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PROJECT REPORT

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DESIGN AND DELVELOPEMENT OF A POWDER FEEDINGSYSTEM FOR TUNGSTEN INERT GAS (TIG) CLADDING

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
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CERTIFICATE

This is to certify that the thesis entitled "**DESIGN AND DELVELOPEMENT OF A POWDER FEEDING SYSTEM FOR TUNGSTEN INERT GAS (TIG) CLADDING**" Submitted by **MR. JAYADEV DAS** in partial fulfillment of the requirements for the award of Bachelor of technology Degree in Mechanical Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance. To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree.

DATE:
PLACE: Rourkela

Prof. MANOJ MASANTA

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ABSTRACT

TIG cladding is a process where materials of different properties can be added/deposited on any structural component for improving its surface properties like hardness, wear resistance, corrosion resistance etc. these materials can be deposited by powder blown system. In this work a powder feeding system has been designed and fabricated for TIG cladding process. Function of different components has been studied. And with proper arrangement this powder feeding system has designed, so that low cost cladding process is possible, using a general purpose TIG welding set-up.

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1 INTRODUCTION:-

1.1 TIG welding Principle:-

Tungsten Inert Gas (TIG) welding is a dormant gas protecting circular segment welding methodology utilizing non-consumable cathode. The cathode is tungsten or tungsten thorium oxide or tungsten+ zirconium oxide mixture. The inactive gas is for the most part argon or argon –helium mixture. The welding zone is supplied with the protecting gas through the annular encompassing the tungsten cathode to adequately dislodge the air around the weld puddle.

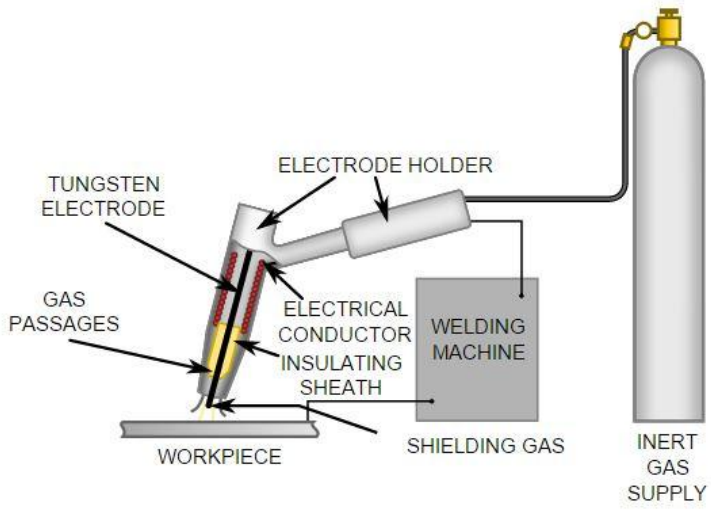

Fig.1: TIG welding set-up

TIG welding is usually used to weld slight segments of stainless-steel and non-ferrous metals, for example, aluminum (Al), magnesium (Mg) and copper (Cu) combinations. It can be utilized to make stronger joints with extensive variety of combinations. Vehicles for the most part utilize TIG welding for stronger joints.

TIG welding process can also be used for deposition of other materials to change the surface properties of the base metal. This process is generally called cladding. Here an external material can be added as filler rod or as powder cladding. Powder cladding is very commonly done by the use of laser. But with the help of Tungsten Inert Gas welding process different property material can be put under test.

Filler metals are additionally utilized as a part of about all uses of TIG, the real exemption being the welding of slim materials. Filler metals are accessible with diverse distances across and are made of a mixed bag of materials. Much of the time, the filler metal as a pole is

added to the weld pool physically, however a few applications require a consequently sustained filler metal, which frequently is put away on spools or loops.

Utilizing filler material will give the weld joint quality yet blending is dishonorable making it insufficient for a settled proportion composite arrangements. In any case, powder encouraging framework will kill this issue. For this situation blending is legitimate. We can improve surface complete in powder feeding system. Though it can provide good strength and durability powder feeding in TIG welding process is less in use. Powder feeding is extensively used in case of laser cladding process.

1.2 TIG and Laser Cladding:-

TIG cladding is a system for saving material by which a powdered or wire feedstock material is softened and united by utilization of warmth with a specific end goal to coat some piece of a substrate or create a close net shape part (added substance producing innovation) .It is frequently used to enhance mechanical properties or build erosion resistance, repair exhausted parts, and manufacture metal network composites.

The powder utilized as a part of cladding is regularly of a metallic nature, and is infused into the framework by either coaxial or sidelong spouts. The connection of the metallic powder stream and the warmth reasons liquefying to happen, and is known as the melt pool. This is saved onto a substrate; moving the substrate permits the melt pool to harden and therefore delivers a track of strong metal. This is the most well-known method, however a few procedures include moving the laser/spout get together over a stationary substrate to create cemented tracks.

Laser cladding process by powder deposition system generally requires a co-axial nozzle, which is costly and required proper alignment with the laser beam. In case of TIG cladding process an external powder feeding system is required that can flow the powder towards the TIG-arc. In present condition the available powder feeding system are mainly designed for laser cladding process and those are very expensive. Therefore simple and cost-effective powder feeding system is essential for TIG cladding process.

