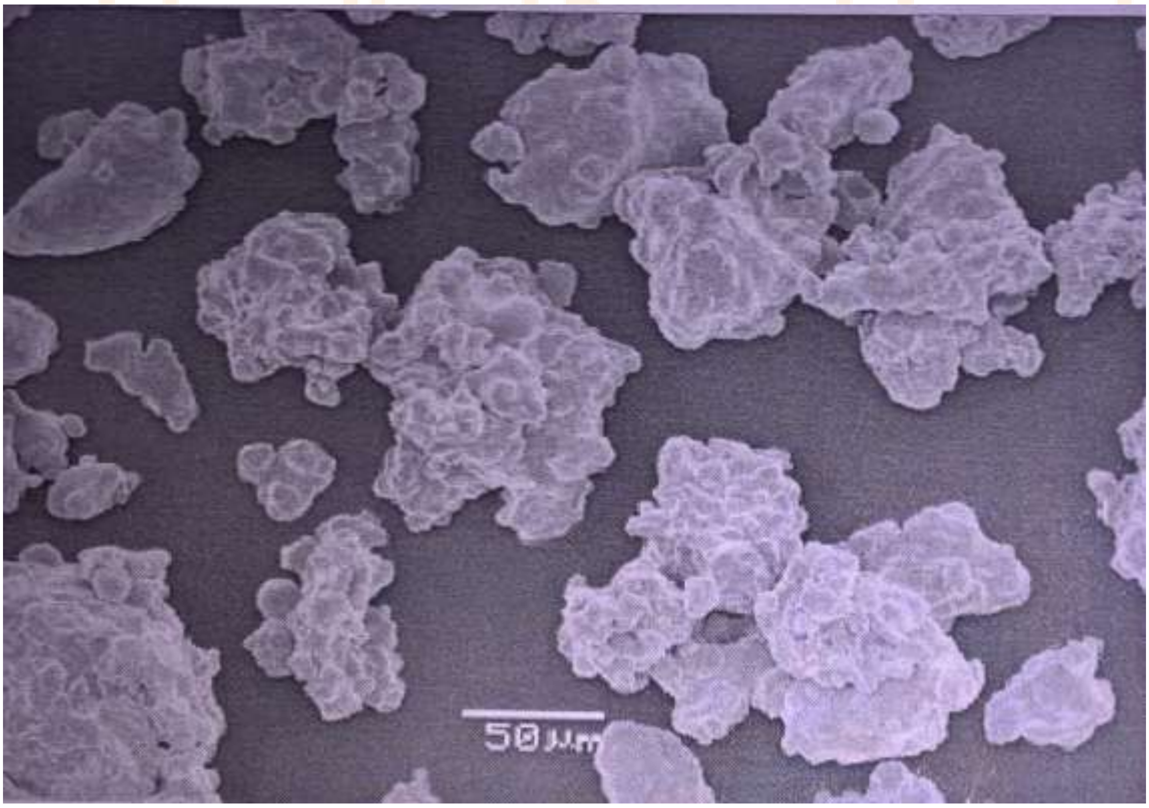

Figure 2.SEM image of iron powder

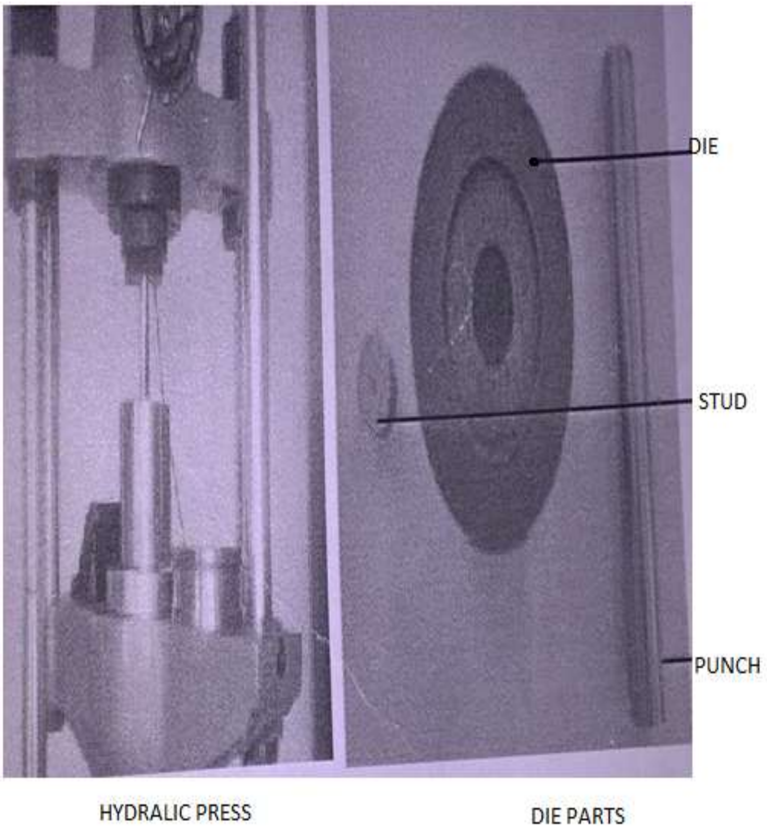

Figure 3.Photograph showing the compaction process

