KAUNAS UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING AND DESIGN

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INFLUENCE OF HARD METAL AND CAST IRON POWDER ON PROPERTIES OF SURFACED COATINGS

Master's Degree Final Project

Supervisor
Assoc. prof. dr. Regita Bendikienė

KAUNAS, 2016

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Mechanical Engineering (621H30001)

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"Influence of Hard metal and Cast Iron Powder on Properties of Surfaced Coatings"

DECLARATION OF ACADEMIC INTEGRITY

20 May 2016

Kaunas

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Ramamoorthy Yashwanth Kumar. Influence of Hard metal and Cast Iron Powder on Properties of Surfaced Coatings. *Master's Final* Project / supervisor assoc. prof. dr. Regita Bendikiene; Faculty of Mechanical Engineering and Design, Kaunas University of Technology.

Study area and field: Mechanical Engineering, Technological Sciences

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SUMMARY

Wear of machinery elements are general problems in engineering applications. The various surface coating techniques are enhanced to improve the wear resistance of the elements. There are many surface coating technologies, such as plasma spraying, thermal spraying, hard facing, laser cladding, chemical and physical vapor deposition processes. Hard facing technique is used for surfacing. Surfaced coatings are made of different composition to reduce the wear rate of metals for the machining process. In this research project, we have used the mixture of composition for coatings. The tungsten carbide as hard metal and cast iron chips are collected and used for the scrap materials. The selection of cast iron waste helps to improve the carbide content for increasing the mechanical strength. For high deposition of this mixture, we have used submerged arc welding as economical welding. The silicon carbide and silicon oxide are prepared by us and used as a flux for welding to improve the chemical composition of material. The plain carbon steel is used as base metal for surfacing. After the welding process, testing of hardness are done before and after tempering at 500 °C,550 °C and 600 °C for improving the toughness, weight loss of coatings to calculate wear and optimized the microstructure of the coatings. These results are compared with others research results and the waste materials are utilized in this composition to analyze the mechanical properties of the coatings.

Ramamoorthy Yashwanth Kumar. Kietlydinio ir ketaus miltelių įtakos apvirintų dangų savybėms tyrimas. *Master's Final* Project / supervisor assoc. prof. dr. Regita Bendikiene; Fakultetas, mechanikos inžinerijos ir dizaino, Kauno technologijos universitetas.

Studijų sritis ir lauke: mechaninės inžinerijos, technologijos mokslų

Keywords: *suvirinimas po fliuso sluoksniu, fliuso mišinys, miltelių mišinys, atleidimas, mikroskopinė analizė, atsparumas dilimui.*

Kaunas, 2016. 54p.

SANTRAUKA

Mašinų elementų dilimas viena iš dažniausiai pasitaikančių problemų inžinerijoje. Elementų atsparumas dilimui gali būti didinamas naudojant įvairias dangas. Yra nemažai paviršiaus sustirpinimo technologijų: plazminis purškimas, terminis purškimas, sukietinimas, lazerinis sustiprinimas, fizikinis ir cheminės nusodinimas iš garų fazes. Sukietinimo technologijos naudojamos sukurti atsparų sluoksnį. Skirtingos sudėties sluoksniai naudojami siekiant sumažinti metalų lydinių dilumą. Šiame darbe buvo naudojami volframo karbido ir ketaus drožlių milteliai. Ketaus miltelių paskirtis – padidinti anglies kiekį dangoje, tuo pačiu padidinti kietųjų karbidų susidarymo tikimybę. Dangoms sudaryti buvo naudojamas apvirinimas po fliuso sluoksniu. Silicio karbido ir silicio oksido milteliai buvo naudojami vietoje fliuso. Apvirinimui buvo naudojami anglinio plieno ruošiniai. Po apvirinimo bandiniai buvo termiškai apdorojami atleidžiant skirtingose temparetūrose: 500 °C, 550 °C ir 600 °C. Atleisti bandiniai buvo dilinami ir matuojamas jų masės pokytis. Rezultatai palyginti su kitų autorių darbais.

KAUNAS UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING AND DESIGN

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Head of Mechanical Engineering Department ______________________ *(Signature, date)*

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Kęstutis Pilkauskas
(Name, Surname)

MASTER STUDIES FINAL PROJECT TASK ASSIGNMENT
Study programme MECHANICAL ENGINERING - 621H30001

Approved by the Dean's Order No. V25-11-7 of May 3rd, 2016 y

Assigned to the student **YASHWANTH KUMAR RAMAMOORTHY**
(Name, Surname

1. Title of the Project

Influence of Hardmetal and Cast Iron Powder on Properties of Surfaced Coatings

2. Aim of the project

The aim of this master thesis is to overlay layers of weld suitable for high wear resistance layer (coating) and to presents results of the composition of various types of the mixture with fluxes used in submerged arc welding.

3. Tasks of the project

Summary, Introduction, 1. Literature overview, 2. Methodology, 3. Experimental results and discussions, 4. Conclusions, References.

4. Specific Requirements

Conducting the final experimental project thesis according to KTU regulations and requirements.

5. This task assignment is an integral part of the final project

6. Project submission deadline: 2016 May 20th.

Task Assignment received ______________________ ______________________
(Name, Surname of the Student) *(Signature, date)*

Supervisor ______________________ ______________________
(Position, Name, Surname) *(Signature, date)*

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INTRODUCTION

The business today is still depending on deterministic models created over a century back, regardless of the certainty that variability is an inherent feature for all machining processes. Subsequently, in this proposition, we build up a stochastic tool life show and propose new methodologies for deciding the most the most efficient substitutional coatings for metal machining process time. Most frequently applied to metals. It is being used in various areas such as "metal" and "wood" cutting industries and various applications. Using tools for a long time in machining makes them wear and lose their strength and sharpness.

The aim of this master thesis is to overlay layers of weld suitable for high wear resistance layer (coating) and to presents results of the composition of various types of the mixture with fluxes used in submerged arc welding and to optimize the surface morphology of the tools and wear resistance test has been done.

The main tasks of this thesis include:

- To select metal powder composition for preparation of coating.
- To exam mechanical properties;
- To apply heat treatment for the welded specimen for further procedure.
- To perform microstructural analysis.
- Examine the wear resistance of the obtained coatings.

-As of late, numerous hard facing composites have been proposed for surfacing keeping in wear resistance.

To overcome this problem a special technique called "hard facing" is followed. Hard facing is the metalworking process to harder the surface of the base metal, where the bulk materials surface is given a protective layer of another material having more superior properties than those of the bulk material. It makes the surface of the tool harder and more rigid. The surface Engineering is employed in bulk material to changes of the properties of the surfaces. The behaviour of characteristics of the surface dependent on the layer of material contacts surfaces area of the material. The results presented in this paper are based on mechanical properties of the surfaced and commercial coatings and are calculated by analyses of the hardness and abrasive wear resistance. Additive value of this research is a possibility to recycle industrial waste, which collects in immense amounts in the metals working industry.

1. LITERATURE REVIEW

1.1 TECHNOLOGIES USED FOR COATINGS

Physical vapour Deposition

PVD techniques utilized as a part of creation are fundamentally two in nature: heat evaporation by the resistance of heat or by utilizing an electron beam heating and sputtering, a thermal procedure. Changes and increases are made to the essential methods of PVD to permit diverse covering materials and substrate sorts to be suited. The process increases intended to change the development nanostructure or creation of the film through control of the needy variables recorded above, include bombardment of the developing film by the latent high vitality and/or responsive particles, substrate heating, synthesis the climate and the incomplete weight, rate , and edge of the rate of steam. Staying coefficient is characterized as the proportion of the gathering molecules to impinging atoms [1].

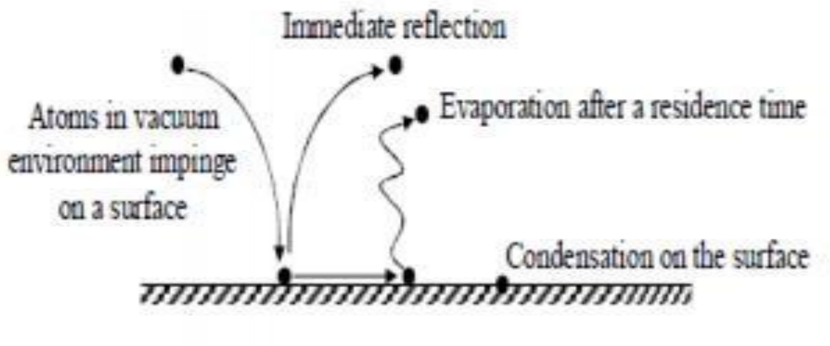


Figure 1.1.PVD Process [1]

Sputtering

Sputtering is a process of transfer of kinetic energy. When a particle hits a surface, the processes followed incident particle with kinetic energy, the angle of incidence, the binding energy of surface atoms, and the mass of the particles collide. In sputtering, ion particles generally incident on, and they can be accelerated by an electric potential applied. If the kinetic energy with which collide with the surface is less than approximately 5 eV, which is likely to be reflected or absorbed on the surface. When the kinetic energy exceeds surface atom bond energy sectors damage will occur on the surface of atoms on enforced as one new positions red. In incident ion kinetic energies above the threshold, typically 10 to 30 eV. Atoms can be dislodged or sputtered from the surface. In normal incidence, multiple internal collisions are required, but in angles inferiors, sputter atoms directly may occur. Atoms and Ions bombed can be condensed into a substrate to form thin Film coatings. Ions bombard the target material at the cathode.

Atoms target cathode is expelled by the Energy and momentum transfer. Sputter atoms from White deposit on the substrate (anode) [2].

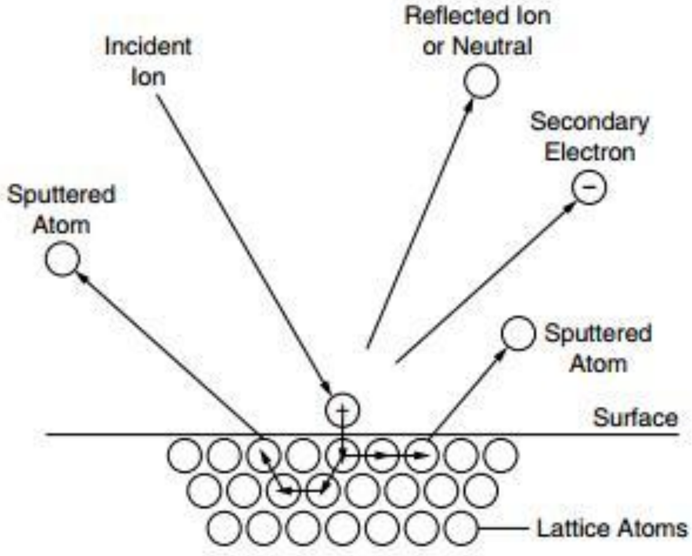


Figure 1.2.Ion impact during sputtering [2]

Radio Frequency Sputtering

Non-leading materials cannot be sputtered directly with a connected dc voltage. Because of positive charge aggregation on the target surface. On the off chance that an air conditioner capability of sufficiently high recurrence is connected, a compelling negative predisposition voltage is created the few such electrons touch base at the objective that while it is certain equivalents the few particles arrive while it is that negative. Since the mass of the electron is little with respect to particles show, the objective is certain for just a brief timeframe, and testimony rates for rf diode are practically proportionate to the dc diode. This resulting negative predisposition sputtering of a protecting allows target. The recurrence utilized as a part of pragmatic applications is most usually 13.56 MHz, a radio recurrence band for industrial purposes allocated by the Federal Communications Commission. RF sputtering and in addition protectors allows conductors and semiconductors to be kept with the same gear and Present sputtering at a lower permits weight (5 to 15 × 10-3 torr). One noteworthy drawback of rf sputtering is the requirement for electromagnetic protecting to hinder the rf radiation. Additionally, the force supplies, coordinating system, and different parts necessary to achieve a full rf system are exceptionally mind boggling [2].