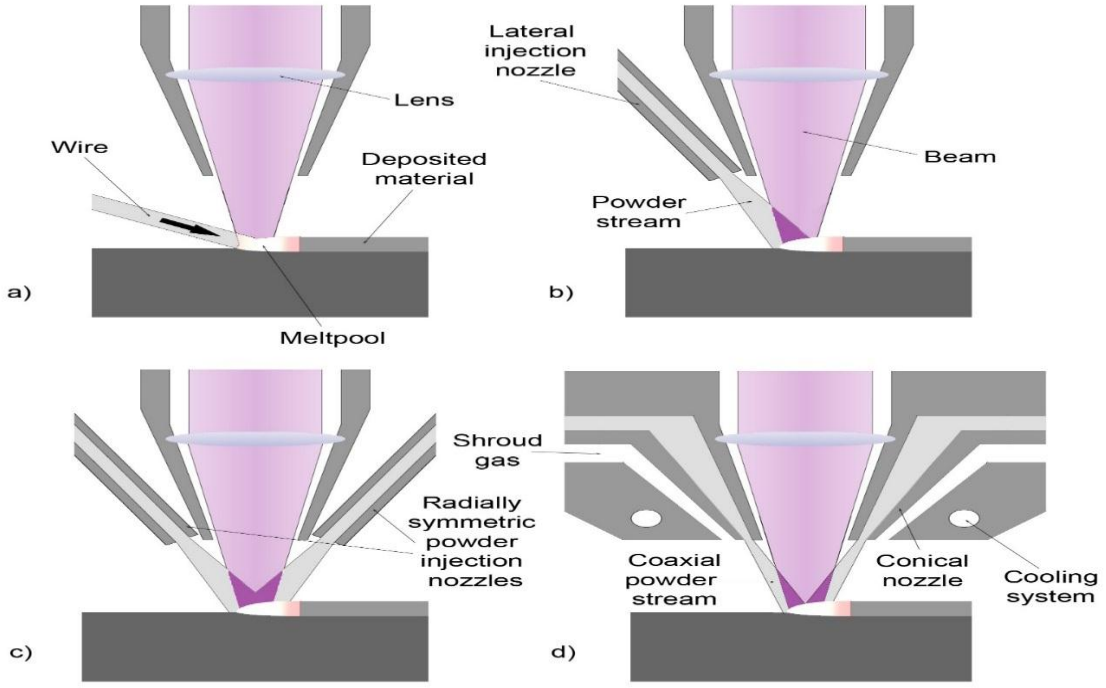

Fig.2: Different way of powder feeding in case of Laser cladding system

1.3 Advantages of powder feeding:-

1. No flash of time requirement.
2. Production time will be reduced.
3. New type of alloy material can be formed by properly fixing the mixing ratios.
4. No solvent is required.
5. Built part is free from crack and porosity.
6. Small heat affected zones (HAZs).
7. Most suited technique for graded material application.
8. Particular deposition.
9. High cooling rate.

1.4 Disadvantages:-

1. It is difficult to ensure the proper flow of powder material.
2. It is difficult to save the unused powder flow.

3. Some substrates can’t be used for this purpose.
4. Getting pure powder of different is not easy.
5. Control of penetration of powder into the weld pool is not easy.
6. Agglomeration process can’t be avoided.
7. Power consumption more in case of TIG cladding process.

In cladding process new amalgams are shaped just at first glance, it doesn't influence the main part of the substrate. To the amount of profundity powder will go will rely on the pace and kind of substrate we are utilizing. In the event of TIG cladding due to circular segment development blending of powdered material with the substrate is fitting. For this situation we can get a fitting amalgam organization. For laser cladding procedure warming must proceed for a more extended time of time however this is not needed for TIG cladding methodology. Since the curve created in TIG welding set-up is much higher and can soften the surface of the substrate effortlessly.

2 OBJECTIVE:-

Objective of my project is to design and fabricate of a powder feeding system for TIG cladding process. So that cladding of different type of powders can be done by using normal TIG welding set-up. Specific objective is,

1. To identify the different components required for the system.
2. To design and drawing of each components.
3. Manufacturing and arrangements of different components.
4. Assembly and testing with different powder material.

3 LITERATURE REVIEW:-

Name of source	Name of author	Journal issue/publication number/Material identity number/publisher	Year of issue	Description
A comparative study of Nd:YAG laser welding and TIG welding of thin Ti6Al4V titanium alloy plate [Ref no-1]	Xiao-Long Gao. And et.al	EM15-2012-029,Switzerland	2013	To verify the effect of TIG and Laser welding method on titanium alloy plate separately and get the results
The application of laser cladding to mechanical component repair, renovation and regeneration, [Ref no-2]	Dr. Sc. IngTorims	Torims T[oms] (2013) The Application of Laser Cladding to Mechanical Component Repair, Renovation and Regeneration, Chapter 32 in DAAAM International Scientific Book 2013, pp. 587-608, B. Katalinic & Z. Tekic (Eds.), Published by DAAAM International, ISBN 978-3-901509-94-0, ISSN 1726-9687, Vienna, Austria	2013	Use of laser cladding process for industrial purpose, laser welding and components study
Laser cladding process and image processing, [Ref no-3]	F. MERIAUDEAU, F. TRUCHETET, D. GREVEY and A.B. VANNES	Journal of Lasers in Engineering	1997	The laser cladding process involves many processing parameters which was studied and applied to image processing

Laser cladding : An experimental and theoretical investigation , [Ref no-4]	Hans Gedda	2004:41\ ISSN:1402-1544\ ISRN:LTU-DT--04/41--SE	2004	Investigation into laser cladding process using CO2 and Nd:YAG laser
Study on effect factors and control process of match between cladding powder and laser beam in co-axial powder feeding laser cladding, [Ref no-5]	Chen L. and et.al	Trans Tech Publications, P.O. Box 1254, Clausthal-Zellerfeld, D-38670, Germany	2012	Study of co-axial powder feeding system in case of laser cladding process
Energy attenuation modelling for laser cladding process with co-axial powder nozzles, [Ref no-6]	Tabernero I. and et.al	Conference article (CA), 16th International Symposium on Electro machining, ISEM 2010, Shanghai Jiaotong University Press	2010	Study of co-axial nozzles for powder feeding in case of laser cladding process and energy distribution
Machine vision system applied to the characterization of a powder stream: application to the laser cladding process , [Ref no-7]	Meriaudeau F. and et. al	SPIE-Int. Soc. Opt. Eng.,USA	1998	Detailed study of machine operated powder stream (powder feeding) system and its application in case of laser cladding process

