STUDY AND OPTIMIZATION OF EDM POWDERED PROPERTIES FOR NICKEL, HE30, SS304

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Abstract: Electro Discharge Machining (EDM) has become an important and cost-effective method of machining extremely tough and brittle electrically conductive materials. It is widely used in the process of making mould, dies, sections of complex geometry and intricate shapes. The work piece material selected for this study is nickel, He30, SS304 performance variables i.e. high material removal rate, low tool wear rate, better surface finish with lower dimensional tolerance. Further a regression analysis can be used for finding the model equations for various performance parameters.the welding properties of the UNS S32304 lean duplex stainless steel were investigated in order to improve the microstructure and mechanical properties. Nickel powder was directly poured inside the joint gap and mixed with the filler metal during the Gas Tungsten Arc Welding (GTAW) process; moreover, the solution heat treatment was performed at 1100 °C for 10 min. The joints were characterized by optical microscopy (OM) and the evolution of the phase percentages in the different zones was studied by means of the image analysis technique. Tensile and hardness tests were carried out on the joints in order to evaluate the improvement of the mechanical properties. The results showed that both the addition of nickel powder during the welding process and the post weld heat treatment made it possible to improve the mechanical properties of the weld joints.

1.0 Introduction:

Electrical discharge machining (EDM) is one of the most extensively used non-conventional material removal processes. Its unique feature of using thermal energy to machine electrically conductive parts regardless of hardness has been its distinctive advantage in the manufacture of mould, die, automotive, aerospace and surgical components. In addition, EDM does not make direct contact between the electrode and the work-piece eliminating mechanical stresses, Moreover, they show higher toughness and plasticity than martensitic steels Due to their unique properties, these stainless steels present some advantages with respect to monophase stainless steels and have many applications in different sectors such as the food, petrochemical, oil&gas and marine industries. Different welding methods can be applied to duplex stainless steels for the production of a range of equipment and structures. Normally, fusion-welding processes can cause damage to the equal percentage of the ferrite and austenite phases, which is responsible for their good engineering properties electrically conductive parts can be machined using EDM irrespective of the hardness. There is no mechanical forces exist because there is a gap between the tool and work piece, only thermal energy is used to manufacture parts EDM can easily tackle exact tolerance because the exact shape of the electrically conductive tool is punched on the work piece material EDM is used for brittle and conductive materials, in this process a spark is produced with the help of DC and a small gap between too and work piece EDM also have some limitation such as high surface roughness and low material removal rate (Effect of Ni). To overcome these limitations powder EDM is introduced. In powder EDM process a small amount of fine powder (nickel , He30, SS304) is mixed in the dielectric fluid of the EDM which enhance the machining properties of EDM Nickel based super alloys are used in the aero engine industry due to their high temperature strength the machining nonconventional

manufacturing processes such as EDM is used. EDM is extensively used in the field of manufacturing dies and molds, also used to manufacture hard components for aerospace industry and automotive industries

Powder type: The powder added into the dielectric fluid could increase the MRR and decrease the tool wear rate (TWR) and improve the surface quality of the work quite clearly. But the different powders would have different impact on the output characteristics of the EDM process. A powder which can be suspended into dielectric fluid of EDM must have following properties:- It should be electrical conductive in nature.

- It must be non-magnetic in nature.
- It must have good suspension capabilities.
- It should have good thermal conductivities.

2.0 literature review:

C.H. CheHaron, B.Md. Deros, (2001), Machining performance can be improved by increasing material removal rate and minimizing surface roughness (SR) of the final product. Machined surface quality is being expressed by surface roughness, which belongs to the smoother surface SR is a critical requirement of the manufactured parts in various cases. To achieve the desired surface finish of a part has a great value for its functional behavior Material removal rate (MRR) directly influences the production rate of the system. To achieve greater production rate higher MRR is required.

Naveen Beri, S. Maheshwari (2008) Although the aim of this survey is to summarize the uses of metallic nickel and describe its life cycle, information on nickel salts is included where needed to understand the life cycle of metallic nickel. The regulation of nickel often addresses nickel metal and nickel compounds as a whole. Apart from REACH, specific provisions on nickel and nickel compounds apply in the work environment, the water environment, drinking water, air quality and waste incineration as well as content in toys and cosmetics etc.