Chemical Vapour Deposition

Coatings are covered utilizing CVD strategies demonstrate the great scope and bond to the base metal. They have the disadvantage high process temperatures to ceramics thin production films over the base metal. Yet, in PVD strategies furnishes films with fine bond at low temperatures, despite the fact that its strides scope limit keeps the uniform covering of pottery over the base metals with complex shapes. The films with high adhesive are delivered at low temperatures. [2]

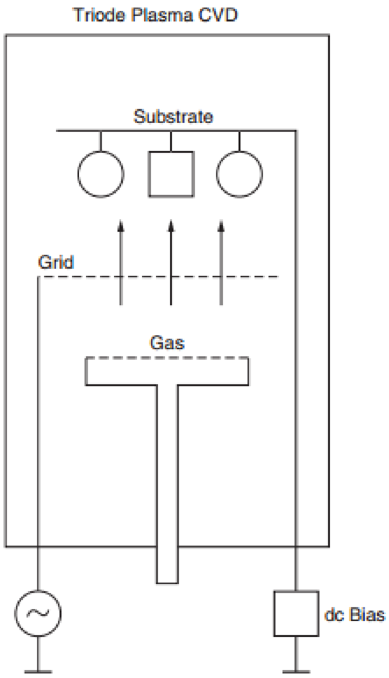


Figure 1.3.Plasma CVD system [2]

Flame Spray Processes

High Velocity Oxy-Fuel Spray (HVOF)

The high-velocity oxy-fuel (HVOF) a technique is a by and large late extension to the gathering of heat spraying. As it uses a supersonic plane, isolating it from warm splashing, the speed of atom impact on the substrate is much higher, realizing upgraded covering qualities. The framework contrasts from flame spraying by an improvement of the nozzle in transit out of the gun. Fuel gases of propane, propylene, acetylene, hydrogen, and normal gas can be used, furthermore, liquid fills, for instance, light oil. In HVOF, a fuel gas, (for example, hydrogen, propane, or propylene) and oxygen are utilized to make an ignition jet at temperature of 2500°C and 3100°C. The molten particles are then propelled with high velocities towards the prepared substrate. The heat imparted into the very fine powder particles.

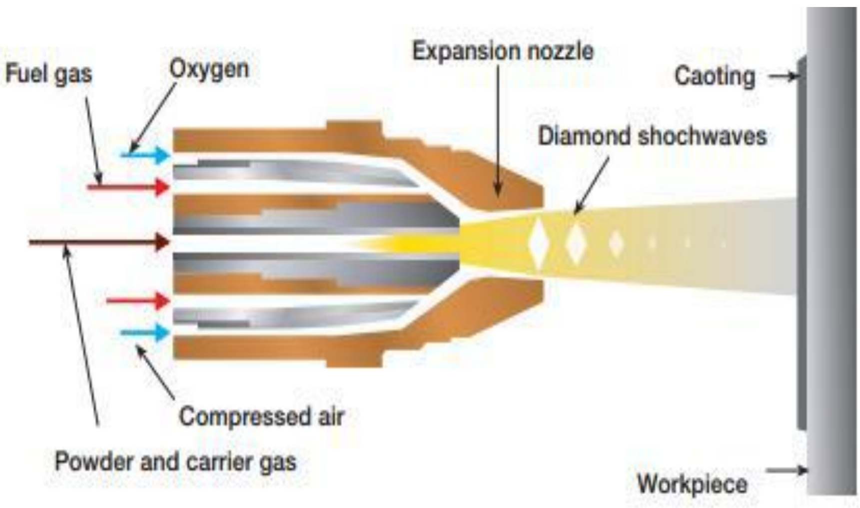


Figure 1.4.HVOF process [2]

Plasma spray process

A high frequency arc is ignited between an anode and a tungsten cathode. The gas flowing through between the electrodes (i.e., He, H2, N2 or mixtures) is ionizes such that a plasma plume several centimetres in length develops. The temperature within the plume can reach as high as 16000° K. The spray material is injected as a powder outside of the gun nozzle into the plasma plume, where it is melted, and hurled by the gas onto the substrate surface. Plasma coatings have roughly one to two percent porosity. Controlled air plasma splash can be close completely thick.

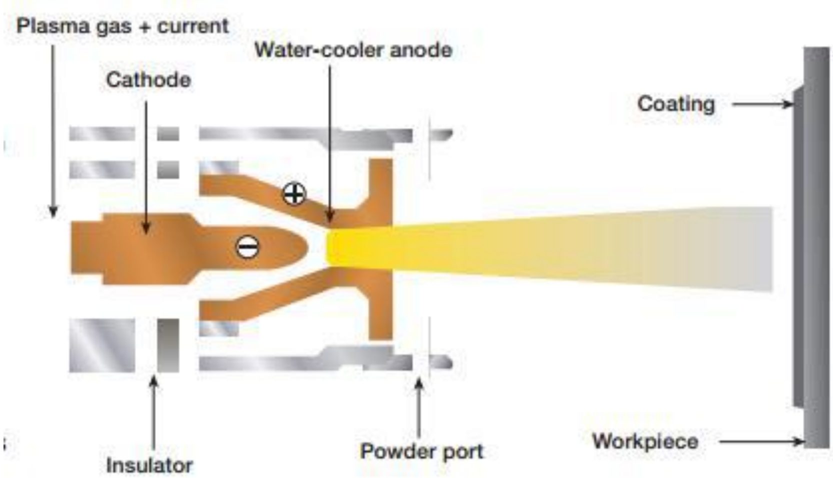


Figure 1.5.Plasma spray process [2]

Table 1.1.Coating process [2]

Coating Process	Typical Coating Thickness	Coating Material	Characteristics	Examples
PVD	1 – 5 µm (40 – 200 µin)	Ti(C,N)	Wear resistance	Machine tools
CVD	1 – 50 µm (40 – 2000 µin)	SiC	Wear resistance	Fiber coatings
Baked Polymers	1 – 10 µm (40 – 400 µin)	Polymers	Corrosion resistance, aesthetics	Automobile
Thermal Spray	0.04 – 3 mm (0.0015 – 0.12 in)	Ceramic and metallic alloys	Wear resistance, corrosion resistance	Bearings
Hard Chromium Plate	10 – 100 µm (40 – 4000 µin)	Chrome	Wear resistance	Rolls
Weld Overlay	0.5 – 5 mm (0.02 – 0.2 in)	Steel, Stellite	Wear resistance	Valves
Galvanize	1 – 5 µm (40 – 200 µin)	Zinc	Corrosion resistance	Steel sheet
Braze Overlay	10 – 100 µm (40 – 4000 µin)	Ni-Cr-B-Si alloys	Very hard, dense surface	Shafts

Table.1.2.Coating material [2]

Material Class	Typical Alloy	Characteristics	Example Application
Pure metals	Zn	Corrosion protection	Bridge construction
Self-fluxing alloys	FeNiBSi	High hardness, fused minimal porosity	Shafts, bearings
Steel	Fe 13Cr	Economical, wear resistance	Repair
MCrAlY	NiCrAlY	High temperature corrosion resistance	Gas turbine blades
Nickel-graphite	Ni 25C	Anti-fretting	Compressor inlet ducts
Oxides	Al_2O_3	Oxidation resistance, high hardness	Textile industry
Carbides	WC 12Co	Wear resistance	Shafts

1.2 HARD FACING

Hard facing is a surface treatment of metals, in which welding metal having excellent resistance to wear and oxidation is deposited onto a surface of a substrate [6]. Hard facing technique is used in wear resistant surfaces deposited on the base metal or on build-up deposits extend service life. Hard facing is usually limited to one, two, or three layers [3]. Hard facing is a minimal effort technique for storing wear safe surfaces on metal segments to develop benefit life. Although principally to restore worn parts to usable condition, hard facing is likewise connected to new segments before being put into administration. Notwithstanding amplifying the life of new and worn parts, hard facing gives the accompanying advantages: [3]

• Fewer new parts required.

• Operating proficiency is expanded by diminishing downtime.

• Less costly base metal can be utilized.

• Overall expenses are lessened.

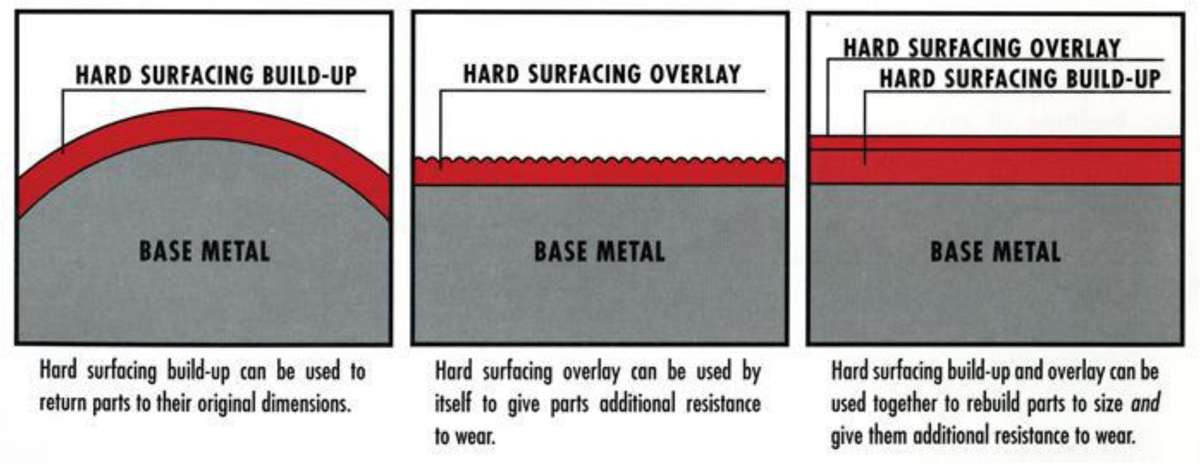


Figure.1.6.Hard facing [3]

1.3 WELDING

Welding is a process for joining two similar or dissimilar metals by fusion. It joins different metals/alloys, with or without the application of pressure and with or without the use of filler metal. The fusion of metal takes place by means of heat. Welding gives a changeless joint however it typically influences the metallurgy of the parts. Welding is consequently normally joined by post weld heat treatment for a large portion of the basic parts. The welding is generally utilized as a creation, what's more, repairing procedure in commercial ventures. A portion of the normal uses of welding incorporates the manufacture of boats, weight vessels, car bodies, seaward stage, spans, welded funnels, fixing of atomic fuel and explosives, and so forth.

1.3.1 Automatic Submerged Arc Welding

In submerged arc hard-facing the electric circular segment traversed the hole between the wire and the occupation under a front of granulated flux. The combination increments fundamental for a hard store might come either from the welding wire in which case an impartial protecting flux would be utilized or on the other hand, a gentle steel filler wire is utilized and the composites are presented by the method for an uncommonly planned flux. At the point when utilizing alloyed wire and a nonpartisan flux, the store attributes as far as hardness and wear resistance are not incredibly affected by minor varieties in welding conditions [9].

SAW includes the development of an arc between a constantly fed exposed wire cathode and the work piece. The procedure utilizes a flux to produce defensive gases and residue and to add alloying components to the weld pool. A protecting gas is not needed. Before welding, a layer of flux powder is set on the work piece surface. The circular segment moves along the joint line and as it does as such, overabundance flux is reused through a container. Staying combined slag layers can be effortlessly evacuated in the wake of welding. As the circular segment is totally secured by the flux layer, heat misfortune is to a great degree low. This delivers a warm effectiveness as high as 60% (contrasted and 25% for the manual metal curve). There is no obvious arc light, welding is without splash and there is no requirement for smoke extraction [9].