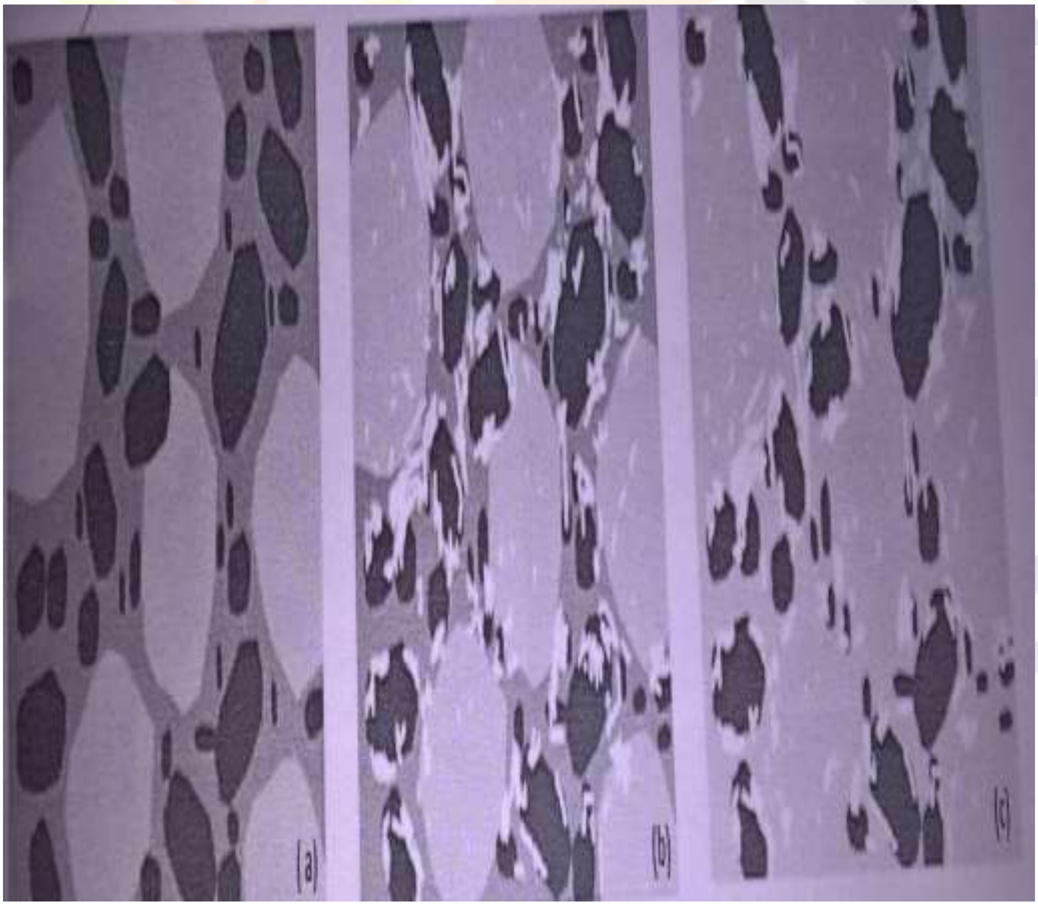

Figure 4.Microstructure developments Fe-Mo-Cr system(a)Heating,(b)sintering temperature(c)Cooling