Maheshwari , P.C. Pandey,(2005) The recent developments in the field of EDM have progressed due to the growing application of EDM process and the challenges being face by the modern manufacturing industries, from the development of new materials that are hard and difficult-to-machine such as tool steels, composites, ceramics, super alloys, Nikel, He30, stainless steels 304, heat resistant steel, etc. Typically, the major cost and time components in die and mould machining by EDM are in the electrode fabrication, which can account for over 50% of the total machining cost

Shunmugam, P. K. Philip(1993) Described a new method of surface modification by EDM By using an ordinary EDM machine tool and kerosene fluid, a hard ceramic layer can be created on the work piece surface with a Ti or other compressed powder electrode in a certain condition. It was observed that a compact ceramic layer can be created on the surface of the metal work piece. Blending of copper powders containing resin with chromium powders to form tool electrode has been investigated by investigated the small area EDM process using a copper–tungsten electrode on SS304 and has reported that the values of the MRR, SR increase for higher values of pulse current.

3.0 Methodology:

The majority of work has been done using mechanically formed tool electrodes and the present EDM user is compelled to search for alternative tooling such as powder metallurgy (PM) method of electrode fabrication which is more economic and faster to manufacture. A complex electrode made by conventional method can cost around 100 times more than a simple square electrode. However, in the PM route a large number of tool electrodes can be made from a single die and punch assembly, resulting in an overall reduction of EDM tooling cost. Therefore, PM turns out to be a viable alternative to produce tool electrode in which the desirable properties of different materials can be combined. Moreover, the thermal, electrical, mechanical and micro structural properties of PM tool electrodes can be effectively controlled by the

process variables such as compacting pressure and sintering temperature. These will affect density and pore shape. An example is an alloy of SS 304, He 30, Ni, made through PM where tungsten particles are uniformly embedded in highly conductive copper matrix. The electrodes made by using powder metallurgy technology from special powders have been used to modify EDM surfaces in recent years, to improve wear and corrosion resistance considering the welding process, two different conditions were considered in this study. In particular, in the first condition, the stainless steel was welded only by using the filler material, while in the second condition nickel powder with spherical morphology and a diameter range of 150 ± 60 µm was pre-poured manually into the joint gap before welding,

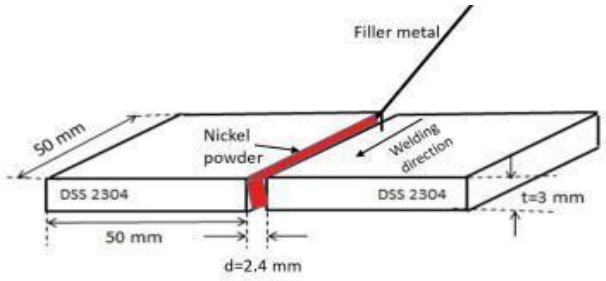


Figure: Layout of the joint with addition of nickel powder

Considering the subsequent microstructural and mechanical investigations of the joints, two different metallurgical conditions were considered after welding. Half of the joints were studied in the as-welded condition, while the other half was subjected to post weld heat treatment at 1100 °C for 10 min followed by water quenching. This temperature was selected because it is higher than the solubilization temperature of all deleterious intermetallic phases and is recommended by other authors in the literature. Moreover, the metallurgical analyses of the base metal in the as-received condition and in the heat-treated condition according to the as-mentioned parameters were considered as a reference

Nickel Powders for Powder Metallurgy:

The nickel powders produced for powder metallurgy applications have been developing step by step over recent decades as customer property specifications have become ever more tringent. Today, there are no „standard" products, only certain families of powders that are based on different morphologies and subsequently fashioned for individual customer applications. Nickel powder production can now be controlled to give the powders the right particle size, density and especially particle shape to enhance the properties of low alloy steel powder metallurgy parts. Additions of nickel to the alloy typically range from 1.75-5%. Nickel-enhanced alloys are increasingly being used for making pressed and sintered parts, particularly in the automotive field.the machining parameters for EDM are discussed such as Pon, also known as machining time current flows and material removed during this time period so MRR and SR depend on Pon, DC, is among the main variables which effect SR and MRR significantly basically it is the current applied to produce spark, Poff, is the time between the two consecutive sparks removed material is washed away during this time. It is evident that SR is directly proportional to the Pon. Reason behind the increasing surface roughness with the increase in discharge duration is the discharge energy released for this period of time The DC was one of the most significant factor for both the SR and MRR, tracked by Pon for MRR the RSM based SR model can be optimized using GA to obtain the optimum values of independent variables

Applications Of Powdered EDM

1) Powdered EDM has promising application for achieving near mirror like surface finish.

