

A  
Dissertation report  
On  
**"Wear and Corrosion behavior of Spheroidal  
Graphite Cast Iron in Biodiesel Blends"**

Submitted in partial fulfilment of the requirement  
Of the degree of

**Master of Technology**

(Process Metallurgy)  
By

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Under the guidance of

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July 2017

## **ABSTRACT**

Biodiesel, as an alternative fuel is steadily gaining attention to replace petroleum diesel partially or completely. Cast Iron has been used in many industrial applications for many years because of its thermal conductivity, good machinability, vibration damping, good strength properties and wear resistance. The aim of this work is to evaluate the wear and corrosion behavior of spheroidal graphitic cast iron in various biodiesel blends such as B100 (100% biodiesel), B20 (20% biodiesel), B10 (10% biodiesel), B5 (5% biodiesel), B0 (100% diesel). The tribological and corrosion performance of biodiesel on cast iron is crucial for its application in automobiles. Cast irons used in automobile engine parts as piston ring material. As biodiesel percentage increases, there is a formation of lubrication layer of ester compounds in palm biodiesel, which results in boundary lubrication which increases wear resistance but increases corrosion of the cast iron. Therefore, high wear and corrosion resistance is critical for ensuring a long life for the cast iron in biodiesel environment. Very less work had been done to evaluate the corrosion and wear behavior of heat treated cast iron in various biodiesel blends. Results showed the phenomenon of selective leaching in the most corrosive media i.e. in palm biodiesel due to fatty acids. Comparisons needed to be done to find which biodiesel blend is better for cast iron as piston ring to ensure longer life. The obtained results in each blend are compared and correlated with each other. The Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) investigation was utilized to analyze the structure and surface morphology.

**Keywords:** spheroidal graphite cast iron, wear, corrosion, palm biodiesel, petroleum diesel, piston ring.

**A Dissertation Report  
on  
Galvanostatic Deposition of Zinc Phosphate Coating on Low Carbon Steel  
using Nano Zinc Oxide and Electrochemical Studies**

**Submitted in partial fulfilment of the requirements**

**of the degree of**

**Master of Technology  
(PROCESS METALLURGY)**

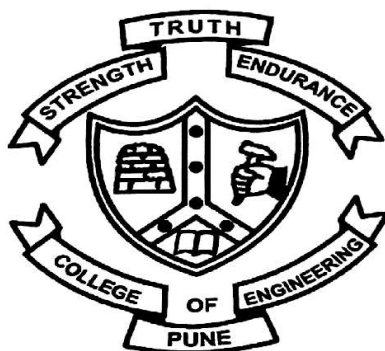
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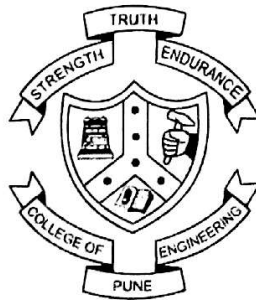
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## **ABSTRACT**

Zinc phosphate coating was developed by galvanostatic method and have been optimized in terms of corrosion resistance. Nano Zinc oxide particles were incorporated into optimized zinc phosphate coating. The crystal structure and chemical composition of coating was studied by scanning electron microscopy and energy dispersive spectroscopy respectively. Corrosion protection performance of the coated low-carbon steel samples in 3.5 wt % sodium chloride solution was evaluated using electrochemical technique. The corrosion rate of Nano ZnO incorporated zinc phosphate coating on low carbon steel was found to be 1.89 mpy which is about 5 times lower than that of uncoated low-carbon steel and 1.2 times lower than that of normal ZnO incorporated zinc phosphate coating. The study reveals the possibility of using Nano ZnO for corrosion protection.

*Keywords:* Galvanostatic deposition, Nano ZnO, phosphate coating, potentiodynamic polarisation study, electrochemical impedance spectroscopy, corrosion rate.

A  
**Dissertation Report**  
ON  
**Cryogenic Treatment and Standardization of Soft Tempering  
Temperatures for High Speed Tool Steels**  
Submitted in partial fulfilment of the requirements of the degree of  
**Master of Technology**  
In  
**Process Metallurgy**  
Submitted By  
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2016-17

## Abstract

In the present work, dimensional distortion and standardization of soft tempering temperatures were 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 a muffle furnace. These two types of steels were then cryotreated at -185 °C for 16 h cryosoaking period followed by soft tempering at 50°C, 100°C, 150°C, 200°C and 250°C. The treated samples were measured for dimensional distortion and characterized for hardness and wear rate. Over the conventional treatment, the cryogenic treated M2 and M35 showed reduction in wear rate at the transition point by 93%. The shift in wear transition was noted with increasing cobalt content and wear regimes were identified followed by discussion on wear mechanism.