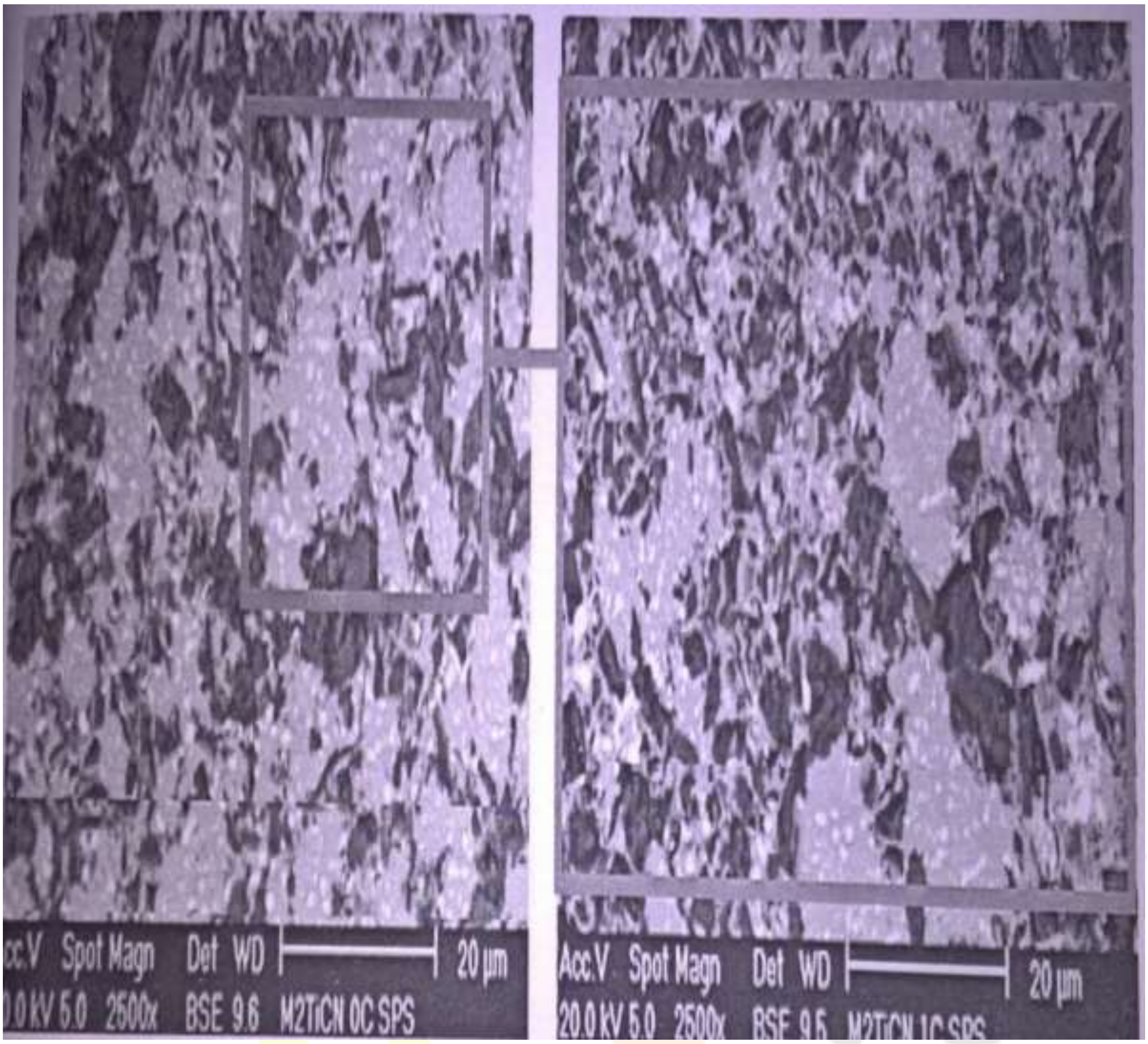

Figure 5.Microstructure developments Fe-Mo-Cr system

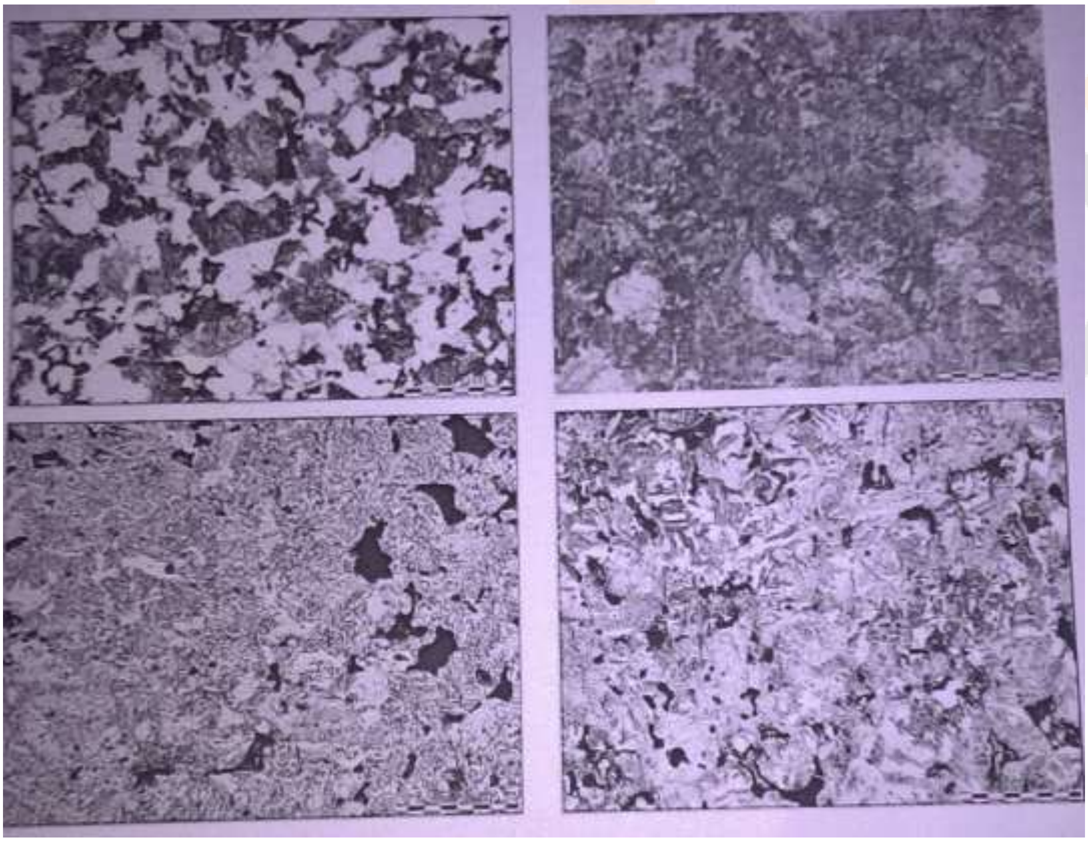

