

Improvement of Mechanical properties of 38MnSiVS5 grade Microalloy steel through Equilibrium cooling

Kalidas J. Suryawanshi(MIS No.121026007)

Under guidance of:

Guide - Prof. (Dr.) S. P. Butee,

Email: spb.meta@coep.ac.in

ABSTRACT

Medium carbon microalloyed (MA) steels are increasingly being used in place of quenched and tempered (Q&T) steels in the automotive industry for cost effective processing. However, the impact toughness of MA steels is inferior to that of Q&T steels, which restrict their use in critical applications. Traditional methods of toughness improvement of MA steels had been: reduction in carbon level, addition of appropriate chemical element such as titanium apart from vanadium, or at times by increasing sulphur content. Further increase of toughness was achieved by reducing the amount of pearlite & microstructure control during the thermo-mechanical processing and subsequent cooling after forging.

In this work, the effect of hot deformation and isothermal cooling temperature on microstructure and mechanical properties of medium carbon microalloyed steel 38MnSiVS5 was studied. In an altogether different approach, it was attempted to improve the impact toughness through microstructure control by equilibrium cooling of samples. CCT diagram available from literature for 38MnSiVS5 microalloyed steel was taken as a guideline and isothermal cooling curves (650-250°C at 100°C interval) were superimposed on this CCT diagram to generate different microstructure phases in the samples processed. Starting with a UTS of 818 MPa and an impact toughness of 13 J for the untreated (as rolled) samples, it was possible to reach to a UTM of as high as 1555 MPa for the quenched, cryo-treated and tempered samples and an impact toughness value of 22.5 J for the samples isothermally cooled at 450°C. The best combination of tensile strength (844MPa) & impact strength (22.5J) was obtained for the sample subjected to 40% deformation at 1050°C & isothermally cooled at 450°C for 30 minutes. Therein, a combined microstructure of Ferrite, Pearlite & Bainite showed improvement in toughness as well strength.

**“Enhancement in Electrical Conductivity of Aluminium Alloys
for Rotors of Induction Motors by
Heat Treatment and Squeeze Casting”**

**Chinmali Onkar Mallikarjun (Physical Metallurgy)
(MIS: 121126002)**

**Guide Name-Prof. M. J. Rathod
(Email id – mjr.meta@coep.ac.in)**

ABSTRACT

Aluminium alloys 150.0 and A413.0 are used for electrical applications and it was found that after casting of this alloy, electrical conductivity decreases as compared to the declared values of ingot. Therefore; effect of Heat treatment on electrical conductivity of cast A413.0 alloy along with effect of pressure during solidification (squeeze casting) on electrical conductivity of 150.0 and A413.0 alloys were investigated in this work. The results showed that, electrical conductivity of heat treated as cast A413.0 alloys could be taken upto the declared values, whereas increasing casting pressure during solidification increased electrical conductivity of both the alloys to some extent, but could not achieve the declared electrical conductivity values. The enhancement in electrical conductivity for heat treated A413.0 alloy was observed due to morphological changes and precipitation of silicon after heat treatment whereas in case of squeeze cast A413.0 alloy the noted increment in electrical conductivity was due to modification of eutectic silicon, reduction in secondary dendrite arm spacing and minimization of defects such as porosities. In case of 150.0 alloy defect minimization was the only reason for improvement in electrical conductivity.

**SYNTHESIS OF TUNGSTEN (W) COATINGS BY HFCVD METHOD ON SS 316L
SUBSTRATE FOR DEVELOPMENT OF FUNCTIONALLY GRADED COATING
(FGC)**

**Dilip Chandrakant Deshpande (Physical Metallurgy)
(MIS No. 121126004)**

**Guide name: Prof. S.T. Vagge
(Email ID: stv.meta@coep.ac.in)**

Tungsten (W) thin film coating was successfully deposited on the stainless steel (SS 316L) substrate by Hot Filament Chemical Vapour Deposition (HFCVD).