4 DESIGN METHODOLOGY:-

A TIG welding powder feeding system was fabricated in the institute workshop with required raw materials and procured components. Before that a detailed design of the functional subsystems were made using computer aided design tools. For this SOLIDWORKS software was used which is very good in product design and analysis. The components that were designed include the mixing chamber, nozzle holding structure, nozzle, powder container andVibrating unit, cam and total piping system. Care was taken so to optimally use the material and space in the production engineering lab along with ease in using. The final components were fabricated in the workshop using the available materials like mild steel and pipes, different clamps, standard nuts and bolts etc. For fabrication purpose the welding machine, grinding machine, drilling machine, round filling tool, and flat filling tool were used. Some components are procured from commercial market to improve accuracy.

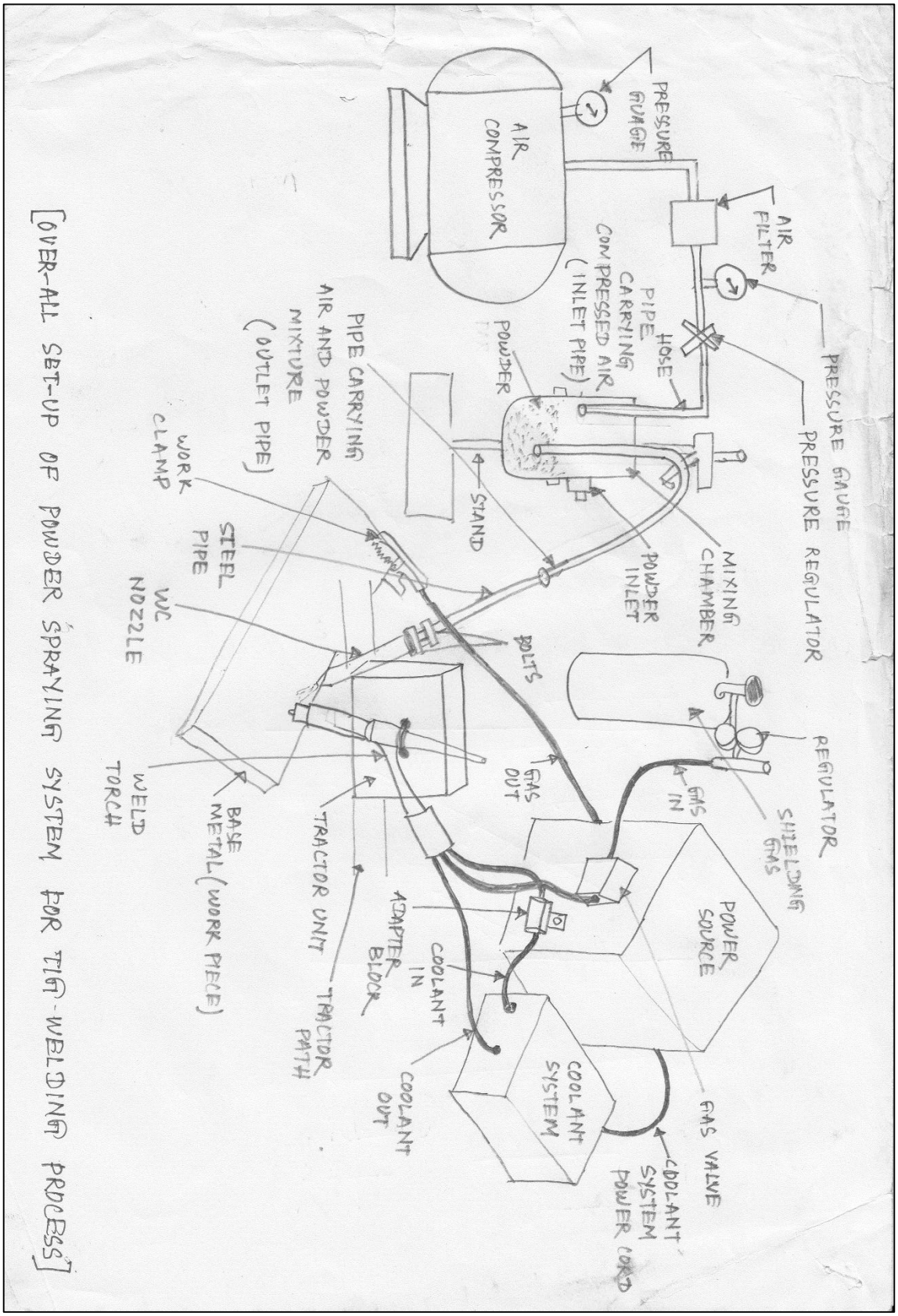

Fig.3: Total Layout

5. DESCRIPTION OF DIFFERENT SUBSYSTEMS:-

Different subsystems are

- Tractor
- Welding torch
- Nozzle
- Nozzle holder
- Flow-Rate Unit and Pressure gauge
- Air compressor
- Mixing chamber
- Vibrating assembly
- Piping system
- Powder materials