Figure 6.The microstructures of steels sintered at 1120^{0}C

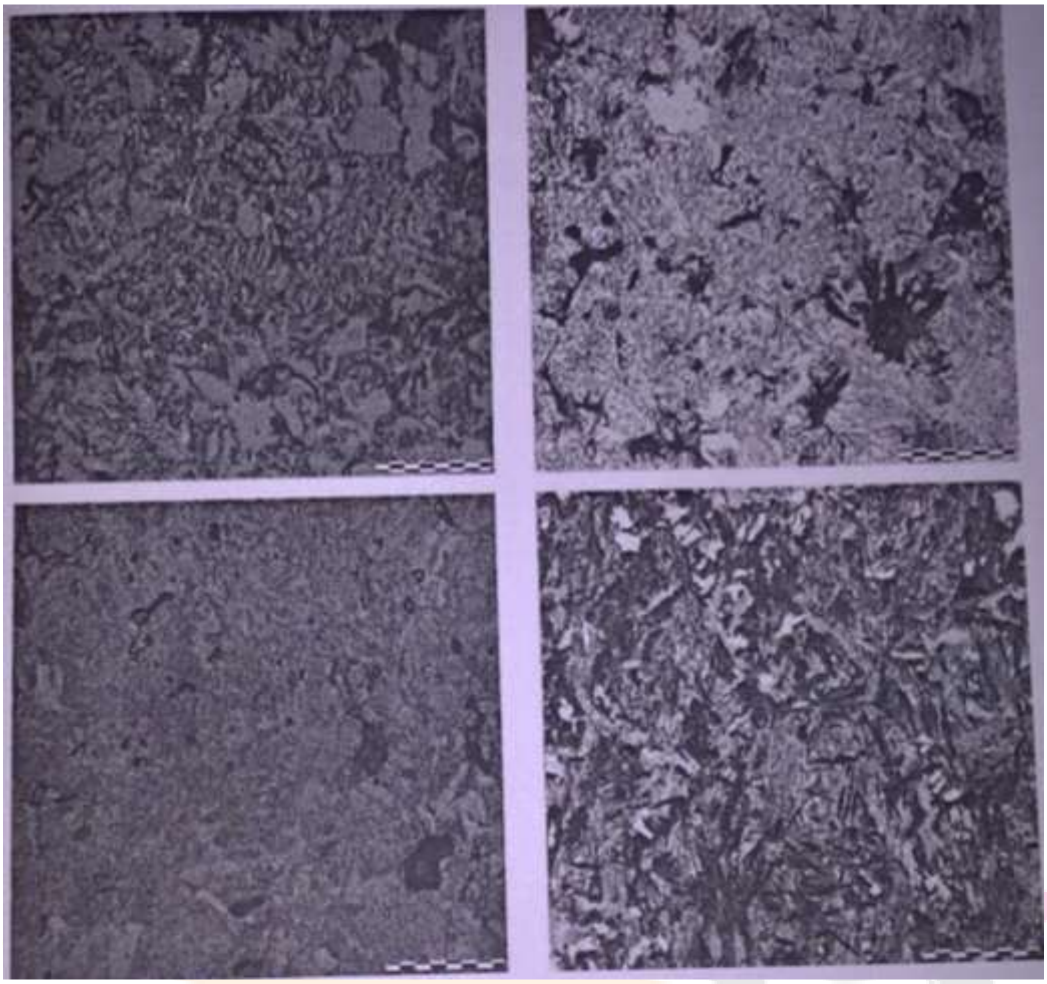

Figure 7.The microstructures of steels sintered at 1250^{0}C