Multi-wire pure tungsten (W) hot filament was used. Hydrogen & Oxygen were used as reactant gases. Filament heating & deposition was performed inside stainless steel chamber under vacuum. The filament current, distance between the filament & substrate surface, temperature at substrate surface, vacuum, reactant gas proportion & duration were precisely controlled during the deposition process.

Characterization was performed with XRD, SEM, EDX, Micro-hardness Tester & Optical microscope. Tungsten coated regions exhibited significantly higher hardness than the un-coated substrate.

The SEM & optical microscope images of the micro-indentation sites reveal that the tungsten coating at the edges of the depressions is intact without cracking or de-bonding, confirming strong adhesion of the tungsten thin film coating with the SS 316L substrate.

Uniform, adherent thin film tungsten coating on stainless steel substrate as an interlayer can facilitate highly adherent DLC coating system with intermediate WC layer, for improvement of functional properties of stainless steel, to suit Biomedical & other industrial applications.

Study of wear characteristics of cryotreated high speed steels

Ashutosh R. Hake (MIS No.121126006)

Under guidance of:

Prof. N. B. Dhokey,

Email: nbdhokey@yahoo.co.in

ABSTRACT

In the present work, wear characteristics and their interrelation with the measured parameters was studied for the selected grades of high speed steels. M2 and M35 specimens were hardened at 1200 °C, followed by triple tempering at 555 °C in the salt bath and similarly T42 specimens were hardened at 1215 °C, followed by tempering four times at 550°C in the salt bath. All three steels were cryotreated at -185 °C for varying length of cryosoaking period followed by soft tempering at 100 °C. The treated samples were characterized for residual stress, carbide density, XRD peak analysis, hardness and wear rate. XRD analysis confirmed that precipitation of tertiary carbides due to cryogenic treatment. Over the conventional treatment, the cryogenic treated M2 and M35 showed reduction in wear rate at the transition point by 90% while 55% in T42. The shift in wear transition was noted with increasing cobalt content and thus wear regimes were identified followed by discussion on wear mechanism.

Keywords: Cryosoaking period; Residual stress; Hardness; Particle shape; Wear transition.

“Development and Study of Wear Resistant, Low Friction Coating for AISI 4140 Steel”

Akshay A Joshi (MIS: 121126007)

Under guidance of:

Prof. Dr. Santosh S. Hosmani

Email: santosh.hosa@gmail.com

ABSTRACT

Good wear resistance along with low friction is a major challenge in tribology of industrial tool and machine component. In the current study, duplex coating system was developed for AISI 4140 steel to achieve the combination of excellent wear resistance and low coefficient of friction. Duplex coating was obtained by boronizing followed by WCC coating (also known as tungsten carbon carbide or tungsten-DLC). This coating had high wear resistance along with low friction of 0.1. WCC coating provides wear resistance and low friction coefficient, but when it comes to load bearing capacity this coating is unsuitable. Boronizing provides high load bearing capacity and gradient hardness. Boronizing due to its hard nature increases wear resistance. Pack boronizing method was used and the effect of container design and time on the boronizing behaviour of steel was studied. WCC coating was deposited by sputtering technique. Boronized and WCC coated specimens were investigated by using optical microscopy, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), x-ray diffraction (XRD) microhardness measurements, surface roughness measurements and adhesion test. X-ray diffraction (XRD) technique was used to investigate the presence of FeB and Fe₂B phase. Sliding wear and friction test performed using pin on disc test machine. Wear and friction behaviour of the duplex coating were compared with the normalized, hardened tempered, and boronized pins of AISI 4140 steel. EDS analysis was effective in understanding and chemical composition of wear debris. Worn out surfaces were observed under optical microscopy and SEM to study the wear mechanism. In this study, possibility of using boronizing plus DLC coating for low wear and friction was checked.