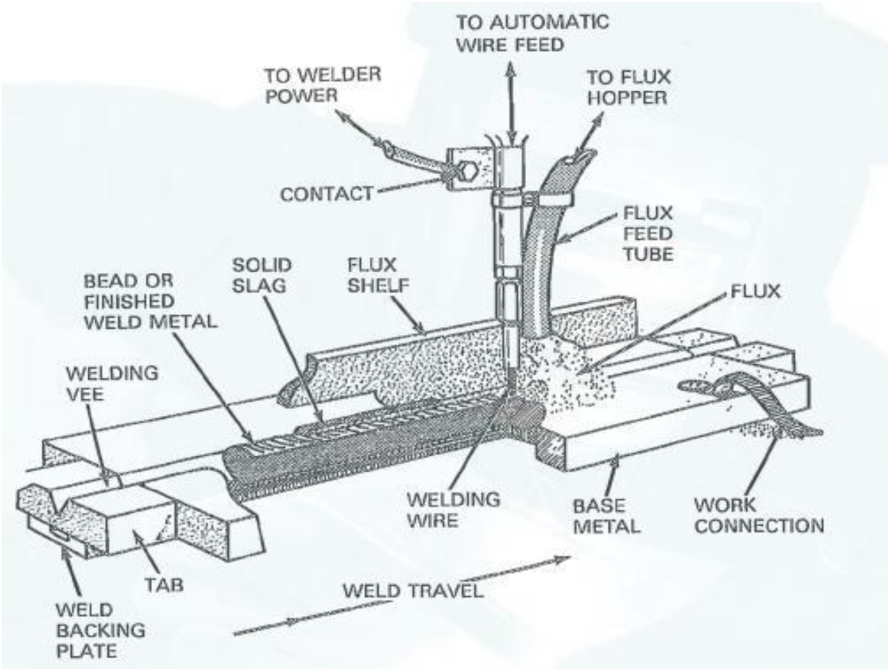


Figure.1.7.Submerged Arc welding [9]

1.4 FLUX

Granular flux utilized as a part of welding is a kind of granular protecting material comprising of various little particles. In submerged circular segment welding (SAW), the granular stream gives a cover over the patch, which ensures against flashes and scatters. In SAW, the granular stream is regularly the way to accomplish high affidavit. The stream is likewise vital in the creation of the kind of weld quality is regular in this specific welding process. Flux Functions in Sub-circular segment welding is the impact of gravity on the power flow in the weld zone and the liquid patch shower constrains the adaptability of submerged arc welding. This procedure must be done in just in the level and flat positions steaks, aside from in unique cases. These uncommon cases incorporate vertical and even welds utilizing extraordinary gear, stories like belts or shoes, to keep the stream in position. The granular stream utilized shower SAW serves a few capacities. Notwithstanding giving a spotless weld pool covers over welding shields and stream. The stream likewise influences the synthetic structure of weld metal, the welding dot shape, and mechanical properties of the weld. Another capacity f of the granular stream is going about as a hindrance that keeps the heat and heat in the welding zone for profound infiltration advancing concentrated.

1.5 HARDNESS TESTING

After applying each layer of hard facing, the specimens were allowed to cool gradually and they were cleaned with the help of a steel brush to remove any slag, inclusions or any other impurity. Finally, when all samples were prepared, they were placed in ash for cooling for about six hours. The samples prepared were tested for their surface hardness. The surfaces of the specimens were prepared for hardness testing with the help of surface grinder by grinding their surfaces. The grinding was done on each sample to get a clean, clear and uniform surface, so that it rests well on the testing table of hardness testing machine as well to obtain accurate values of hardness on the plain surface.

1.5.1 Rockwell hardness testing

Rockwell hardness tester was utilized to decide the hardness of various hard faced work pieces. Before initiating the test all the weld dots were readied by keeping weld dot top surface level with the help of surface processor. The scale utilized was HRC. Space was made with the assistance of distance across tip indenter. The Rockwell scale is a hardness scale taking into account space hardness of a material. The Rockwell test decides the hardness by measuring the profundity of the entrance of an indenter under an expansive burden contrasted with the infiltration made by a preload.

Figure.1.8.Rockwell hardness tester

1.5.2 Types of Rockwell testing

At the point when testing metals, space hardness connects with the quality of the material. This essential connection allows monetarily vital non-destructive testing of mass metal deliveries with lightweight, compact gear, for example, hand-held Rockwell hardness analysers, which are each separately adjusted for precise readings.

(a) Regular Rockwell hardness testing

The Regular Rockwell hardness testing machine has the penetrator to get the hardness values after applying minimum or maximum load. The increment in depth is due to the increment in load is the linear measurement that forms the basis of Rockwell hardness tester readings. This kind of testing measures the hardness of the specific material that is being used. Diverse scales are used for ferrous metals, nonferrous metals, and even plastics .Rockwell hardness join A, B, C and F for metals and M and R for polymers.

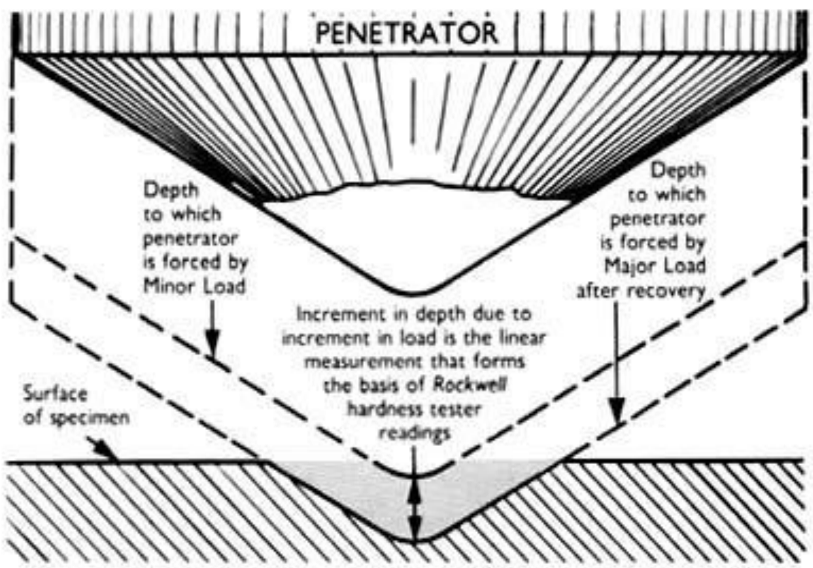


Figure 1.9(a).Regular Rockwell hardness testing

(b) Superficial Rockwell hardness testing

This kind of Rockwell testing uses a surface-sensitive estimation of hardness, rather than measuring the mass hardness of the metal or plastic. This methodology is gainful for testing dainty examples of materials, tests with hardness edges at the surface, and little regions. Shallow Rockwell hardness scales are N and T for metals and W, X and Y for non-metallic materials and sensitive coatings.

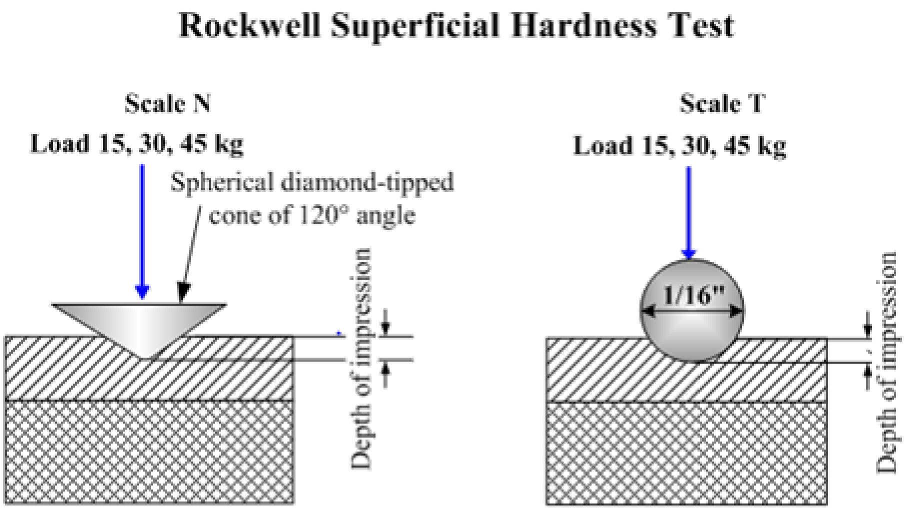


Figure.1.9 (b).Superficial Rockwell hardness testing

The advantage of Rockwell hardness is

- Hardness value of material is displayed easily.
- This decreases all the repetitive counts required in different courses utilized for the hardness estimation of materials.
- It has an enormous following in the commercial enclosure due to its velocity, reliability, quality, power and area of indentation.

1.6 HEAT TREATMENT

Heat treatment is a warming and cooling system of a metal or an amalgam in the solid state with the inspiration driving changing their properties. It can moreover be said as a methodology of heating and cooling of ferrous metals especially distinctive sorts of steels in which some outstanding properties like hardness, unbending nature, sturdiness etc, are invited in these metals for fulfilling the uncommon limit objective. It includes three essential stages specifically (i) heating of the metal (ii) splashing of the metal and (iii) cooling of the metal [9]. The speculation of heat treatment relies on upon the way that a change happens in the internal structure of metal by heating and cooling which impels properties in it. The major controlling variable is the rate of cooling the material after heat treatment process. Fast cooling the metal from over the essential achieve results in hard structure. In spite of the fact that direct cooling conveys the converse impact i.e. sensitive structure. In any heat treatment operation, the rate of warming and cooling is basic. A hard substance is difficult to shape by cutting, confining, etc. During machining in the machine shop, one requires machinable properties in occupation piece thus the properties of the job piece may require heat treatment, for instance, strengthening for influencing non-abrasiveness and machinability property in a work piece.

1.6.1 Objectives of Heat Treatment

The major objectives of heat treatment are given as under

1. Eliminating interior stresses induced during hot or freezing point working.
2. Refinement of particle size
3. It opposes to heat and corrosion.
4. It improves mechanical factors such as ductility, strength, hardness, toughness, etc.
5. It helps to improve machining properties.
6. Induces increased wear resistance
7. It eliminates gases.
8. Great execution of electrical and magnetic properties is achieved.
9. Chemical composition changes
10. Improvement of shock resistance.

Tempering

Tempering is the process which is done after the hardening treatment is applied, steel is often harder than needed and is too brittle for most practical uses. Also, severe internal stresses are set up during the rapid cooling from the hardening temperature. [10] To relieve the internal stresses and reduce brittleness, you should temper the steel after it is hardened. Heating the hardened steel is done above fundamental temperature when the structure is totally of austenite and subsequently quenching it in a fluid salt manner having the temperature to the extent of 150-500°C. This is done to avoid change to ferrite and pearlite and is held dousing temperature for a period satisfactory to give complete advancement to a moderate structure insinuated as bainite then cooled to room temperature. The temperature should not be held under 4 to 5 minutes for each millimeter of the territory. In the wake of treating structure is changed into helper structure like martensite, troosite, sorbite and spheroidised.

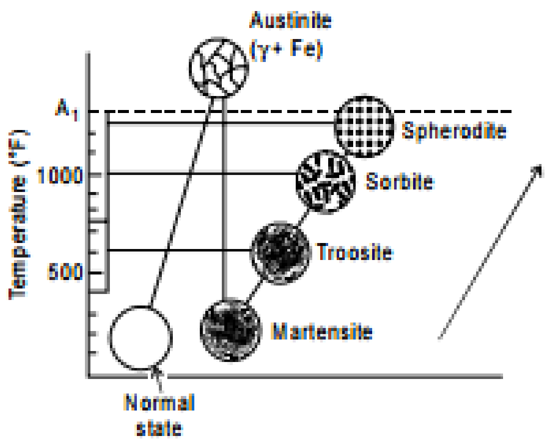


Figure.1.10.Structures of martensite, troosite, sorbite and spherodite [9]

Low tempering

Hardened steel parts requiring treating are warmed up to 200°C and afterward quenched in oil. Treating is utilized to hold hard small scale structure of martensite which expands fragility [9].

Medium Tempering

Solidified steel parts requiring treating are heated in the temperature extent of 200-350°C. This methodology gives troosite structure. Troosite structure is another constituent of steel obtained by extinguished treating martensite. It is made out of the cementite stage in a ferrite cross section that can't be controlled by light amplifying lens. It is less hard and delicate than martensite. It is moreover made by cooling the metal bit by bit until change begins and after that cooling rapidly to keep its completion. It has a dull appearance on scratching. It is weaker than martensite [9].

High temperature tempering

Solidified steel parts requiring heat treating in the temperature range 350-550°C .This procedure gives sorbitol structure. Sorbite structure is created by the change of tempered martensite. It happens when the steel is heated at a genuinely quick rate of temperature of the strong answer for typical room temperature. Its properties are moderate between those of perlite and troosite .Parts requiring heat tempered in the temperature scope of 550-750 °C [9].

Aus -tempering

It is an extraordinary sort of strengthening procedure in which the steel is warmed or more the change .Range abruptly in a then extinguished liquid salt shower at a temperature of 200 to 450°C. It kept up at that temperature until the open air temperature and balance. The part is then warmed and cooled at a moderate rate. Aus - quenching delivers fine bainite structure steel however with insignificant twisting and residual stress. Aus - Tempering is primarily utilized parts of airship motors [9].

Mar-tempering

It is a type of annealing process in which and alloys heated above transformation Range suddenly in a then quenched molten salt bath at a temperature of 80 to 300 ° C. It maintained at that temperature until the outdoor temperature and equalize. The part is then reheated and cooled to a moderate speed. Tempered martensite steel framework produces, but with minimum distortion and residual stresses [9].