5.1 Tractor and welding torch set-up:-

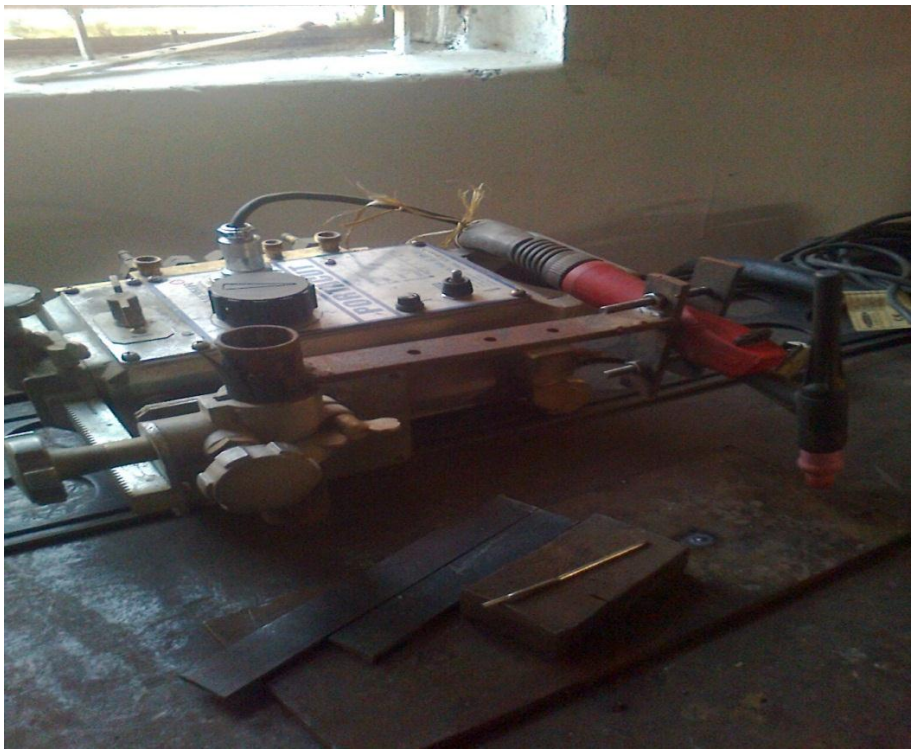

Fig.4: TIG Torch with movable Tractor

Tractor is operated automatically and welding torch is clamped to it.

5.1.1Welding Torch:-

TIG welding lights are intended for either programmed or manual operation and are furnished with cooling frameworks utilizing air or water. The programmed and manual lights are comparative in development, however the manual light has a handle while the programmed light typically accompanies a mounting rack. The point between the centerline of the handle and the centerline of the tungsten cathode, known as the head edge, can be fluctuated on some manual lights as per the inclination of the administrator. Air cooling frameworks are frequently utilized for low-momentum operations (up to around 200 A), while water cooling is needed for high-flow welding (up to around 600 A). The lights are associated with links to the force supply and with hoses to the protecting gas source and where utilized, the water supply.

Fig.5: TIG welding torch de-assembled

5.1.2 Tractor:-

It is used to control the movement of the welding torch automatically. It has many ports which makes it multi-functional. It also has support structures for fitting any other assembly to aid the welding.

Fig:-6 [Tractor]

5.2 POWDER DELIVERY SYSTEM:-

It is the very essential part of the design. Its sub-systems are described below.

5.2.1 Air compressor:-

Air compressors pack the air to high weight taking data vitality from electric engine or interior ignition motor. In powder encouraging high weight air plane is obliged so that the powder in it can strike the work piece at high speed. Positive-dislodging air compressors work by driving air into a chamber whose volume is decreased to pack the air. Cylinder sort compressors utilize this guideline by pumping air into an air chamber through the utilization of the movement of cylinders. They utilize one-path valves to direct air into a chamber, where the air is compacted. Rotational screw compressors likewise utilize positive-relocation pressure by mating two helical screws that, when turned, send air into a chamber, whose volume is diminished as the screws turn slowly. Vane compressors utilize an opened rotor with changed razor sharp edge arrangement to lead air into a chamber compacting the volume. The utilizations of compressors are to supply high-weight air to fill gas barrels, to supply direct weight air to a submerged surface supplied jumper, to supply direct weight air for driving some and school building pneumatic HVAC control framework valves, to supply a lot of moderate-weight air to power pneumatic apparatuses, to fill tires, to deliver vast volumes of moderate-weight air for huge scale modern utilize, for example, oxidation for petroleum coking or bond plant sack house cleanse frameworks. For this reason a compressor with limit 50 bar fueled by electric engine is utilized. The electric engine has the particular as takes after. Power-3 HP, speed 1415 rpm, 3 stage impelling engine.

Fig.7: Air compressor

5.2.2 Mixing chamber:-

The high pressure air from the compressor is passed through a FRL unit to remove any impurities. Then it is fed to the abrasive chamber which has one inlet for the incoming compressed air and outlet for mixture of abrasive particles and air. The abrasive particles are introduced from the side so to form a cyclone to facilitate better mixing. The chamber is of cylindrical shape made up of mild steel.