**Keywords:** Cryosoaking period; Hardness; Grain size; Wear transition.

A  
Dissertation Report On  
**Standardization Process of synthesis of metallic iron from mill  
scale**

Submitted in partial fulfillment of the requirements  
of the degree of  
Master of Technology  
(PROCESS METALLURGY)

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2016-17**



## ABSTRACT

The mill scale is known for its richness in iron content approximately 72%. In present work, mill scale was milled and oxidized to  $\text{Fe}_2\text{O}_3$  in ball milling and tubular furnace to know by hydrogen gas which results in production of reduced iron powder. The reduction was carried out at various temperatures (850-925°C) during different time ranging between 60,120,180 min in an atmosphere of pure  $\text{H}_2$ . The produced iron powder was characterized by chemical analysis, X-ray diffraction and scanning electron microscopy. The maximum iron content (97.1% Fe) in the iron powder was obtained by reduction of  $\text{Fe}_2\text{O}_3$  at 875°C for 180 min. The reduced iron powder was then consolidated at different compacting pressure ranging from 500MPa to 700MPa. These compact were sintered at 1120°C in 90% $\text{N}_2$ +10% $\text{H}_2$  atmosphere.

**Key Word:** Mill scale, Reduction by hydrogen, Iron powder.

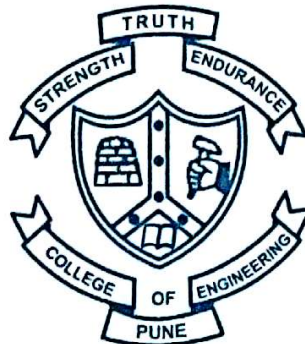


A  
Dissertation Report On  
**Design and Development of Pressure-less Sintering For  
Diamond Cutting Tool**

Submitted in partial fulfillment of the requirements  
of the degree of  
Master of Technology  
(PROCESS METALLURGY)

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2016-17

## Abstract

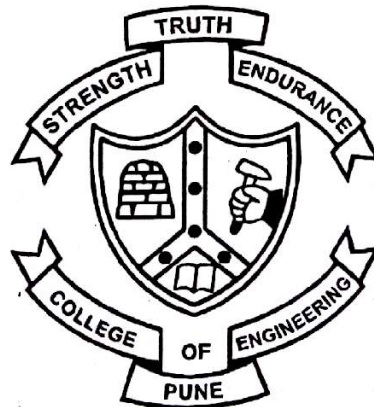
The diamond wire saw beads (DWSBs) find huge applications in the stone cutting industries. The performance of Diamond wire saw beads, in terms of cutting productivity and the service life depend largely on its physical and mechanical properties. Besides hardness, the wear resistance of bead is a major parameter that affects wire-sawing operation. As part of the research work, WSBs were fabricated by varying chemical composition of Reduced iron, atomized iron, electrolytic iron powder and bronze (85% Cu-15% Sn) as liquid phase additives and other essential elements like nickel, tungsten, and tin. These powder mixes were blended in a mixer for 1h. Then this blended powder was mixed manually with synthetic diamonds (5%) and (2%) paraffin wax. The WSBs were fabricated by using pressureless sintering at pressure of 400 MPa and 870°C sintering temperature. It clearly shows that sinter ability of wire saw bead enhances due to presence of liquefying agent such as bronze. The effect of pressure and properties like green density, sintered density, hardness and wear rate on Pressureless sintering WSBs made from Reduced iron, Atomized iron and Electrolytic iron were analyzed.

A  
DISSERTATION REPORT  
ON  
**Wear Resistant Coating of Aluminium Alloy by Laser Assisted  
Thermit Reaction**

Submitted in partial fulfillment of the requirements  
of the degree of  
**Master of Technology  
(Process Metallurgy)**

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## Abstract

Thermit reaction is used in industry mainly in fusion welding. However, in this work, it is used to make wear resistant coating on aluminium alloy substrate using laser heat to control the reaction. The aim of this study is to increase wear resistance and hardness of aluminium 6068 alloy substrate. The substrate was initially coated with slurry of powder mixture of  $\text{Al}:\text{Fe}_2\text{O}_3$  in alcohol to a constant average thickness of  $120\text{ }\mu\text{m}$ . A continuous wave fibre laser beam with the maximum power of  $400\text{ W}$  was used to heat the coated layers. A constant scan spacing of  $2.8\text{ mm}$  was used and the shielding provided with argon gas. Laser clad layers were produced by varying the parameters like amount and ratio of aluminium and iron oxide powders in the mixture, laser power and scanning speed. The coated specimens were analysed for microstructure, coating thickness, coating composition along with hardness and wear behaviour of the coatings. With the scanning speed of  $1\text{ mm/s}$  and laser power of  $220\text{ W}$ , a maximum coating thickness of  $349.5\text{ }\mu\text{m}$  for the powder with  $75\text{Al}:25\text{Fe}_2\text{O}_3$ ; it resulted in hardness of  $356\text{ HV}_{0.1}$ . XRD analysis indicated that the coated layer is a composite mixture of phases like  $\text{Al}$ ,  $\text{Fe}$ ,  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$ , confirming the thermit reaction during laser heating.