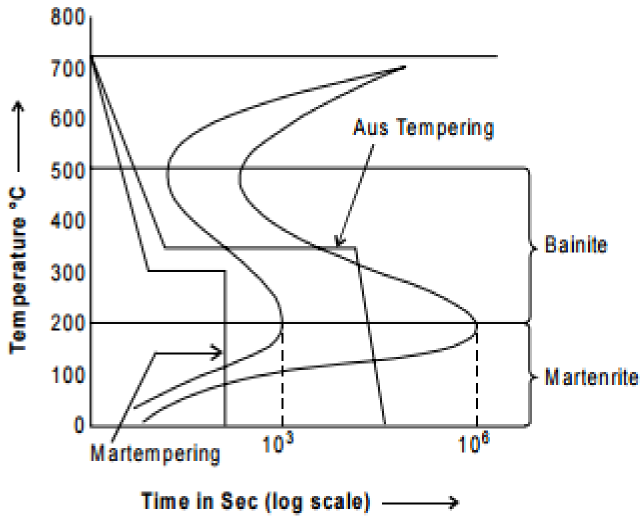


Figure.1.11.Aus tempering and mar tempering process [9]

1.7 WEAR FOR ENGINEERING MATERIALS

Wear is a process of removal of material from one or both of two solid surfaces in solid state contact, occurring when two solid surfaces are in sliding or rolling motion together. There are many types of wear that are of interest to the user of coatings, including sliding wear and friction, abrasion of low and high voltage, dry particle erosion and erosion suspension. To avoid substrate damage, possible coatings are practiced in this experiment. Coatings experience shear, tensile and compressive stresses which may lead to failure by cracking and spalling [8].

Coating characteristics

In practice, coatings may confer one or more of the following wear resistant properties: (i) corrosion protection; (ii) wear resistance; (iii) hardness; (iv) high melting temperature; (v) low permeability and diffusion for oxygen to prevent internal substrate corrosion; (vi) high density, to avoid gas flux through open pores to the substrate; (vii) stress free or in a state of compressive stress at the working temperature; and (viii) good adhesion.

In selecting a reasonable wear test, the accompanying focuses ought to be considered: (i) guarantee that the test is chosen measuring the craved properties of a material; (i) if the material is in a mass frame or is a thick or slight film; (ii) if the strengths and pressures restricted. They are reasonable for testing; (v) if abrasives are Currently, considering the span of the grating, the shape and speed;(V) if the contact between the segments is rolling, sliding, or just effect disintegration, or a mix of these, considering that the surface completion of test tests ought to be like current segments; (Vi) if the temperature and mugginess elements are essential; (Vii) if the test environment. It is like the genuine workplace; (Viii) the term of the test; and (ix) if the materials. It is utilized as a part of the run of the mill tests of real materials utilized as a part of parts of the machine. Tests are utilized for quality control capacities. For instance, thickness, porosity, grip, quality, hardness, malleability, substance organization, weight and wear resistance. Damaging tests do exclude lattices, entering visual, attractive particles and acoustic procedures. Numerous tests for cutting apparatuses with and without covering are done in machine devices, snacks, including machines, processing machines, drills, drawbores, and saws.

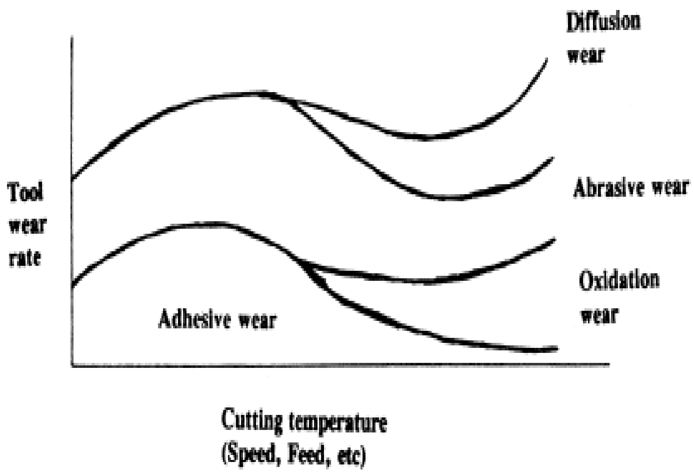


Figure.1.12.Wear mechanisms for continuous cutting [7]

1.7.1 Types of wear

1. Adhesive wear
2. Abrasion wear
3. Surface fatigue
4. Erosion wear

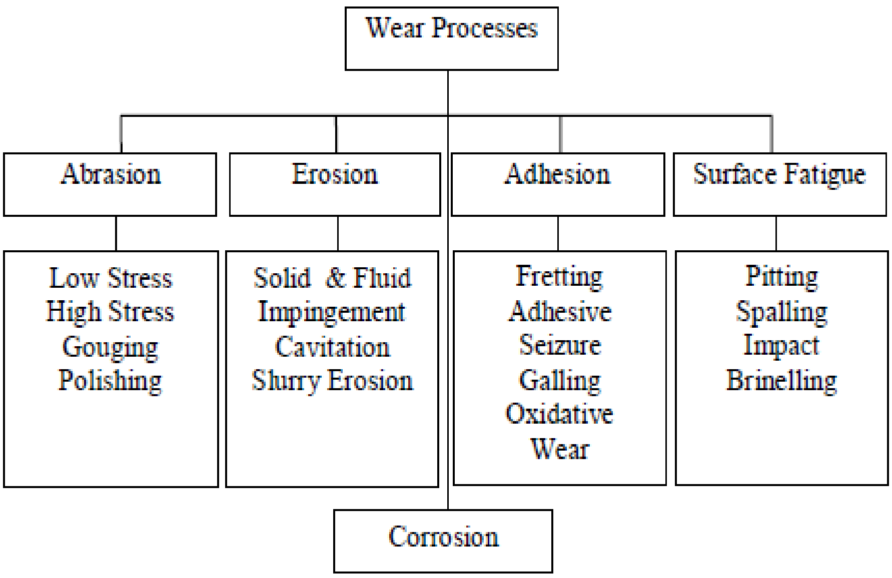


Figure.1.13.Flow chart of various wear mechanisms [8]

Adhesive wear

For the most part, expulsion of surface film material because of attachment and ensuing slackening amid relative movement. Gentle attachment exchange and slackening of surface movies as it were. Extreme attachment in frosty welding of metal surfaces because of metal to metal contact. The system in extreme attachment is when two surfaces are united under burden, severities of the two surfaces stick to each other. The conditions at the interface of these intersections are like those of a cool weld. Solid bonds are framed however without much entomb dissemination of particles and recrystallization as would happen in a hot weld [10].

Arrangements:

- Decrease burden, rate and temperature.
- Improve oil cooling
- Use perfect metals
- Apply surface coatings, for example, phosphating
- Modify surface, for example, particle implantation.

Abrasion wear

Scraped spot is the wearing of surfaces by rubbing, crushing, or different sorts of grating. It for the most part happens because of metal – to – metal that rubs away metal surfaces and can be brought on by the scouring activity of sand, rock, slag, earth, and other coarse material [10].

Answers for counteractive action:

- Remove grinding by upgraded air and oil filtering, clean oil dealing with practices, improved seals, and flushing and visit oil changes.
- Minimize shot peening, beading, or sand affecting of surfaces since abrasives can't be completely cleared.
- Increase hardness of metal surfaces.

Erosion wear

Cutting of materials by hard particles in a high-speed liquid impinging on a surface. This kind of wear happens results from sharp particles impinging on a surface, for example, the cutting of materials by hard particles in high-speed liquid impinging on a surface. This activity is especially similar to that of sandblasting [10].

Solutions for prevention:

- Remove rough by enhanced air oil sifting, clean oil taking care of practices, enhanced seals, and flushing and visit oil changes.
- Increase hardness of metal surfaces.
- Reduce effect point to under 15 degrees.

Surface fatigue

Metal removed by cracking and pitting, due to cyclic elastic stress during rolling and sliding. This type of wear is produced when repeated sliding or rolling occurs over a track [10].

Solutions for prevention:

- Decrease contact pressures and frequency of cyclic stress.
- Use high standard quality vacuum melted steels.
- Use less abrasive surface completion.

Corrosion wear

Corrosion wear is the gradual deterioration of unprotected metal surfaces caused by the effects of the atmosphere, acids, gases, alkalis etc. This type of wear creates pits and perforations and may eventually dissolve metal parts [10].

2. METHODOLOGY

2.1 SELECTION OF MIXTURE AND FLUX

In this work, we selected tungsten carbide and cast iron as the mixture for preparation of samples for testing the mechanical properties. Tungsten carbide has the good mechanical properties of coatings and it has been used as hard metal and cast iron has the enough carbon content to form carbides in coatings. The particles of the tungsten carbide have high content of fine and uniformly arranged on base metal to give good wear resistance. The glass powder SiO and SiC have been used as the flux in overlay welding for coatings and to improve the hardness. The waste materials of tungsten carbides are used as the alloying element. The waste materials of cast iron are utilized as the mixture with tungsten carbide as hard metal.

2.2 PREPERATION OF THE MIXTURE POWDER

In our research work, the specimens which is in the powdered structure are set up from the waste materials which we have gathered and the required specimens been are made. As we look into the readied tests here each of the specimen powder their display own extraordinary properties. In this work, the general specimen powder been which are utilized are silicon carbide and silicon oxide. These examples will be utilized as powder flux and they will use as general flux. Alternate fluxes are 100% of SiC and half SiC+ half SiO are has been utilized.

Table.2.1.Different samples with different flux and mixture

Sample No.	Mixture	Flux
52	90% HM + 10% cast iron	100% SiC
53	80%HM + 20% cast iron	100% SiC
54	70% HM + 30% cast iron	100% SiC
55	60% HM + 40% cast iron	100% SiC
56	50% HM + 50% cast iron	100% SiC
62	90% HM + 10% cast iron	50%SiC +50% SiO
63	80%HM + 20% cast iron	50%SiC +50% SiO
64	70% HM + 30% cast iron	50%SiC +50% SiO
65	60% HM + 40% cast iron	50%SiC +50% SiO
66	50% HM + 50% cast iron	50%SiC +50% SiO

The Fig 2.1-2.4 shows the actual pictures of the fluxes been used and the powder mixture has been used in the experiment. The table 2.1 shows the different samples different flux mixture. Specimens 52 to 56 have 100% silicon carbide. SiC is a hard material. It need to see whether addition of the tungsten carbide and with various percentage of cast iron will increase the hardness in the specimens. Specimen 62 to 66 has the equal mixture of silicon carbide and silicon oxide (50% SiC+50% SiO). The samples mentioned above have different composition of mixture with hard metal and cast iron. Here every powder has its own property which is exceptionally useful in getting the required solidified layer that will be quality weld. The solidified surface acquired throughout the specimens may be or may not be great in its properties, which are high wear resistance, hardness, microstructural changes.

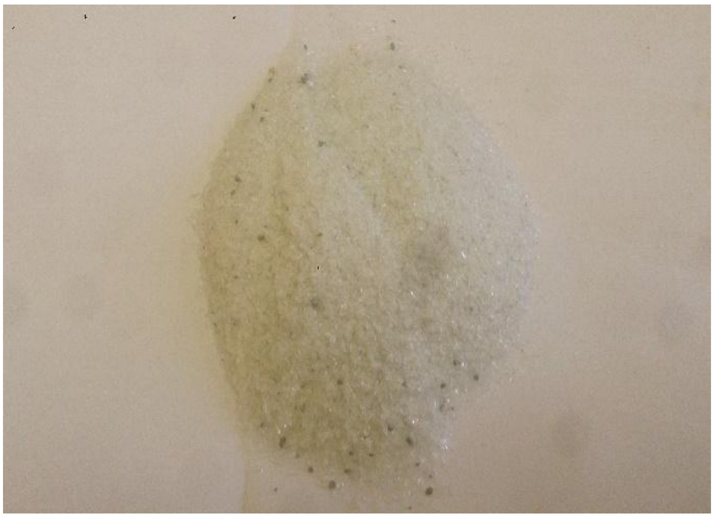


Figure.2.1.Grounded Silicon Oxide

Figure.2.2.Grounded Tungsten Carbide

Figure.2.3.Grounded 50% SiC+ 50% SiO

Figure.2.4.Annealed tungsten carbide

These powder mixtures are prepared manually with hand and crushed properly to get fine and uniform grains for effective properties. The silicon carbide and cast iron are extracted from waste materials. The annealed tungsten carbide are grinded to powder and the glass powder (SiO) is also grinded from waste glass bottles.