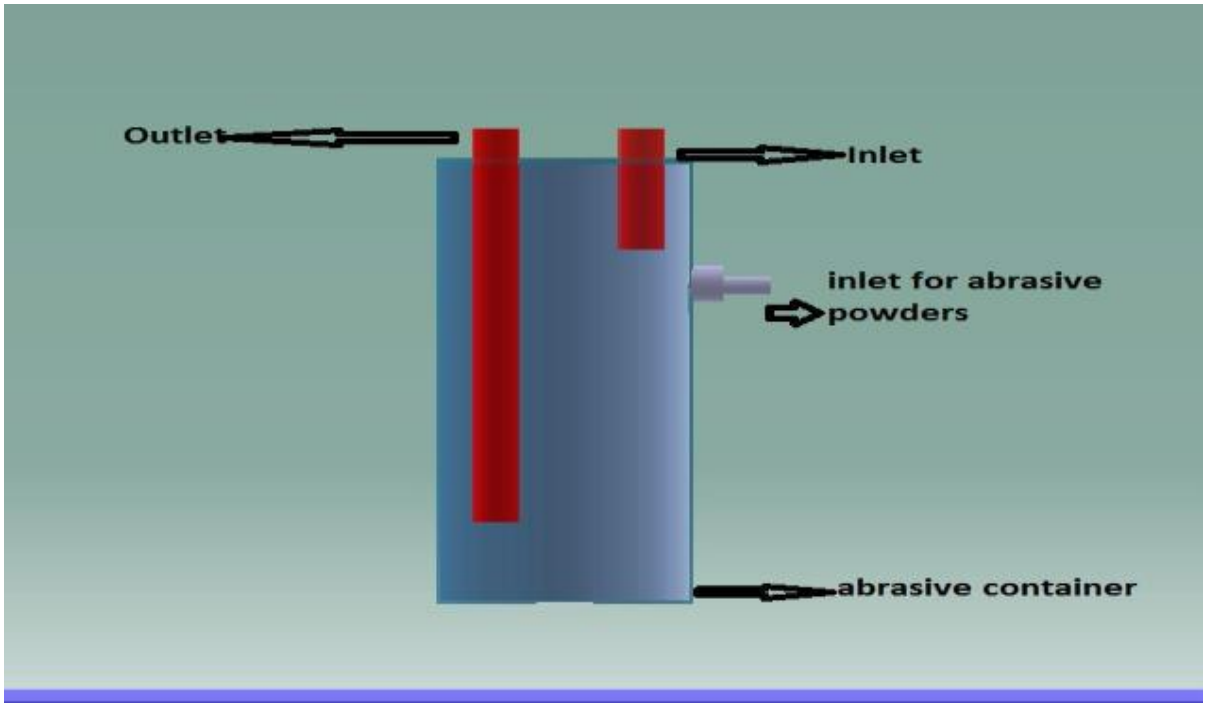

Fig.8: Mixing chamber (front view)

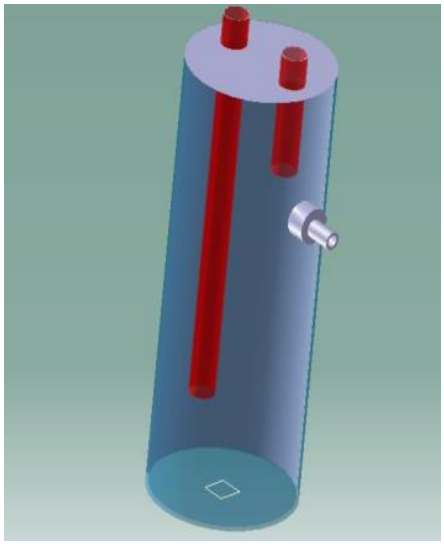

Fig.9: Mixing chamber (isometric view)

Fig.10: mixing chamber

5.2.3 Vibrating assembly:-

The vibration of powder container is required for the through mixing of the powder particle and air. The vibration is made capable by rotating cam action .The cam is connected to the electric motor and touches the end of the powder container. The container is hinged to an extension made out of the base. The powder flow rate can be varied by varying the speed of the motor. The whole system is made up of mild steel material in the institute workshop. Induction motor is used for this purpose.

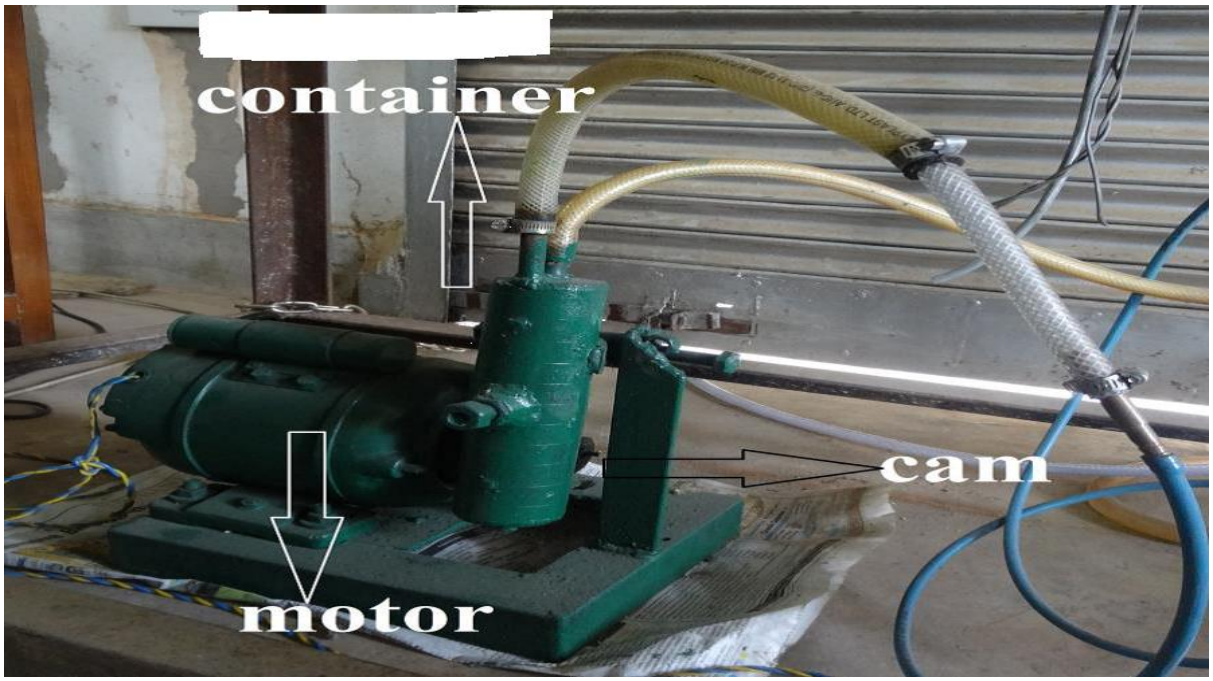

Fig.11: Vibrating assembly for mixing chamber

An incitement or offbeat engine is an AC electric engine in which the electric current in the rotor expected to create torque is acquired by electromagnetic impelling from the attractive field of the stator winding. An instigation engine consequently does not oblige mechanical, separate-excitation or self-excitation for all or a piece of the vitality exchanged from stator to rotor, as in general, DC and huge synchronous engines. An actuation engine's rotor can be either wound sort or squirrel-pen sort. Three-stage squirrel-confine prompting engines are generally utilized as a part of modern drives in light of the fact that they are rough, solid and practical.We can change speed as per our requirement and change the powder flow. Also air compressor is fitted to the motor piping which was shown in the figure.