“Development and Study of Wear Resistant, Low Friction Coating for AISI 4140 Steel”

Akshay A Joshi (MIS: 121126007)

Under guidance of:

Prof. Dr. Santosh S. Hosmani

Email: santosh.hosa@gmail.com

ABSTRACT

Good wear resistance along with low friction is a major challenge in tribology of industrial tool and machine component. In the current study, duplex coating system was developed for AISI 4140 steel to achieve the combination of excellent wear resistance and low coefficient of friction. Duplex coating was obtained by boronizing followed by WCC coating (also known as tungsten carbon carbide or tungsten-DLC). This coating had high wear resistance along with low friction of 0.1. WCC coating provides wear resistance and low friction coefficient, but when it comes to load bearing capacity this coating is unsuitable. Boronizing provides high load bearing capacity and gradient hardness. Boronizing due to its hard nature increases wear resistance. Pack boronizing method was used and the effect of container design and time on the boronizing behaviour of steel was studied. WCC coating was deposited by sputtering technique. Boronized and WCC coated specimens were investigated by using optical microscopy, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), x-ray diffraction (XRD) microhardness measurements, surface roughness measurements and adhesion test. X-ray diffraction (XRD) technique was used to investigate the presence of FeB and Fe₂B phase. Sliding wear and friction test performed using pin on disc test machine. Wear and friction behaviour of the duplex coating were compared with the normalized, hardened tempered, and boronized pins of AISI 4140 steel. EDS analysis was effective in understanding and chemical composition of wear debris. Worn out surfaces were observed under optical microscopy and SEM to study the wear mechanism. In this study, possibility of using boronizing plus DLC coating for low wear and friction was checked.

ELECTRO DEPOSITION OF m-AMINO PHENOL ON LOW CARBON STEEL AND CORROSION PROTECTION STUDIES

Jaydeep M. Khade (MIS NO-121126008)

Guide name- Dr.P.P.Deshpande.

Email-pravinpd@hotmail.com

ABSTRACT

Galvanostatic deposition technique is used to obtain uniform and adherent poly m-aminophenol coating on low carbon steel samples in basic hydroalcoholic medium. These coatings were characterized by using FTIR spectroscopy and electrochemical methods. The existence of C–O–C etheric and –NH₂ groups in the FT-IR spectrum confirms presence of m-aminophenol. Corrosion rate of poly (m-aminophenol) in 3.5 % NaCl is found to be 2.14 mpy which is about 2 times lower than that of unpainted low carbon steel in neutral medium. Electrochemical studies reveal better corrosion resistance of poly (o-aminophenol) coated steel samples as compared to red primer coated steel in both short term and long term immersion. The protection efficiency of poly (m-aminophenol) and red primer intact coated steel just after immersion is 99.25% and 98.94% respectively. At the end of 196 hrs the protection efficiency decreased to 67.73 and 5.82%. The protection efficiency for poly (o-aminophenol) damaged coating and red primer damaged coating just after immersion is 98.41% and 96.97 % ohm/cm² respectively. At the end of 196 hrs the protection efficiency decreased to -26.51% ohm/cm² and -56.79% respectively. The poly (m-aminophenol) coating is more efficient in short term as well as long term corrosion protection than the red primer coating. In addition, poly (m-aminophenol) coated steel can withstand pin holes and exhibit better corrosion protection from drying and wetting cycles in atmosphere than uncoated low carbon steel. It is found that the poly (m-aminophenol) coating prevents corrosion of low carbon steel in 3.5 wt% NaCl by barrier mechanism.

Design and Development of Diamond Wire Saw Beads for granite cutting application

Pravin B. Nimbalkar (MIS No.121126011)

Under guidance of:

Guide - Prof. N. B. Dhokey,

Email: nbdhokey@yahoo.co.in

ABSTRACT

The diamond wire saw beads (DWSBs) find huge applications in the stone cutting industries. The properties of marbles/stones vary from mine to mine. The performance of Diamond wire saw beads, in terms of cutting productivity and the service life depend largely on its physical and mechanical properties. Besides hardness, the wear resistance of bead is a major parameter that affects wire-sawing operation. As part of the research work, a simulated wear test rig was fabricated in order to provide rotational motion (30 rpm) to wire saw bead (WSB) and tangential motion (1500 rpm) to granite disc where in bead was allowed to slide on the counter face disc of granite material and thus wear performance of wire saw bead was investigated at applied load of 0.5kg. The WSBs were fabricated by varying chemical composition of electrolytic iron powder, tin and bronze (75% Cu-25% Sn) and other essential elements like nickel, copper, tungsten, aluminum and tin. These powder mixes were blended in a mixer with a ball to powder ratio of 10:1 (by wt.) for 2 h. Then this blended powder was mixed manually with synthetic diamonds (5%) and 2% kenolube. The cobalt free WSBs were fabricated by using hot press sintering furnace at 820°C, 880°C, 900°C and 920°C hot-press sintering temperature. The effect of sintering temperature and various alloying elements on its properties like sintered density, hardness and wear rates were analyzed and compared with commercially available WSB containing 22% cobalt. It clearly shows that sinterability of wire saw bead enhances due to presence of liquefying agent such as Sn and bronze. The abrasive wear gives rise to the severe continuous grooving marks on granite disc, which might come due to exposure of diamonds. This is followed by discussion on wear mechanism provided in the given system. Overall, the cobalt free WSBs can be successfully fabricated at ordinary low cost (63%) and less energy (12%).

Design and Development of Soft Magnetic Composite (SMC) Component

Sandeep B. Patil (MIS No.121126013)

Under guidance of:

Guide - Prof. N. B. Dhokey,

Co- Guide: - Prof: V S Bandal

Email: nbdhokey@yahoo.co.in

ABSTRACT

Soft Magnetic Composites (SMCs) are basically pure iron powder particles coated with a very thin, electrically insulated magnesium compound coating. This makes it possible to have low power losses and also localized eddy currents in the individual particles. This report includes fabrication of toroidal core of size $\text{Ø } 30 \times \text{Ø } 20 \times 10$ mm and TRS specimen of size $31.7 \times 12.7 \times 5$ mm using Mg compound coated SMC (M-SMC). The die was designed in order to fabricate green compacts of SMC followed by curing at 600°C , 800°C and 1000°C in the controlled argon atmosphere in tubular curing furnace. The effect of temperature on uncoated and coated SMC cores was studied. The effect of doping of non-magnetic and magnetic elements in M-SMC powder was studied. The electrical and magnetic properties of cured SMC cores were analyzed by using Impedance Analyzer, B-H Analyzer and Power Analyzer and compared with commercial cores available in market. The mechanical properties like TRS, Micro-hardness are also studied. M-SMC core cured at 800°C showed the improvement in electrical properties at high operating frequency up to 13000 kHz and magnetic properties at an applied magnetic field of 800 A/m.

Synthesis of $ZnNb_2O_6$ Nano-ceramics, Polycarbonate- $ZnNb_2O_6$ Composites and their Dielectric Properties

Nikhil P. Silam(MIS No.121126015)

Under guidance of:

Guide - Prof. (Dr.) S. P. Butee,

Email: spb.meta@coep.ac.in

ABSTRACT

Nano-powders of $Zn_xNb_2O_6$ ($x=0.95-1.05$) and pure phase $ZnNb_2O_6$ ceramics were prepared by Co-precipitation (CPT) and Pechini technique respectively. The precipitation sequence of pure phase $ZnNb_2O_6$ during co-precipitation was studied by characterizing the powders retained on two different filter papers of sizes 41 and 44 number and those which have remained suspended in the solution after filtration. The samples were analyzed for XRD (done after pre-firing the powders at $700^\circ C$ for 2h), SEM and TG-DTA. The SEM microphotographs of coprecipitated powders demonstrated almost circular particle morphology and an average powder particle size of 50nm. XRD results of samples pre-fired at $700^\circ C$ showed crystalline $ZnNb_2O_6$ phase formation associated with peaks of either Nb_2O_5 or ZnO . TGA results demonstrated higher weight loss and DTA results exhibited peaks of desolvation reactions for the filtered particles (analyzed after drying). Interestingly, instead of an expected co-precipitation of ZnO plus Nb_2O_5 powders, it was observed that the reaction rather involved rapid initial precipitation of Nb_2O_5 particles characterized by its more initial occurrence, followed by relatively finer ZnO powder precipitation occurring sluggishly towards the end.