Presently with alternate specimens along the flux, we are going to add different composition of mixtures to the specimens. The mixture which has been utilized is tungsten carbide as hard metal and cast iron. Presently the methodology continues as before structure the specimen 52 to specimen 56 with the same request as of from specimen 62 to specimen 66. The synthesis of cast iron 2% to 6.67 % of carbon in iron is called as cast iron and underneath 2 % of carbon called as steels. The structure of the cast iron has appeared underneath in table 2.2.

Table.2.2.Composition of Cast iron

Carbon	Silicon	Manganese	Phosphorous	Sulphur
2.5 to 3.7 %	1.0 to 3.0 %	0.5 to 1.0 %	0.1 to 0.9 %	0.007 to 0.10 %

2.3. WELDING PREPERATION AND PROCESS

The welding setup utilized is Submerged curve welding (SAW). In our exploration we are utilizing the base metal for surfacing is modest plain carbon steel. The substance arrangement of plain carbon steel is as per the following, (Carbon 0.14-0.22 %; Silicon 0.12-0.3 %; Manganese 0.4-0.65 %; Sulphur ≤0.05 %; Phosphorus ≤0.04 %) .We are utilizing plain carbon steel as its modest and effectively accessible. It's one of the exceptionally utilized material. The measurement of the base metal example strips or pieces utilized for welding is 135*10*10mm.The specifications of real time welding machine as follows as;

- Torch- MIG/MAG EN 500 78
- Welding current 180 – 200 A
- Voltage 22 – 24 V
- Travel speed – 14.4 m/h
- Wire feed rate – 25.2 m/h.
- Electrode diameter – 1.2 mm
- Electrode material- Low carbon steel
- Chemical composition of the electrode- Carbon < 0.1 %; Silicon < 0.03 %, Manganese 0.35-0.6 %, Chromium < 0.15 %, Nickel < 0.3%

Figure.2.5.Submerged arc welding

The welding setup has the clamp to lock the specimen in place. For the specimen 52 to 56, we are using the material mixture of hard metal and cast iron and only the various fluxes are being used. Now for the specimen 62 to 66 material mixtures of hard metal and cast iron is being used along with the prepared flux. The flux is poured on the plain carbon steel; the weld overlay is performed in the single pass. For the specimen 52 to 66 mixture is added to the specimen up to a height of 3mm, upon that we cover with the prepared flux. Above steps are done in as per the procedure.

In our research thesis SAW setup has been used. The basic important principal of this SAW setup is to weld the powdered mixture on the base metal specimen pieces. This is the primary or initial step in the research. The equipment for SAW has a basic setup with the electrode holder with automatic wire feeder, which feed the electrode wire at a constant set speed. Power supply will be connected to the electrode holder, welding gun, power source (step-down transformer), work piece holder, emergency stop button. In current research flux is fed manually and finally earthling connection to complete the circuit.

The arc is produced, when current is passed between the work piece and the electrode wire. The powder to be welded may be fed automatically or fed manually. The powder will be welded to the base metal once the arc is started and the circuit is completed. During welding, flux is imparted to the specimens and will begin to dissolve or condense on the weld.between the weld and the climate. This will harden and gets to be slag. The slag can be separated once it's hardened.

2.4 HARDNESS MEASUREMENT TEST

After the welding, the illustrations are taken to test their hardness under Rockwell hardness testing machine Figure-2.6. The cases are grounded level and cleaned from the waste to make a level surface for the material testing. These attempted case hardness numbers are noted down. Hardness is described as the impenetrability to space. This hardness is processed by measuring the depth or area of indentation on the example. The improving harder the material lesser space. A portion of the known material hardness testing is [15]

- Rockwell hardness test
- Brinell hardness test
- Vickers hardness test
- Knoop testing

• Durometer IRHD testing

• Case depth testing

The most broadly perceived material hardness testing done in the whole world is the Rockwell hardness test. It's connected as HR (Hardness Rockwell) as the hardness number doesn't have units. In this examination we are using Rockwell hardness test with qualities measuring as HRC, which implies that the materials used as a piece of this investigation go under C scale to evaluate the hardness. As it's less requesting to perform and accurately stood out from another kind of hardness testing. This test prompted a vast part of the metals. In this test, the invariable significance of space is measured. In the first place minor weight is associated with the material to be tried by using a valuable stone indenter.

This initial load will be taken as zero load (reference position), this load breaks through the surface finish of the material. Once the minor load is applied the major load is applied. This will sum up the total required load. This load will be applied for the pre-determined time called dwell time (take few seconds) for elastic recovery. Presently the significant load is discharged, now the contrast between the position from the pre-load to the real load i.e. the profundity load esteem between the preload esteem and the significant burden quality is measured. This distinction out there is changed over into hardness number which will have appeared on the dial. The preparatory test load ranges from 3kgf to 200kgf and the aggregate test strengths range from 15kgf to 150kgf.

A= profundity came to by indenter subsequent to applying minor load.

B= position of indenter amid significant load.

C= last position came to by the indenter after the versatile recovery.

D= separation measured by taking the distinction between the minor & significant load.

Different type of indenter is used for different metals. Conical diamond with a round tip indenter for harder metals. Ball indenter for softer metals with ball diameter ranging from 1.5 mm to 12. 7 mm. Here each specimen is broken down to several individual pieces that are to be tempered after the initial reading are taken. The tempering temperature varying from 500°C to 600°C. Again after each tempering temperature the hardness has been measured for further analysis.

Table 2.3 Rockwell hardness scale for the different metals

LETTER	TYPE OF MATERIALS USES FOR MEASUREMENT
A	Carbides, thin steel & shallow case hardened steel
B	Copper alloys, soft steels, aluminium alloys, malleable iron
C	Steel, hard cast iron, pearlitic malleable iron, titanium, deep case hardened steel
D	Thin steel and medium case hardened steel and pearlitic malleable iron
E	Cast iron. aluminium and magnesium alloys, bearing metals
F	Annealed cooper alloys, thin soft sheet metals
G	Phosphor bronze, beryllium copper, malleable irons
H	Aluminium, zinc, lead
K,L,M,P,R,S,V	Bearing metals and other very soft and thin metals including plastics.

Figure.2.6.Analog Rockwell hardness

2.5 HEAT TREATMENT (TEMPERING) FOR THE SAMPLES

Hardness in a material is considered as the imperviousness to plastic deformation. Solidifying includes the heating to such a temperature to deliver an austenitic structure, hold it at that temperature and extinguish in water or oil. After cooling by extinguishing, to a great degree fast rate of cooling is acquired. In steels, if the rate of cooling is quicker than the basic cooling rate, microstructure contains martensite structure, in charge of expanding hardness in steel.

Hardening heat treatment extreme hardness develops in plain carbon steels but reduce its hardness. They become very fragile and unsuitable for use in most conditions. Therefore, the secondary heat treatment called tempering is taught in materials that can be put before service. The experiment consist additionally tempered steel heat treating several sub-critical and then a cooling temperature in any case at room temperature. The other reason why the temper must be accomplished in hardened steel that is, the austenite is retained in the microstructure. It tends to change and unstable with time dimensions. This change in the dimensions must be an impediment in some components that must retain their dimensions or are made the exact dimensions. By tempering, it retained austenite becomes non-equilibrium, but more troostite stable, sorbite or bainite. The purpose of tempering is to revive residual internal or tensions, to improve ductility increased, hardness, impact resistance, hardness reduced to convert retained austenite.

Here in this experiment, the specimens are initially cleaned and after that arranged for treating. The Furnace is exchanged on and its interior temperature is conveyed to the required treating temperature. At that point, the specimens to be tempered are kept in the broiler and left for 60 minutes. At that point, the specimens are taken out and permitted to cool in still air. The treating temperature begins from 500°C, 550°C, and 600°C. At that point, the hardness test is led by the tempered example. Later these specimens are set up for the microstructure investigation. The heater which we are utilizing is Nabertherm electric heater where the maximum temperature which can reach is 3000°C Figure-2.7. In this heater treating, as well as the other heat treatment operations like normalizing, stress relieving, hardening of ferrous and non-ferrous metals, and other heat treating process.

Figure.2.7.Furnace for tempering process

2.6 MICROSTRUCTURAL ANALYSIS

When every one of the examples is tempered with the distinctive treating temperature. We have to prepare them for microstructure examination. To start with these examples are set in a little round and hollow compartment. At that point, the example whose face to be utilized for microstructure investigation will be put confronted down in the compartment. One side of the holder will be shut utilizing sticky tape so that the epoxy blend won't come up short on the holder. At that point, the epoxy blend of 10-section gum and 1-section hardener is blended and poured in the compartment Figure-2.8. At that point permitted to set. It is ideal to leave overnight to set. All of them these examples are expelled from the holder. Presently the face to be broke down will be prepared with coarse crushing, then fine pounding and last cleaning. These examples are mirror completed for better precise microstructure. The top surface of the surface is etched properly for microstructural examination.

Figure.2.8 Polisher and resin

Figure.2.9 Prepared samples for microstructural analysis and etched

The examples are initially put in a holder and secured firmly. At that point, the grating paper is settled on the wheel utilizing cement shower. At that point the holder is put on the grating wheel, this entire setup will be set in the LamPlan cleaning machine Figure-2.10 and run the setup for the required time. Each time the diverse grating paper is changed once the setup keeps running for set time. Last we do cleaning. Here we change the wheel to buffing wheel. A liberal measure of jewel cleaning specialist is connected on the haggle procedure is rehashed again until we get a mirror wrap up on the face to be investigated.

Once the cleaning is done, these examples are put under the magnifying instrument, sometime recently putting the substance of the example are scratched with the arrangement HNO3 with 4% liquor Figure-2.9. Once the face is scratched these are put under magnifying lens Figure-2.11. As scratching will uncover the microstructure, where we can see the different examples covered up. So the effect of this change can be physically investigated in the item while doing wear test. After the carving, the examples are analyzed under various amplification from 5X, 20X, 50X the investigated surface photos for examination. The prior and then afterward treating example's microstructure are investigated and the changes in the diverse examples are noted. This gives an unmistakable comprehension of auxiliary changes because of treating which thus the outcomes may turn out either positive or negative.

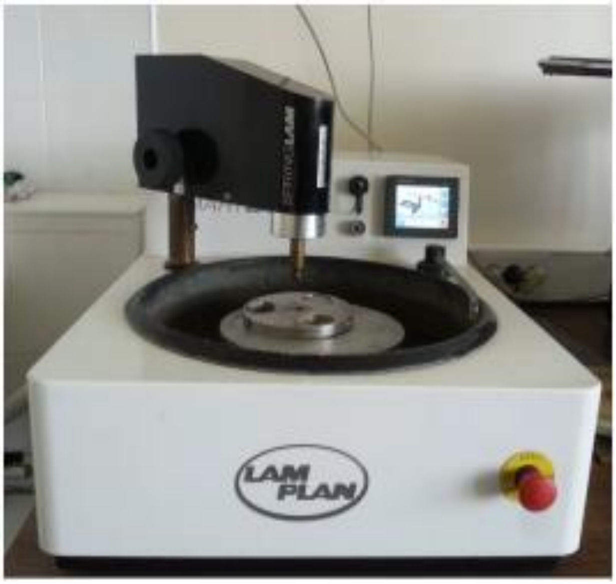


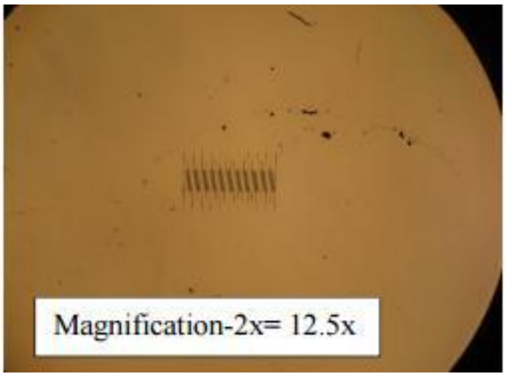
Figure.2.10 Lamplan machine

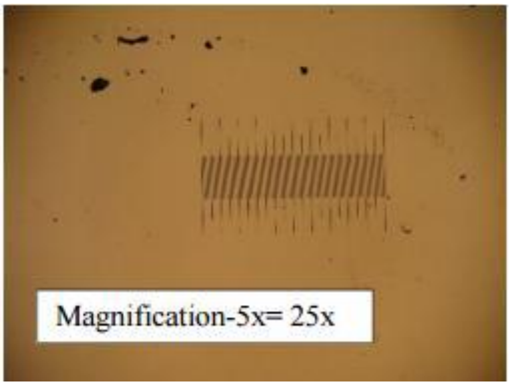
Table.2.4 Stages for polishing the samples

Stages	Time	Speed(rpm)	Grit size
1st	5 mins	300	220
2nd	5 mins	300	1500
3rd	5 mins	300	2500
4th	5 mins	300	Polishing wheel
5th	10 mins	450	Polishing wheel

Figure.2.11 Microscope for microstructural analysis

Presently the reviewed microstructure is caught by the camera settled onto the magnifying instrument. Here the diverse amplification is utilized. The photos acquired ought to be doled out with the scale that demonstrates the constant amplification of the microstructure on the photographs. The amplification appears in the Figure Figure-2.12. Here the full scaling is 1mm or 1000μm. The 10 sections in the scale 100 μm and the singular scale is 10 μm.