5.2.4 Flow-Rate Unit:-

FR stands for filter regulator which is necessary for filtering the air and regulating the pressure. The common impurities suspended in the compressed air are dust particles of various sizes, moisture, and oil particles. Excess moisture present in the pipeline may result in coagulation of particles and jam the nozzle opening. Air filters have a porous membrane having various pores sizes like 5, 10, or15 μms. They block the particles larger than the pores.

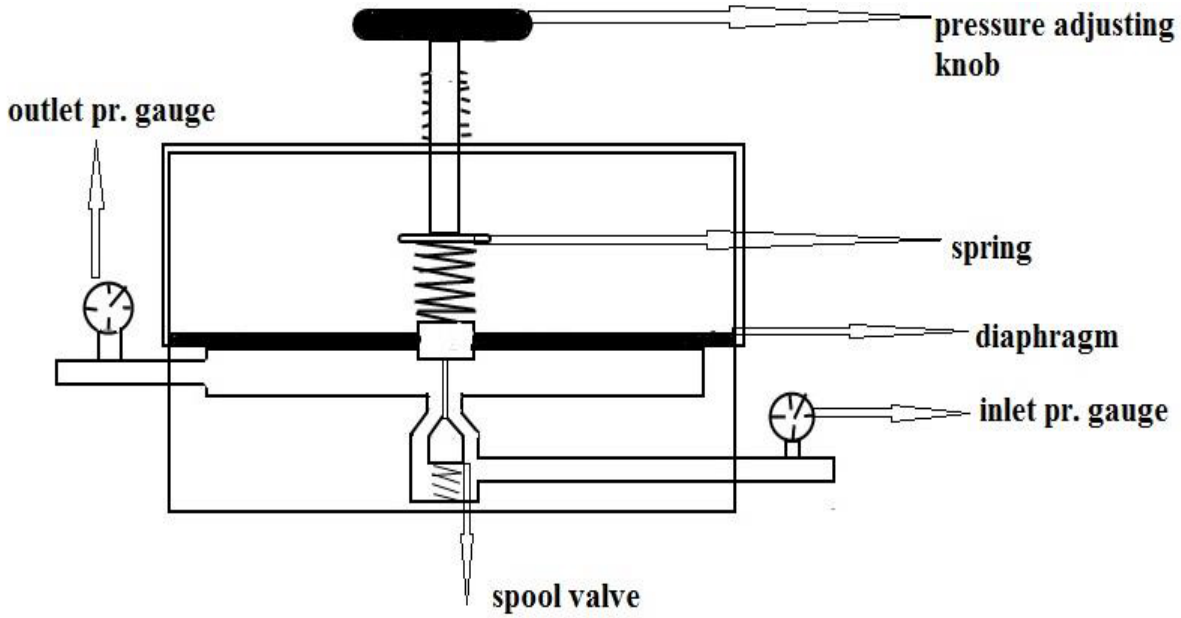

Fig.12: Pressure regulator working

The line weight is controlled by weight controller. A weight controller has a limiting component, a stacking component, and a measuring component. The limiting component is a sort of valve. It can be a butterfly, valve globe valve, poppet valve, or some other sort of valve that is equipped for working as a variable confinement to the stream. The stacking component applies power to the confining component. It can be a basic weight, a spring, a cylinder actuator, a stomach actuator in blend with a spring. Here a solitary stage weight controller, a power parity is utilized on the stomach to control a spool to manage weight. With no channel weight, the spring over the stomach pushes it down on the spool, holding it open. At the point when bay weight is presented, the open spool permits stream to the stomach and weight in the upper chamber increments until the stomach is pushed upward against the spring power, bringing on the valve to lessen stream, in this manner halting further increment of weight. By changing the top screw by turn, the descending weight on the stomach can be improved, obliging more weight in the upper chamber to look after balance. Along these lines, the yield weight of the controller is controlled inside a protected cutoff.

5.2.5 Nozzle:-

Nozzles are the mechanical devices which increase the velocity of fluid in exchange of pressure drop. They are commonly used in internal combustion engines, space rockets, missiles, fire extinguishers etc. In powder feeding system the high velocity jet is created by the nozzle action. As the powder particles strike the nozzle they may erode the nozzle surface. So very high wear resistant materials such as tungsten carbide and sapphires are used. Tungsten carbide nozzles are used for circular cross-sections in the range of 0.12-0.8 mm diameter, for rectangular sections of size 0.08 x 0.05 to 0.18 x 3.8 mm and for square sections of size up to 0.7 mm. Sapphire nozzles are made only for circular cross-sections only. The size varies from 0.2 to 0.7 mm in diameter. Nozzles are made with an external taper to minimize secondary effects. Nozzles made of tungsten carbide have an average life of 12 to 30 hours whereas nozzles of sapphire last for about 300 hour of operation. The rate of powder feeding and accumulation of powder material are influenced by the distance of the tip nozzle from the work piece. The powder particles from the nozzle follow a parallel path only for a short distance and then the jet of particles flares resulting in the oversizing of the hole. Despite their simple design, nozzles can be troublesome at times. The main drawbacks are short life of expensive parts, clogging of orifice due to dirt or moisture, wear, miss alignment and damage to the jewel.