The powders were subsequently subjected to calcination and sintering to obtain dense single columbite phase ceramics and their dielectric properties were studied. Minimum calcination temperature to form pure $ZnNb_2O_6$ in case of Pechini was $800^\circ C$, whereas, in case of CPT all the constituents did not react even after calcination at $900^\circ C$. By varying the compaction pressures and sintering temperatures, a density of almost 80 % maximum could be achieved in the ceramics pellets made using powders from both routes. Sintering temperature required for samples made by Pechini was $1000^\circ C$, whereas, it was $1200^\circ C$ for samples made by CPT route.

The XRD pattern of CPT powders demonstrated single phase ZnNb_2O_6 only after sintering at 1200°C . Chemical compound was analyzed by XRD and dielectric properties were studied by precision impedance analyzer, which showed: $\epsilon_r = 25.5$ and $\tan \delta = 0.02$ for ZnNb_2O_6 made by CPT technique and $\epsilon_r = 16.3$ and $\tan \delta = 0.007$ for ZnNb_2O_6 made by Pechini technique. The highest dielectric constant value of 28.5 with $\tan \delta$ of 0.03 was obtained for $\text{Zn}_{1.05}\text{Nb}_2\text{O}_6$ phase.

The pure ZnNb_2O_6 calcinated powders obtained from both routes were also used to fabricate the polymer matrix composites by using them as fillers in polycarbonate (PC) matrix. ZnNb_2O_6 (ZN) was varied from 0 wt. % to 60 wt. % in the PC matrix. The dielectric and microhardness properties of the composites made were studied. The dielectric constant of the composites measured at 1 MHz increased approximately to 18 and 10 in case of powders made by CPT and Pechini respectively as against a dielectric constant of 3 (at 1MHz) obtained for pure Polycarbonate. The dissipation factor of these composites varied in the range of 0.012 to 0.029. SEM microphotographs showed a uniform dispersion of ZN in the PC matrix up to 40 wt. % addition. The XRD of composites made using CPT powders showed multi-component phases, whereas, those made using Pechini powders showed pure ZN phase. The microhardness of the composites increased upto 24.2 Hv (for Pechini) and 21.6 Hv (for CPT) as compared to pure PC, which was 16 Hv. These results demonstrated the suitability of these composites as well as the ceramics pellets made as class one type dielectric materials for resonant circuit applications.

Keywords: Co-Precipitation, Dielectric Properties, Pechini, Polymer Matrix Composite and Zinc niobate (ZnNb_2O_6).

“Effect of Metallic Powders on the Electrical Properties of the Polycarbonate Matrix Composites”

**Unmesh Ashok Vibhute (Physical Metallurgy)
(MIS-121126016)**

Guide Name-Dr. R. K. Goyal
(Email id – rkg.meta@coep.ac.in)

ABSTRACT

The polymer matrix composites are widely studied for the applications in electrostatic discharge (ESD), electrostatic painting (ESP), and electromagnetic interference (EMI). The aim of this project was to study the effect of stainless steel (SS) and cobalt (Co) powders on the electrical properties of the polycarbonate (PC) matrix composites prepared by solution method followed by hot pressing. The experimental and theoretical densities of both PC/SS and PC/Co composites were close to each other. Dispersion of SS and Co particles in the PC matrix was studied by optical microscopy and scanning electron microscope (SEM). It was found that 3-dimensional network of the SS or Co particles formed in the PC matrix at 50 wt% and 70 wt% filler content, respectively. The conductivity increased from 1.4×10^{-15} S/cm for pure PC to 0.6×10^{-3} S/cm and 4.1×10^{-3} S/cm for 70 wt% of SS and 90 wt% of Co filled composites. The improvement in the conductivity of the composites was about eleven orders of magnitude than that of pure PC. The dielectric behaviours of PC/SS and PC/Co composites were also investigated as a function of frequency and volume fraction of fillers. Microhardness of the composites increased with increasing SS/Co content in the PC matrix. The linear CTE determined for the temperature range of 40-80 °C (below T_g) decreased from 103×10^{-6} /°C for pure PC to 55×10^{-6} /°C for PC/SS (50 wt%) composites.