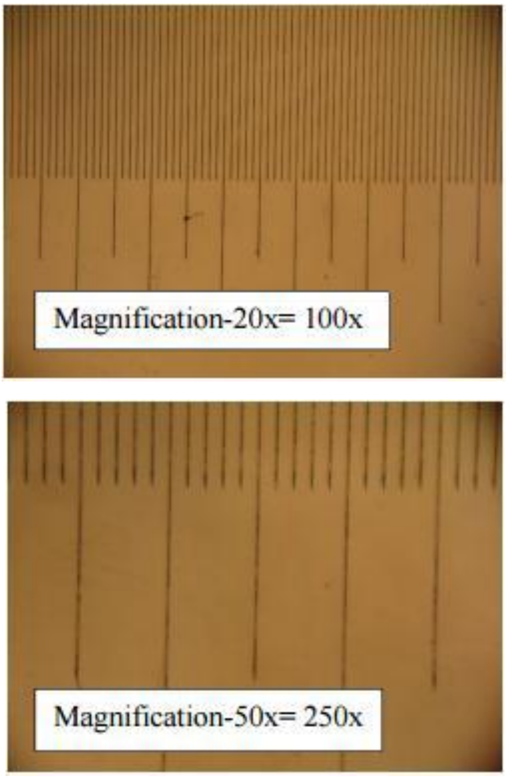


Figure.2.12. Magnification range for samples

2.7 WEAR TEST

"Wear is the progressive loss of substance from the surface of the body caused the mechanical action, i.e., contact and relative motion with a solid, liquid and gaseous counter – body" [12].

Figure.2.13. Wear test machine

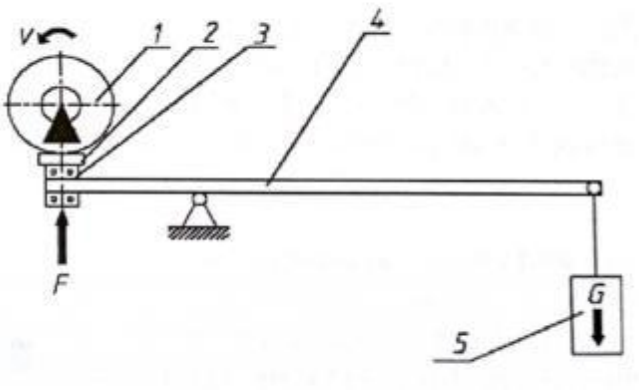


Figure.2.14. Schematic representation of wear analysis setup [13]

1-Cylindrical hardened metal disc

2- The specimen to be analysed

3- Specimen holder

4- Connecting rod

5- Balancing weights

The wear test is led to break down the wear safe property of the examples arranged. This wear test will give us a thought where the particular uses of the example can be chosen. In this exploration work in the wear test we break down the aggregate sum of welded layer getting evacuated. The measure of loss of the materials will in 0.0001g. The mass of the examples is weighed after every test. The test will be directed for each 40m go of the hard circle wheel. The specimens are cut, processed and ground to a required size i.e. 6mm in width. The diameter of the solidified wheel is 41mm. The example is set in the example holder which thus holder is settled on one side of the interfacing bar and on the other side adjusting weights is set. With the setup set up around 320N of power is connected to the surface of the example to be worn. The rpm is the wheel is fixed to 50 rpm. The complete setup of the framework appears in the Figure-2.14. The time taken for the wheel to travel 40m is Figured as below.

Calculations:

Velocity – 50 rpm, Diameter- 41mm, Radius- 21.5mm

$2\pi r$ = 2*3.14*21.5= **128.8mm**

Now by multiplying the velocity with the circumference of the wheel we get the distance travelled by the wheel.

128.8*50 = 6440mm= **6.44m** [distance travelled by the for one minute]

Presently to Figure the time required for the wheel to travel 40m

60secs - **6.44m**

X (in seconds) = (60*40) / 6.44= 372.67 = **372. 7 seconds (approx.)**

Converting to minutes we get **6.13 minutes**

Presently we run the example for 6.13 minutes, then we begin to measure the example for the loss of materials from the surface for each 40 m travel. This will proceed until 200m is finished for every example. The abatement in weight will give the wear of the examples. At the point when there is less diminish in weight then wear resistance in the examples will be increasingly and the other way around. The wear of the examples will have meant in grams. The examples are said something the measuring machine which surrenders exact qualities to fifth digits in decimal. The examples arranged for wear test is appeared in Figure-2.15. The measuring machine utilized as a part of the examination is appeared in the Figure-2.16.

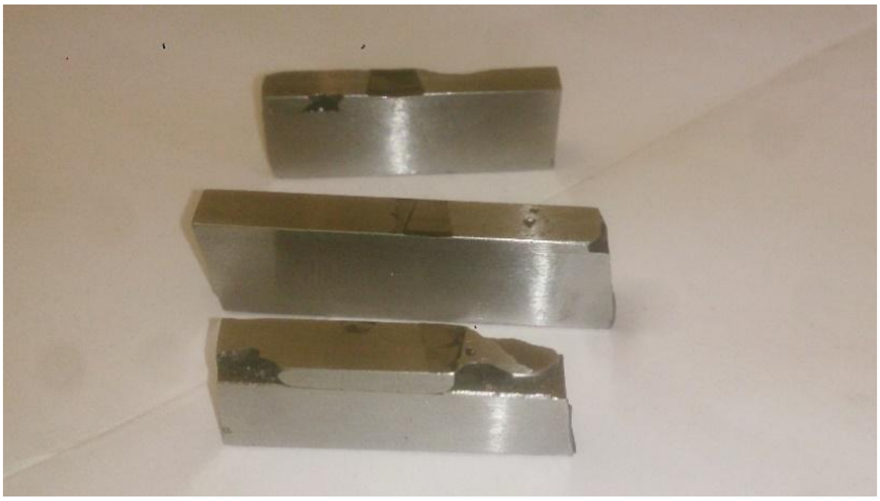


Figure.2.15 Samples after wear test and surface wear seen in this sample

Figure.2.16 Weighing machine

3. RESULTS AND DISCUSSIONS

Presently according to the necessities of the proposition work led, we examine about the outcomes got from all the different trials. As from the submerged bend welding the examples are over welded and grounded level for the hardness test. Once the underlying hardness testing is done, every example is cut into three sections one section will be utilized for treating hardness testing, one is utilized for microstructure examination after surface completing and the last one will be utilized to make 6mm width wear example for wear investigation. In this, we are going to examine the outcomes got and examination with each other.

The coatings are applied using welding over the surfaces to improve the mechanical properties and to get good wear resistance. The welded samples are with the composition mixture of tungsten carbide and cast iron from the waste materials with the standard flux and the additives are added. These additives are crushed from the waste materials like grinding wheels and glass bottles. These waste materials are utilised as flux in this research.

Figure.3.1.Welded samples

3.1 INVESTIGATION OF HARDNESS TEST RESULTS

The Rockwell hardness HRC test is directed on the underlying welded example, the readings are noted down immediately subsequent to welding, around 8 to 10 readings are taken for every example and the normal is computed. The blend is added just to examples from 52 – 66. The 2 sorts of flux are being utilized as a part of this examination. Mostly being silicon carbide, silicon oxide and last half silicon carbide and half silicon oxide. These fluxes have their own particular impact on the examples. The welded tests of these fluxes with hardness before treating and subsequent to treating procedure are demonstrated as follows. The treating procedure completed for 60 minutes. The table-3.1 demonstrates the diverse hardness HRC at different conditions.

Table.3.1.Hardness of samples

Sample No	Hardness before tempering, HRC	Hardness after tempering, HRC		
		500°C	550°C	600°C
52	37.4	39.6	40	40.6
53	41	35.4	47.6	54.8
54	23.1	27.8	37.8	44
55	40.3	44.4	54.8	50.8
56	29.1	43.6	56	54.4
62	23.2	24.8	27.2	32
63	43.6	32	26.6	33.2
64	28.3	38.4	37	39.2
65	42.4	37.2	44	38.4
66	36.6	37.4	42.2	41

From the above table, specimen from 52 to 56 fluxes have 100% silicon carbide only, which has the highest HRC before tempering process and the specimen from 62 to 66 flux mixture have 50% silicon carbide and 50% silicon oxide. The hardness in the weld is retained due to a certain amount of the silicon carbide present in the flux mixture.

In specimen 52 – 66, we can see that the mixture of cast iron and tungsten carbide as hard metal which helps for gaining the hardness. This mixture acts as an alloy. The other flux mixture with just silicon carbide and silicon oxide has almost similar hardness. Least hardness was found with 23.1 HRC in specimen 54 with 100% silicon carbide with the mixture of 70% HM and 30% CI. The highest hardness was found with 54.8 HRC in specimen 53 with flux of 100% SiC and with the mixture of 80%HM and 20% CI. Even in the specimen 52 and 53 has hardness almost similar to specimen 55. From the results of above experiments, it shows that the mixture of cast iron has acted as alloy element to increase hardness. By flux, 50% SiC and 50% SiO with the mixture of 50% of HM and 50% of CI has high hardness.

Samples of 62 to 66 are welded with the flux of 50% SiC and 50% SiO and with the mixture of the percentage of Tungsten carbide and Cast iron. Specimen 63 has high hardness with a mixture of 80% of hard metal and 20% of cast iron before tempering process. But specimen 63 and 65 has low hardness after tempering process at 600°C. By flux, 50% SiC and 50% SiO with the mixture of 50% of HM and 50% of CI has high hardness.

Once the specimen's hardness readings are noted. They are subjected to the tempering process to impart toughness in the specimens. During tempering, we may expect increase in hardness or decrease in hardness or the hardness may remain the same. The tempering temperature varies from 500°C, 550°C to 600°C all the samples are heat treated for one hour in different temperature. Then we analyse how much hardness has been increased or decreased. The further explanation can be clearly seen through the graphs.