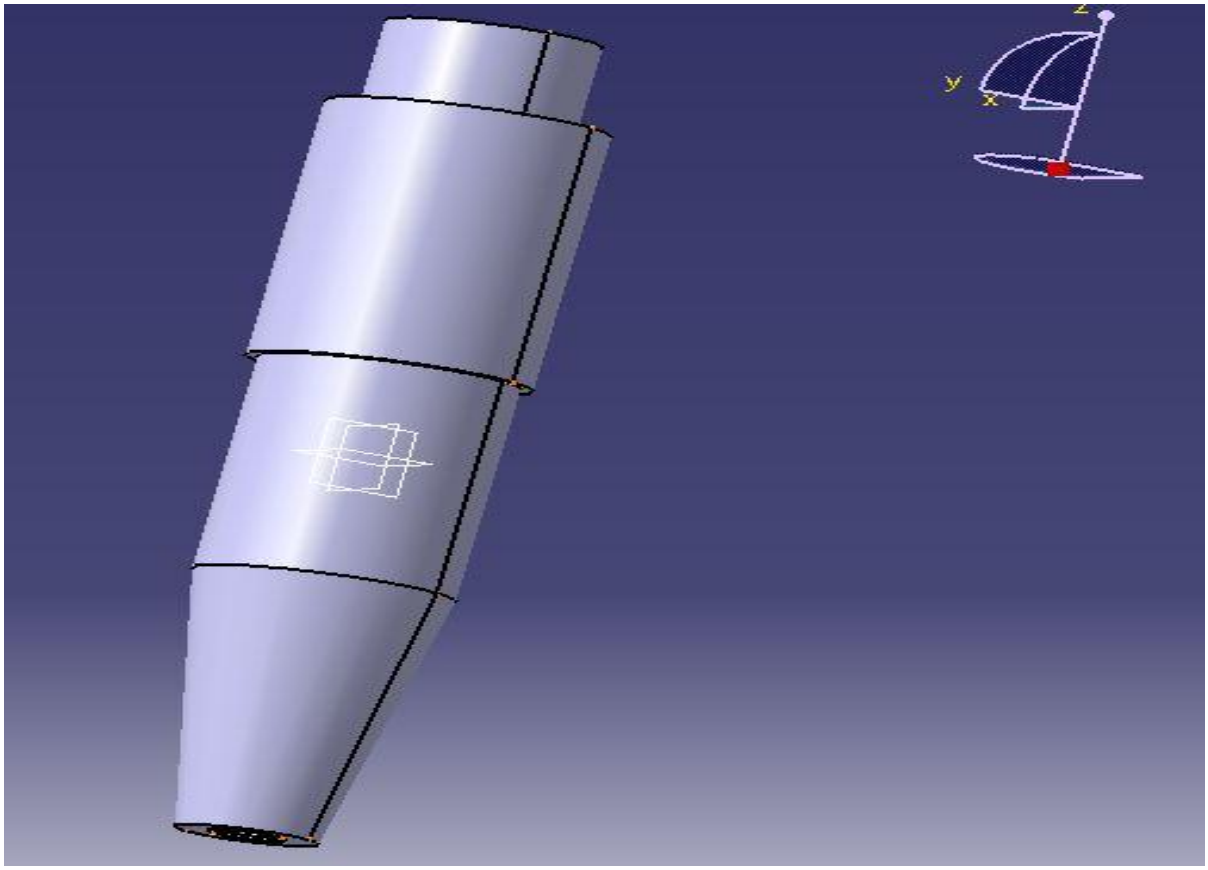

Fig.13: Nozzle, isometric view

Nozzles having orifice diameter 1 mm is used to facilitate the variation. The nozzle material is tungsten carbide. They are procured from outside to increase the efficiency and accuracy.

5.2.6 Nozzle holder:-

It is the structure made in the welding shop and carpentry shop to support the nozzle during powder feeding process. This is attached to the tractor by arc welding process. First a 5mm mild steel bar is welded to the tractor parallel and then three holes of similar dia. (6-8 mm) were made by power drilling machine.

Fig.14: Bar welded to the tractor

Then a 15-18cm bar of thickness 5mm was cut bay hack saw in the welding shop. And then it was fixed to the 1st hole from left side of the 1st bar by nut and screw. Dia.

Of the screw is 6mm. before that a hole was created by round filing process in the 2nd bar approximately to the accommodate the nozzle and steel pipe fitting in a slant manner and with a 60 degree angle to the horizontal.

Nozzle and steel pipe fitting was made by cutting a 15-17 cm long steel pipe and fixing it with nozzle by 2 steel nuts tightly. For this purpose threading of 28g was made on one side of the steel pipe by Centre lathe.

Fig.-15: Nozzle fitted to the tractor

5.2.7 Piping system:-

The piping systems are required for carrying the compressed air from the compressor to the mixing chamber and from the mixing chamber to the nozzle orifice via the filter regulator. It is required to maintain the pressure in the line without eroding the pipe. Here nylon braided hoses having 12 mm internal dia. is provided. This is used because of long life, light weight, durability and easy availability. Also the head loss is very small when it occurs a bend. The hose is composed of reinforcement of synthetic yarn in between two or more layers of soft PVC. The yarn is reinforced in longitudinal directions as well as crosswise so as to increase the strength.