A  
**Dissertation Report**  
ON  
**Fabrication of Thermoelectric Material- Manganese Silicides ( $\text{MnSi}_{1.73}$ )  
through Powder Metallurgical route and analysing its Thermoelectric  
Properties**

Submitted in partial fulfilment of the requirements of the degree of  
**Master of Technology**

In  
**Process Metallurgy**

Submitted By

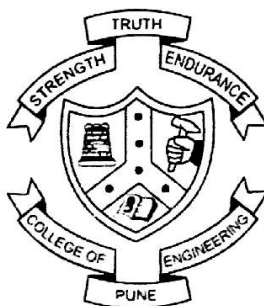
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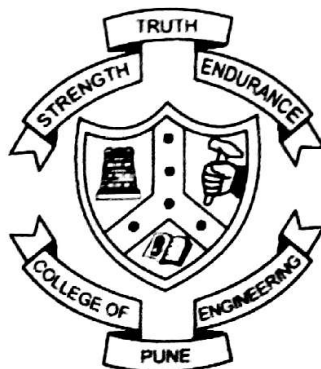
## Abstract

Owing to the increased demand for energy and the negative environmental consequence of energy generation from fossil fuels, thermoelectric materials can be used to convert waste heat into electricity, have received renewed attention in the past decades. Thermal management and energy crisis have been two major problems in this 21st century. Amongst the thermoelectric materials, Manganese-Silicide (MnSi) is emerging as an alternative promising high temperature semiconductor useful for temperature from 600-900°C.

Mechanical Alloying process has been used to produce Manganese-Silicides (MnSi). The powders of Manganese (99.6%, less than 10 $\mu$ ) and Silicon (98.5%, 200 mesh) were blended in an attritor mill (AM) for 6-10h. Then the milled powders were hot compacted by using Hot Press Sintering (HPS) with the permutations of temperature (900-1000°C), pressure (35-45MPa) and holding period (4-8min). The compacted samples were annealed in vacuum furnace at 900°C for 12h holding period. Phase transition during the process was investigated using DTA, XRD, SEM and EDS. Thermoelectric properties were determined by using in-house developed Seebeck set-up. The Seebeck coefficient was found to increase with increase in temperature with the maximum of around 67.5 $\mu$ V/K at 978K and the ZT value was estimated to be around 0.85 at the same temperature.

**Keywords:** Manganese-Silicides, Annealing, Thermoelectric, Mechanical alloying.

A  
**Dissertation Report**  
On  
**Evaluation of Heating and Cooling Trend of Solar Salt in Heat  
Exchanger Behaving as a Thermal Storage**  
Submitted in partial fulfillment of the requirements of the degree of  
**Master of Technology**  
In  
**Process Metallurgy**  
  
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## ABSTRACT

Use of solar thermal energy without its conversion into other forms is most efficient. Several other methods requires conversion of thermal energy to electrical energy which is further converted to chemical energy in battery or is converted to potential or kinetic energy through pump or motor . Inefficiencies in thermal to electrical energy conversion are compounded by inefficiencies that may exist in the conversion of stored energy to usable energy.

Major drawback of solar energy is variation of solar intensity with time and weather condition. To minimize this drawback and to extend the solar generation period when solar is not available thermal energy storage coupled with heat exchanger is must.

Solar thermal applications with integrated energy storage operate for longer duration and increase reliability to the system. Performance and size of thermal storage depends on efficiency of heat exchanger to transfer maximum heat from receiver to thermal storage using heat exchanger and proper selection of material for thermal storage.

For thermal energy storage a non-eutectic molten salt mixture consisting of 60 wt % sodium nitrate ( $\text{NaNO}_3$ ) and 40 wt % potassium nitrate ( $\text{KNO}_3$ ) is most suitable. Advantages of molten salts are the high thermal stability, relatively low material costs, high heat capacity, high density, non-flammability and low vapor pressure. Due to the low vapor pressure pressurized vessels are not required. Compared to organic heat transfer fluids the melting point of molten salts is higher.

The project aims towards design and fabrication of innovative heat exchanger which acts as a thermal storage. Instrumentation with cluster of thermocouple to observe the heating and cooling temperature of salt bath at different depth and location at regular interval of time with and without insulation.

It was observed that thermal energy storage capacity is increased with insulation and solar salt can retain heat at higher temperature for maximum duration. Peak rise in temperature of solar salt is greater than without insulation. At the same time the temperature distribution with insulation is more uniform throughout the salt bath.