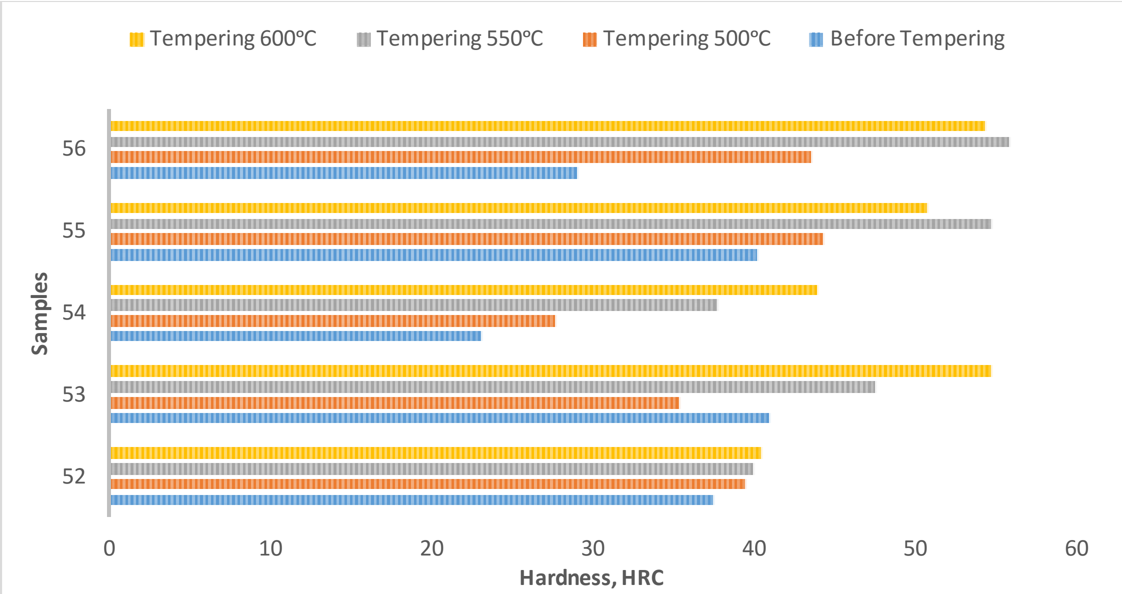


Figure.3.2.Hardness of samples with 100%SiC coatings

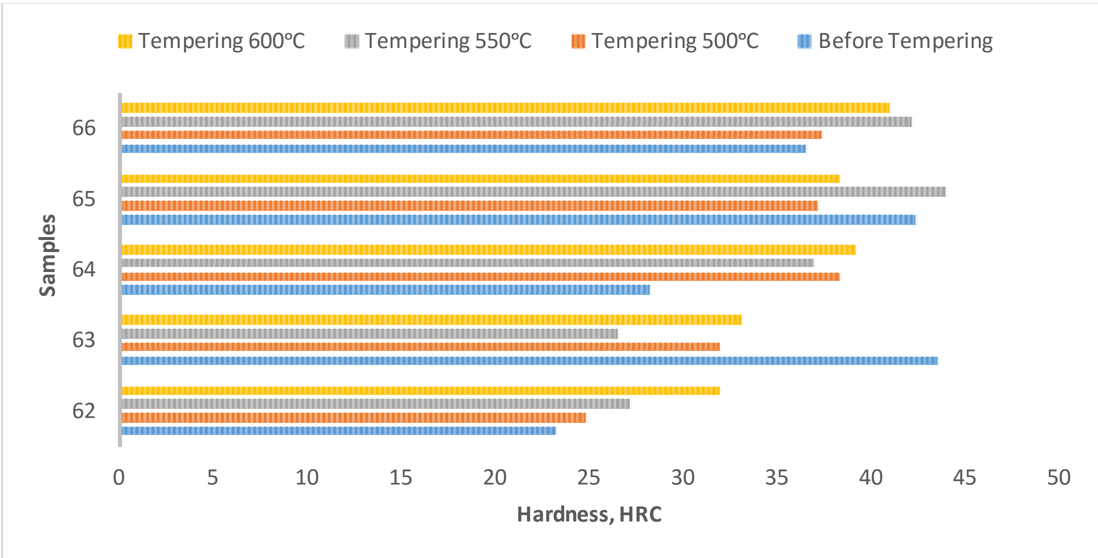


Figure.3.3.Hardness of samples after tempering (used flux 50%SiC +50%SiO) coatings

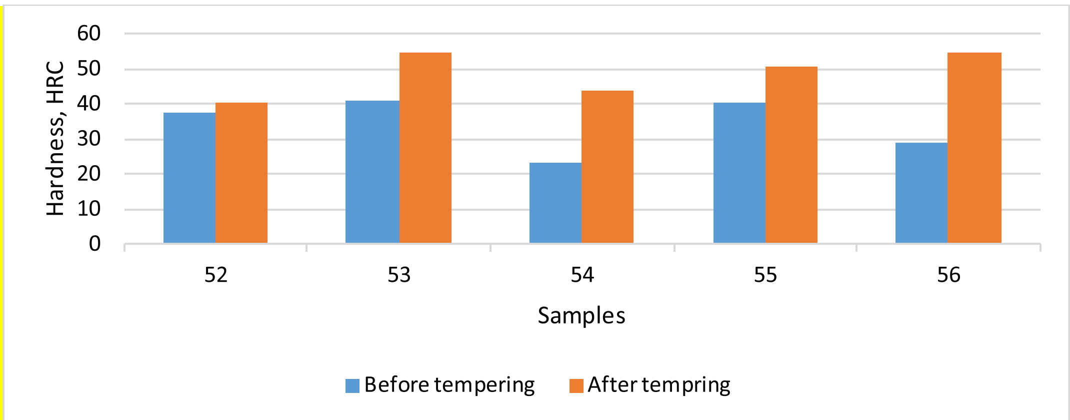


Figure.3.4.Hardness of coatings before and after tempering (used flux 100%SiC)

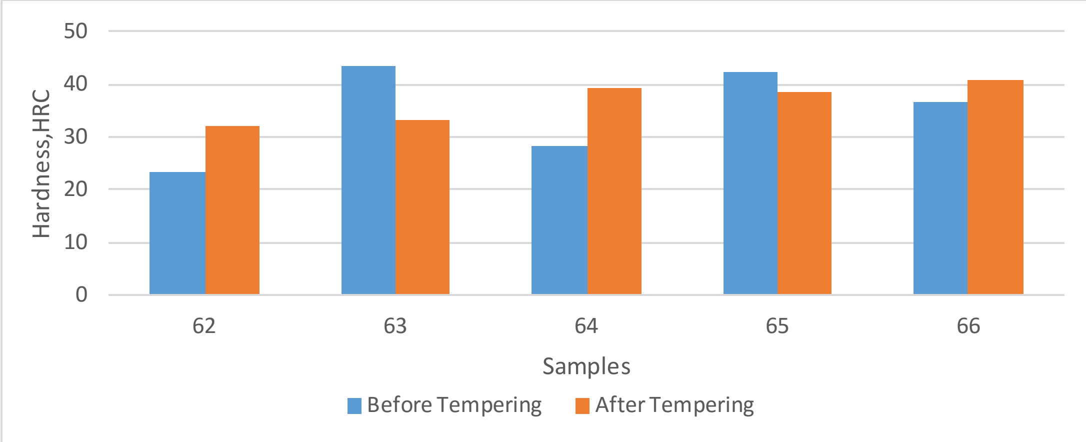


Figure.3.5.Hardness of coatings before and after tempering (used flux 50%SiC+50%SiO)

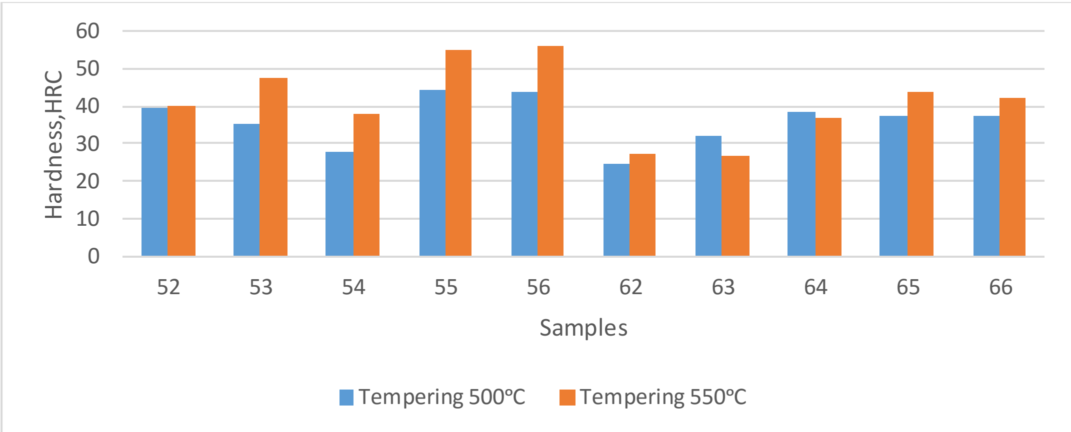


Figure.3.6.Hardness comparison of 500 °C vs 550 °C

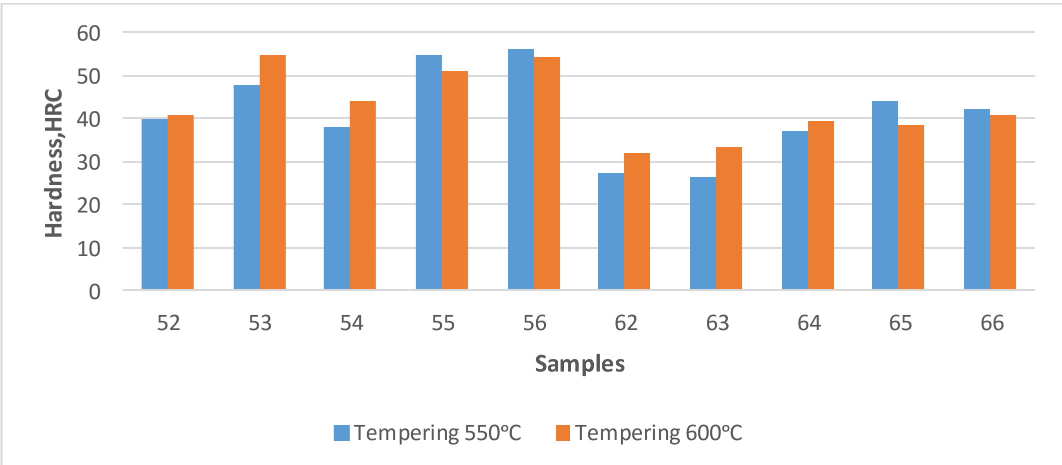


Figure.3.7.Hardness comparison of 550◦C vs 600◦C

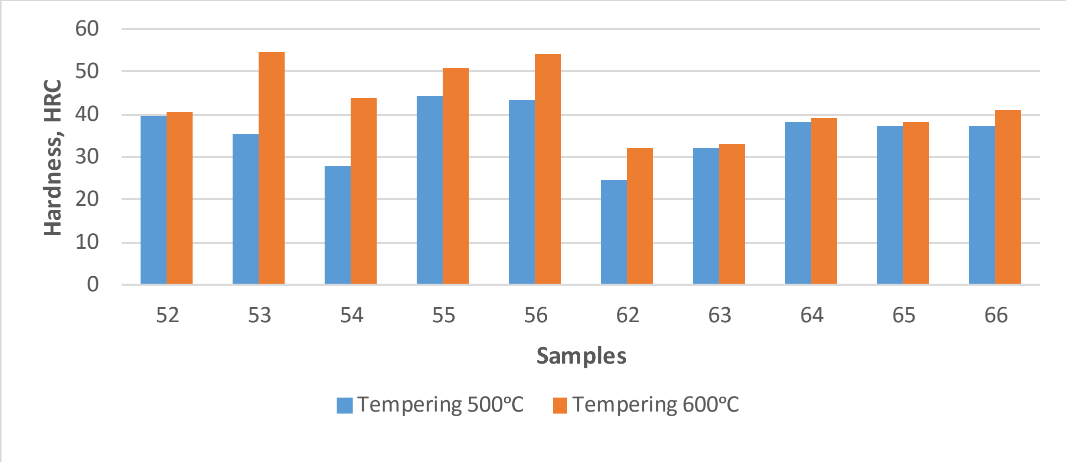


Figure.3.8.Hardness comparison of 500◦C vs 600◦C

3.2 WEAR TEST RESULT AND ANALYSIS

Presently going to the wear test we have led the test on the chose which are example 52 and 56 and example 62 and 66. Here for these examples the fluxes utilized are silicon carbide and silicon oxide. With example 52 and 56 the flux utilized is 100% silicon carbide. For the example 62 and 66 the flux utilized is 50% SiC & 50% silicon oxide. The composition 90%WC & 10% CI and 50% WC & 50% CI mixtures used in 52 and 56 specimens and and the same compositions are also used in 62 and 66 specimens respectively.

As per the computations for wear test, we Figure 6.13 minutes for 40 meters in example. The wear testing done up to 200 meters in example to organize the weight reduction of every example.