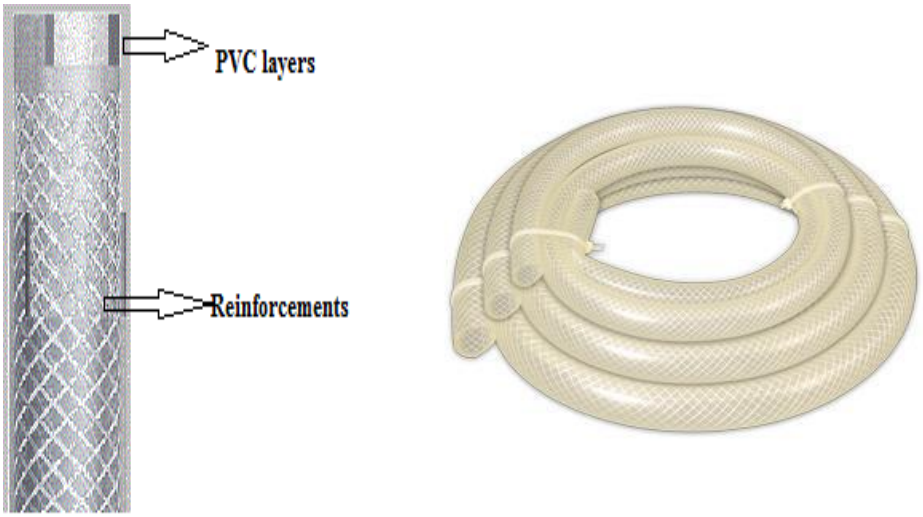

Fig.16: Braided hose pipe Structure

5.2.8 Powder materials:-

Metal powder is a powdered metal such as aluminium powder and iron powder. Carbide powder can be used for this purpose because it is very light and easily available.

Table-1: Characteristics of the used iron powder

Bit size average (nm)	Allowed changes (nm)	Special surface area g	Volume density (g/cm3)
80	≥60~100	>8	0.06~0.8

6 DESCRIPTION OF WORKING OF TOTAL SYSTEM:-

In this system powder was stored in a container which was perfectly air tight, clean and polished properly. Then its inlet end was connected to the compressor pipe and properly tightened. Then the outlet end was connected to the pipe through which powder and air mixture came out. That container is the mixing chamber for the air and powder. That container was connected to an induction motor by cam joint. Other end of the outlet pipe was connected to the steel pipe properly. That steel pipe's other end was threaded by centre lathe. Then a tungsten carbide nozzle was fitted to the thread part tightly and bolted. The nozzle holding part is explained earlier.

Operation of the system is explained below briefly.

When the compressor is plugged in and started then air will rush to the mixing chamber. Powder in that mixing chamber will agitated, when the motor is plugged in and

stated because of the cam motion the mixing chamber will vibrate. Because of the vibration powder and air will mix properly and due to high pressure mixture will be expelled out of the chamber through the outlet pipe to the nozzle end. As air is used as carrier gas agglomeration will reduce.

Fig.17: Total assembly of TIG cladding setup in the welding shop

7 RESULTS:-

Set-up for TIG cladding process was made and tested for proper flow of powder. Test for the proper mixing of air and powder material was done. Functionality of different components was checked. First, abrasive particles were tested by putting them into the mixing chamber. Other powder materials can be tested as per the availability. Low density powder e.g. aluminum, carbides will give better results. Flow rate can be controlled by controlling the motor rpm.

8 CONCLUSION AND SCOPE FOR FUTURE WORK:-

Laser cladding process is a heat-concentrated-at –a –point process. And heat affected zones (HAZs) are there in this process. Though it is used widely but it is very costly and can't available easily. Mass production can't be done by laser cladding. And moreover the nozzle set-up in the laser cladding process is quite difficult. Despite this widespread research s are going on this topic to make it industry oriented and cost effective.TIG cladding is a very versatile process. We can produces cladded metals by using simple TIG welding set-up, which is easily available and cost effective.

TIG cladding is the best substitute for laser cladding. It uses a simple TIG welding set-up for the cladding process. In my project I arranged all the different components of the TIG cladding and tested for different powder material for the effect on the different substrate material. And very simple nozzle set-up is used for this purpose.

In future this TIG cladding set-up can be improvised by using automatic torch movement and modern power techniques. New improved nozzle can led the research in a long way. Different components like mixing chamber, piping system can also be improvised. Use of new techniques can avoid the agglomeration process in the container and piping system. Advanced powder and air mixing process are also available, which can be used.

In the present time TIG welding and TIG cladding is used for high temperature welding and surfacing. But further research can led this use to mass production of different alloyed surface products. By TIG cladding process we can produce different exotic materials.

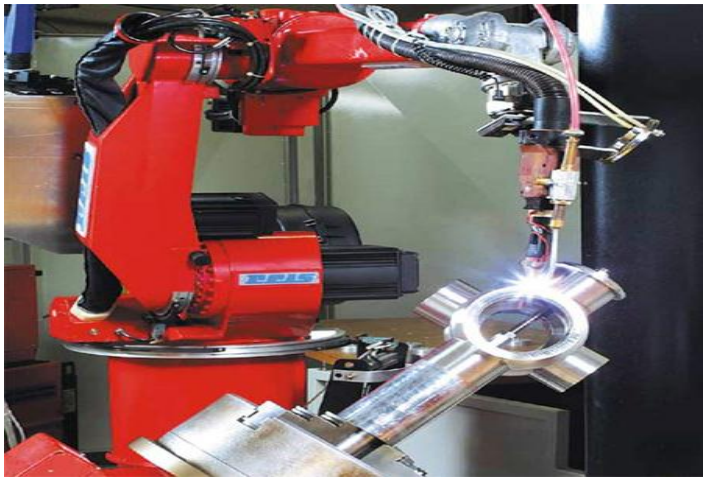

Fig. 18: Use of TIG surfacing in the industry

The above figure give the idea that TIG cladding can be used by robots also, which can a productive research area for scholars.

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