A  
Dissertation report  
On  
**"Corrosion and Wear behavior of medical grade  
AISI 316L stainless steel in Simulated Body Fluids"**

Submitted in partial fulfilment of the requirement  
Of the degree of

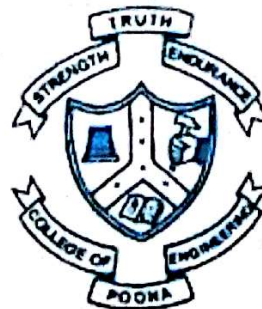
**Master of Technology**

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July 2017

## ABSTRACT

Metals are widely used in number of applications in medical field for internal support as transplant and biological tissue replacements. Stainless Steel, Co-Cr alloys and Ti alloys are mostly used biomaterials in biomedical applications. Development of biomaterials with high corrosion and wear resistance is critical for ensuring a longer life for the biomaterial. The aim of this work is to evaluate the corrosion and wear behavior of medical grade 316 L austenitic stainless steel as a biomaterial in simulated body fluids such as 3.5 wt% NaCl, Hank's Balanced Salt Solution (HBSS), saline water and natural sea water as lubricants and as electrolytes. AISI 316 L has better chemical bio compatibility and mechanical properties which are comparable with that of human bone. The wear rate was found to be more in saline water and less in sea water than other lubricants. The corrosion rate was found to be more in sea water and less in saline water than all other electrolytes. The Scanning Electron Microscopy (SEM) investigation was utilized to analyze the microstructure and surface morphology. The obtained results are compared, correlated and presented in the report. Various wear phenomenons have been observed such as abrasive, adhesive, fatigue wear on the surface of SS 316 L after the wear tests. Results showed the phenomenon of pitting corrosion on the metal surface. The alloy gets passivated in all electrolytes which can be attributed to oxidizing nature of the concentrated acids. Very few researchers have studied the corrosion and wear behavior of SS 316 L in saline water even though it is one of the most severe lubricants for wear in case of 316 L stainless steel. As saline water is used for patients as body fluids, it is essential to understand its interaction with implants. Also, very less work has been reported on comparative study of corrosion and wear behavior of SS 316 L in various body fluids. The corrosion and wear rate of SS 316 L in saline water has been compared with other simulated body fluids.

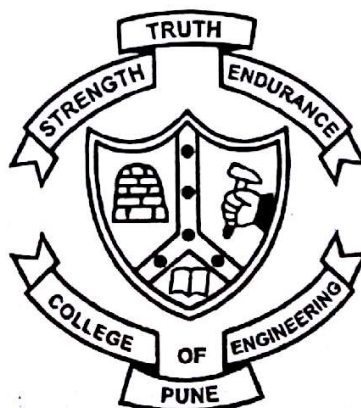
**Keywords:** saline water, stainless steel, biomaterial, wear, lubricants, implant, body fluids, electrolytes, pitting corrosion, passivated, etc.

A  
DISSERTATION REPORT  
ON  
**Effect of weld ferrite, heat input, and coating flux on impact energy  
of SS308L and SS316L tested at -196<sup>0</sup> C**

Submitted in partial fulfillment of the requirements  
of the degree of  
**Master of Technology**  
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## ABSTRACT

In the present investigation, E308L and E316L austenitic stainless steel electrodes with three different delta-ferrite ( $\delta$ -Fe) contents and two different coating flux types were subjected to two different heat inputs during Shielded Metal Arc welding (SMAW). Effect of these parameters on impact toughness of E308L and E316L shielded metal arc weldments at  $-196^{\circ}\text{C}$  were investigated. Twelve weld assemblies were evaluated for E308L electrode and twelve for E316L electrode. These were prepared to obtain three ranges of weld ferrite number (ferrite no. 0 to 2, 4 to 6, 8 to 10) in each. Two coating fluxes (-15 type and -16 type) were used to prepare the weld with two different heat input ranges (0.8 to 1 kJ/mm and 1.3 to 1.5 kJ/mm). The impact toughness requirement of weld metal is governed by design codes. The ASME code which is widely accepted in engineering design recommends the use of lateral expansion as obtained in a Charpy Impact test. The minimum observed value should be  $\geq 0.38$  mm. The other approach is that of European code (TUV) which proposes a minimum value of Charpy energy  $\geq 32$  Joules. In this investigation both these parameters were evaluated for arriving at optimized welding parameters. From the results obtained it is found that the low weld ferrite range with low heat input and -15 coating type (basic flux) electrode give comparatively higher impact energy and lateral expansion at cryogenic temperature ( $-196^{\circ}\text{C}$ ). The optimized welding parameters also result in a weld that satisfies the codal requirement.

**Keywords:** E308L, E316L, Shielded Metal Arc Welding (SMAW), Cryogenic temperature, delta-ferrite ( $\delta$ -Fe) number, Microstructure, Impact toughness, Lateral expansion.