Table.3.2.Tempered samples for wear test

Specimen number	**Wear (weight loss in g)**					
	0 meter	**40 meter**	**80 meter**	**120 meter**	**160 meter**	**200 meter**
Specimen 52	18.96520	18.96155	18.95920	18.95625	18.95420	18.95100
Specimen 56	17.20435	17.20400	17.20150	17.20035	17.19835	17.19760
Specimen 62	15.60405	15.59770	15.59065	15.58525	15.57875	15.57440
Specimen 66	12.54930	12.54355	12.54285	12.54160	12.54060	12.53805

Table.3.3.Weight loss in grams

Specimen number	**Wear (weight loss in g)**					
	0 meter	**40 meter**	**80 meter**	**120 meter**	**160 meter**	**200 meter**
Specimen 52	0	0.00365	0.006	0.00995	0.0117	0.0149
Specimen 56	0	0.0053	0.01278	0.01893	0.02418	0.02843
Specimen 62	0	0.00635	0.0134	0.0188	0.0253	0.02965
Specimen 66	0	0.00575	0.0065	0.00775	0.00875	0.0113

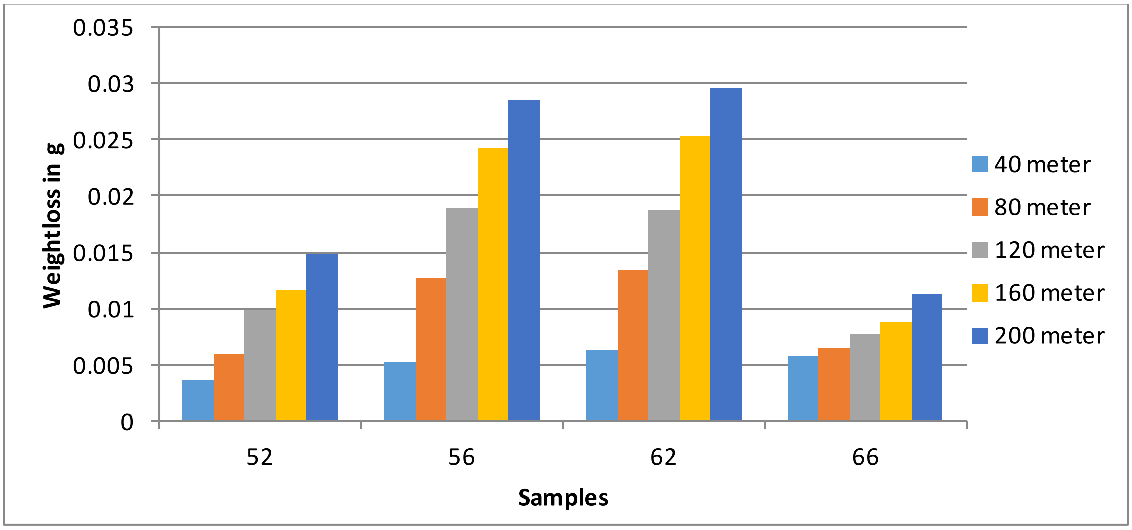


Figure.3.9 Weight loss in wear test

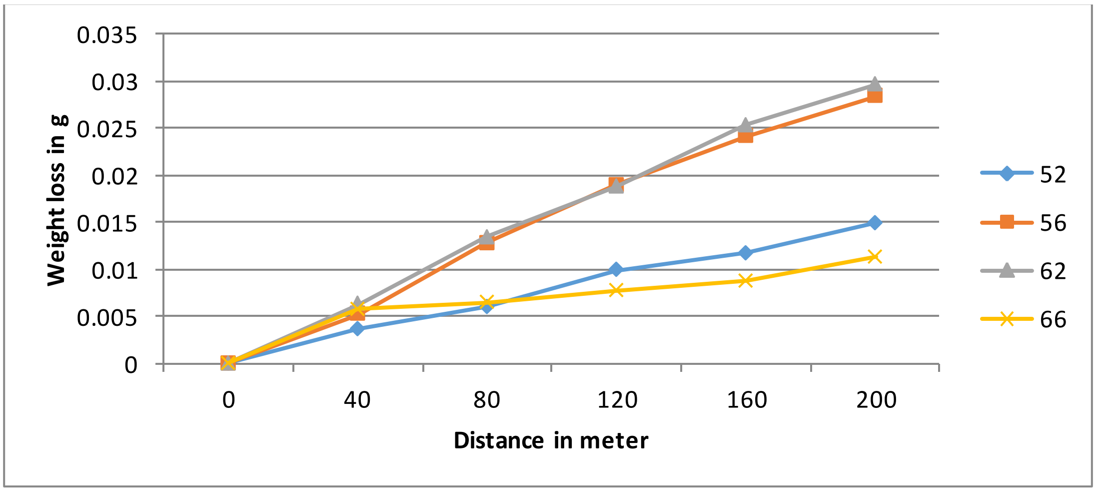


Figure 3.10 Weight loss for coatings

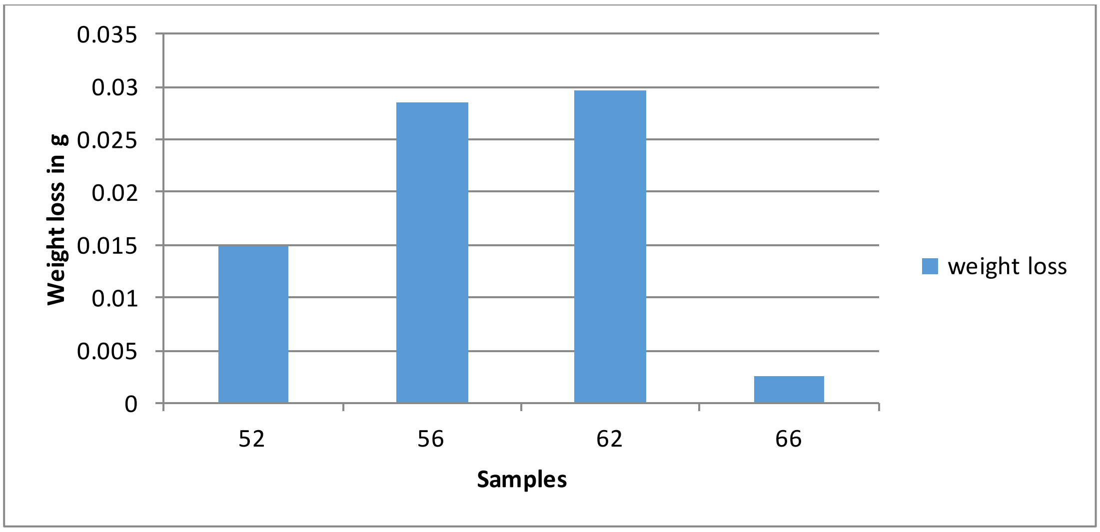


Figure 3.11 Final weight loss of coatings

From the graph of wear test, the weight loss in each meter shows the de creasing in weight of the samples. The weight losses in milligrams in all samples tested in wear test. The specimen 56 has low weight loss comparing to other specimens tested in wear test. From this graph, we can see the high wear resistance material with the mixture of 50% HM and 50% CI. Sample 62 shows the low wear resistance material with the flux of 50% SiC and 50% SiO. The tendency of the wear losses for samples decreases because these specimens are made of mixture tungsten carbide and cast iron and the tungsten carbide has very good wear resistance property.

3.3 MICROSTRUCTURAL ANALYSIS

Microscopic examination is an extremely useful tool in the study and characterization of materials. Several important applications of microstructural examinations are per the following to ensure that the relationship between the properties and structure (and defects) are properly understood, to predict the mechanical properties and characteristics of the elements, once these relationships have been established, to design alloys with new property combinations, to figure out if or not a material has been accurately warming treated, and to find out the method of mechanical crack. The microstructural analysis is conducted on welded samples before and after tempering.

Figure 3.11, 3.12 and 3.13 microstructure of the samples with a mixture of tungsten carbide and cast iron. Here, we can see the formation of carbides, to give high hardness for this composition of material. After tempering process were carried out in these samples the transformation of structures austenite to martensite.

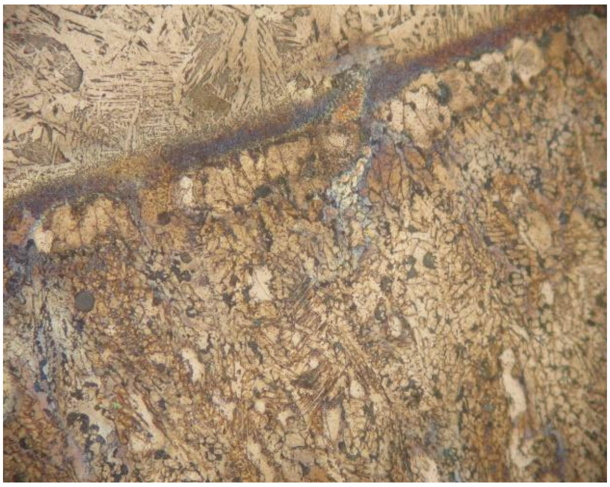


Figure.3.12 Microstructure of sample 53 (Magnification 200X)

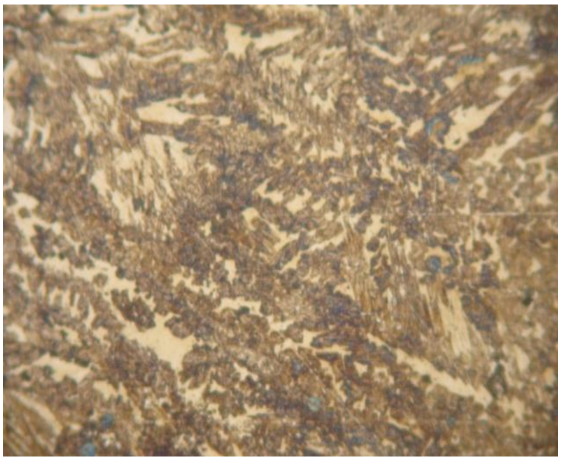


Figure.3.13 Microstructure of sample 53 after tempering (Magnification 200X)

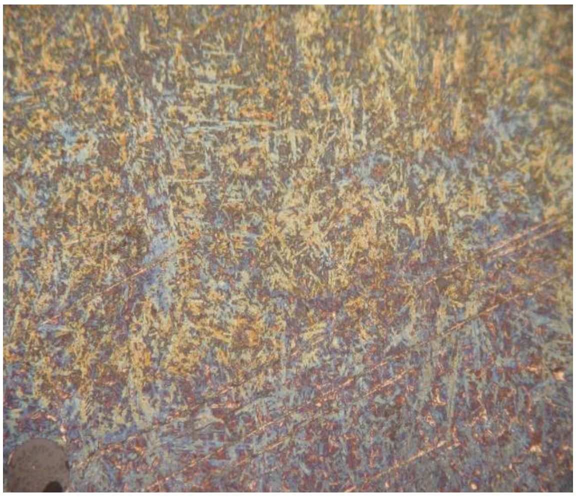


Figure.3.14 Microstructure of samples 62 after tempering (Magnification 200X)

From the microstructural analysis, we can see the transformation of austenite to martensite structure. The specimen with flux of 100% of SiC undergone for microstructural examination. The welded samples are kept up to 600◦C, here the transformation of grains to ledeburite eutectic structure. The microstructure shows the changes between before tempering and after tempering process. The toughness of the material has increased after the tempering process and the hardness of the material has been improved in both fluxes.

The various microstructure of the overlay welding surfaces with the different composition of hard metal and cast iron with standard flux and also with the combination of glass powder to form the coarse ferrite microstructure and with small perlite amount in Figure 3.11, 3.12 and 3.13. The transformation of microstructure of specimens has been inspected.

4. CONCLUSION

1. By submerged welding, we actualized cladding system for getting the quality weld. We directed hardness test, treating at various temperature, microstructure examination lastly wears test. We have utilized example 52 to 66 with just the flux blend and the example 52 to 66 with the mixture of tungsten carbide (Hard metal) and cast iron blend. The base metal of these samples is plain carbon steel. We have utilized general flux to contrast the outcomes got and the flux blend was arranged.

2. The experiment was done with the various compositions of materials and mixture of fluxes in each sample shown above and the above charts show the increasing and decreasing of hardness in each sample after tempering process. The hardness of sample 53, 55, 56 is improved after tempering at 600◦C comparing to the hardness before tempering. The tempering process helps to reduce the stresses and brittleness of the materials and gives the efficient hardness in this sample.

3. The mixture of tungsten carbide and cast iron gives high toughness and hot hardness to withstand the cutting temperature of the cutting tools and also for other applications.

4. From the results and discussion, sample 55 has the good hardness at 550oC with the composition of 60% of hard metal and 40 % cast iron and heated with the flux of silicon carbide.

5. Sample of flux with 100% SiC has the high hardness at tempering at 600oC comparing with above samples with the flux of 50% of SiC and 50% of SiO

6. So the experiment with this mixture gave good hardness in some samples, so the implemented technology and the techniques used in the experiment reduced some internal stress and improve wear behaviour of the cutting tools.

7. These materials can be coated on the metal machining process to improve tool life and these materials can be recycled for coatings for various applications. Coatings with less wear a resistive segment material with that of a high resistive material offers a perfect strategy for surface assurance.

8. At the point when pulverized glass powder is used of a flux for submerged arc welding, the electric arc is steady, fluid metal is all around shielded from air impact, also,

astounding surfacing is accomplished. Extension of different materials powder into the glass powder engages to change microstructure and properties of the overlying or weld metal.

9. The hard facing layers formed by the flux SiC and the glass powder made of crushed from waste materials. Layers with carbides by adding the percentage of tungsten carbides and cast iron. The surfacing of plain carbon steel with cast iron chips and powdered hard metal are mixed with the standard flux and with the added additives to obtain the good wear resistance.

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