Figure 8.The fracture surfaces of PM steels in SEM analysis.

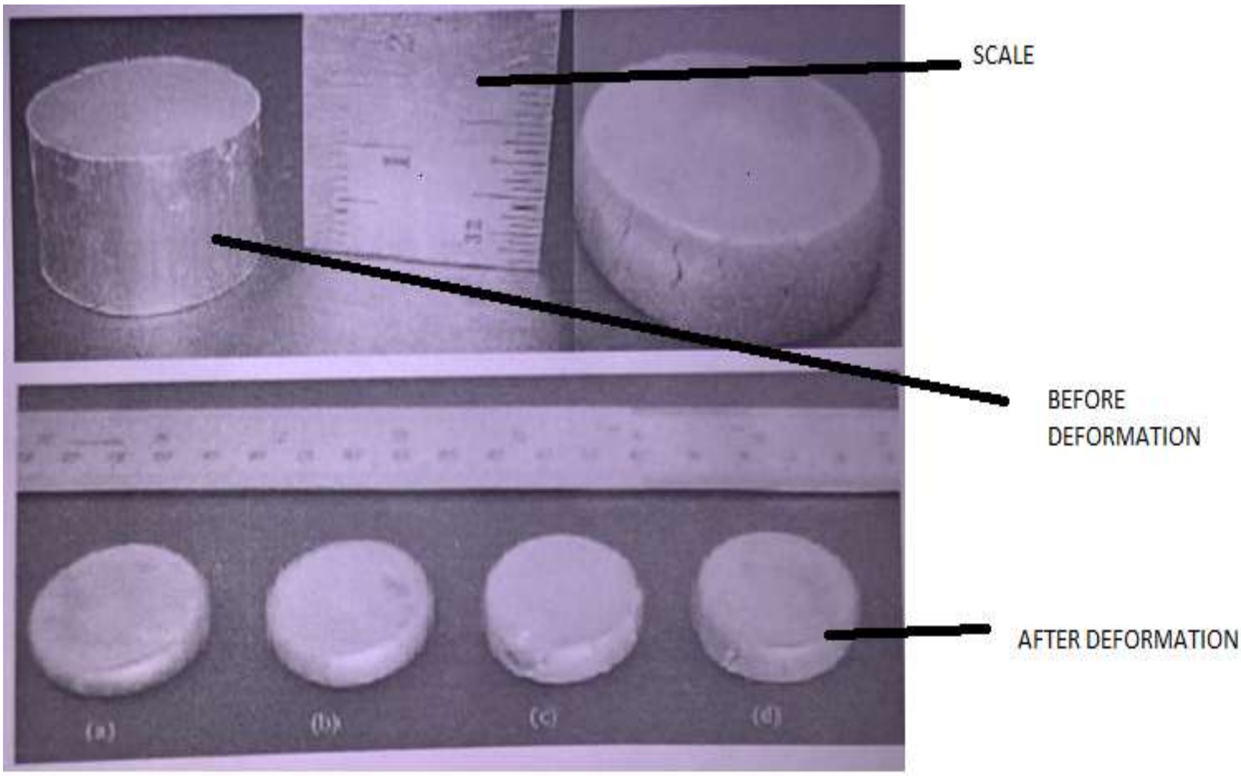

Figure 9.PM steels performs before and after deformation.

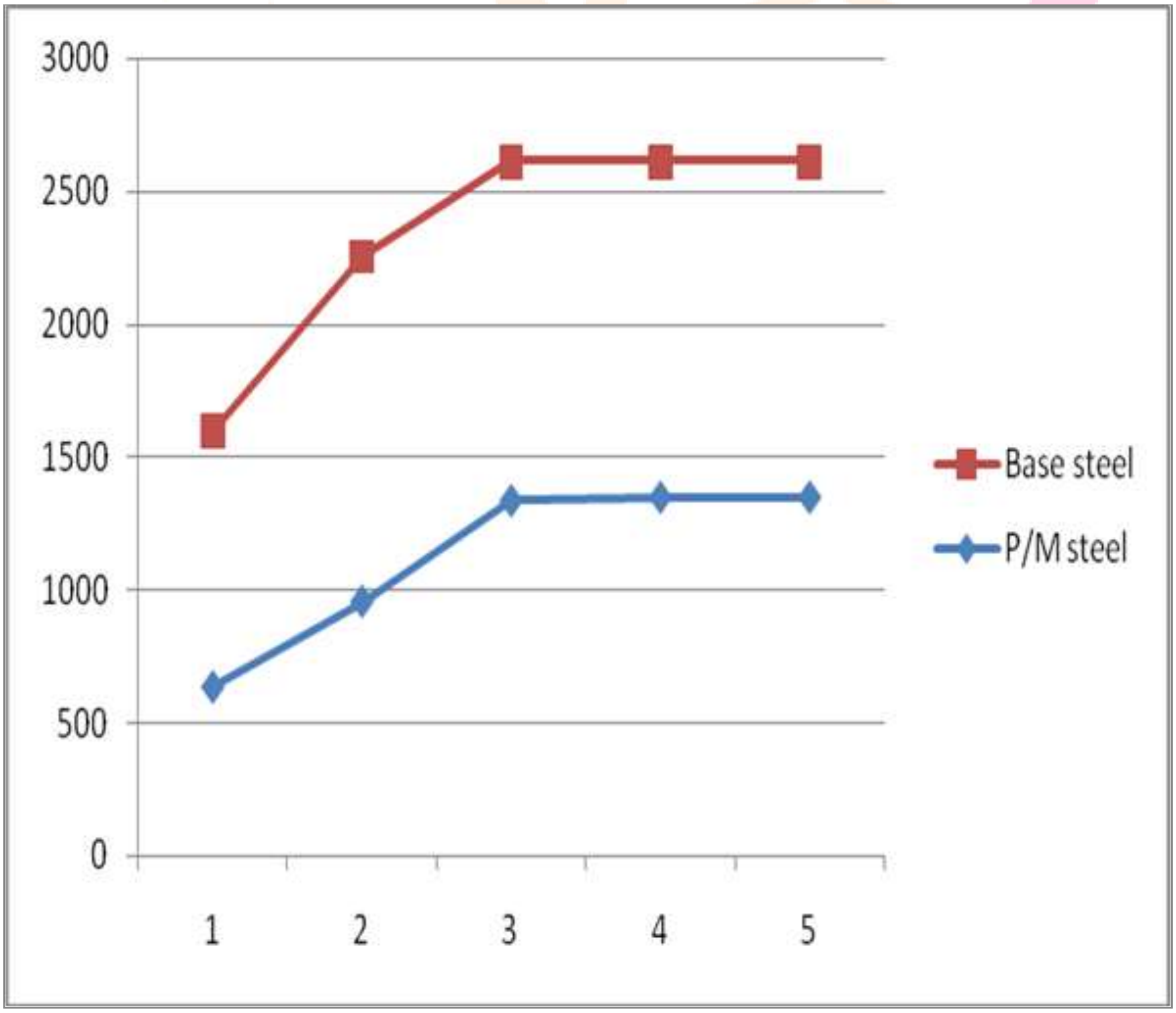

Figure 10.Vickers hardness values of P/M steel

Table 1.Methodology

S.NO	PROCESSES	PROCEDURE
1	Selection of material	Ferrous alloy,Mo,Cr
2	Green compact	Blending and Mixing ,Compaction
3	Sintering process	Muffle furnace at 600^0C
4	Cold upsetting	100^0C
5	Forming behavior studies	-
6	Micro structure analysis	-