2) Advanced materials such as MMC"S, insulating ceramics like SS304 etc. have been successfully machined by dispersing various powders in to the EDM dielectric.

3) Making and machining of micro product & sophisticated micro mechanical Element. It is the use of light, thin, compact, special purposes work such as micro-engines, micro pumps, micro-robots etc.

4) Enhancement of machined surface functional properties, such as wear resistance, corrosion resistance and reduced friction coefficient, through surface modification

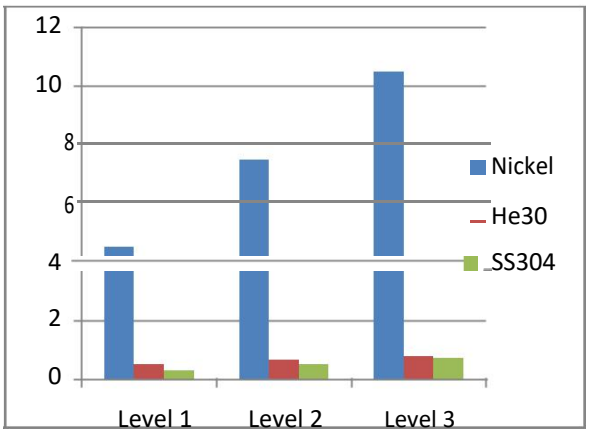
4.0 Results:

EDM research has concentrated on achieving faster and more efficient metal removal rate coupled with a reduction in tool wear and improved surface characteristics The majority of work has been done using mechanically formed tool electrodes and the present EDM user is compelled to search for alternative tooling such as powder metallurgy (PM) method of electrode fabrication which is more economic and faster to manufacture. A complex electrode made by conventional method can cost around 100 times more than a simple square electrode. However, in the PM route a large number of tool electrodes can be made from a single die and punch assembly, resulting in an overall reduction of EDM tooling cost. Therefore, PM turns out to be a viable alternative to produce tool electrode in which the desirable properties of different materials can be combined. Moreover, the thermal, electrical, mechanical and micro structural properties of PM tool electrodes can be effectively controlled by the process variables such as compacting pressure and sintering temperature. These will affect density and pore shape. An example is an alloy of He30,SS304, made through PM where tungsten particles are uniformly embedded in highly conductive copper matrix. The electrodes made by using powder metallurgy technology from special powders have been used to modify EDM surfaces in recent years, to improve wear and corrosion resistance

Table 4.1 Powdered EDM Parameters Levels

	Level 1	Level 2	Level 3
Nickel	4.5	7.5	10.5
He30	0.5	0.66	0.78
SS304	0.3	0.5	0.7

Investigated how machining characteristics and surface modifications affect stain less steel during electrical discharge machining (EDM) processes with semi-sintered electrodes. It was found that the composition of the semi-sintered electrodes was transferred onto the machined surface efficiently and effectively during the EDM process and that the process is feasible and can easily form a modified layer on the machined surface.



Graph: Powdered EDM Parameters Levels

it is observed that PM tool electrodes have a significant role in metal removal process in addition to their contribution in surface treatment/modification applications and a need is felt to correlate the usefulness of He30,Ni made through powder metallurgy (PM) with a view to optimize the process parameters

Conclusions:

The invention of EDM many advancements in the machining process has been made. EDM has the capability of machining intricate profiles and materials which are difficult to cut. characteristics to be achieved. During EDM of stain steel it is found that electrode material, current and duty cycle has significant effect on both the performance parameters. Best parameter selection within the experiment range for maximum MRR is with He30, at 10.5 a current, 0.66 duty cycles and 0.7 Kg/cm2 and for minimum surface. So if the requirement is to have high MRR then it is recommended to use Cu electrode and if the requirement is to have better surface finish only on the machined surface of Ni, He 30 then it is recommended to use SS304, electrode made through PM. that many fundamental issues of this new development, including the machining mechanism are still not well understood. The complexity of this process, particularly in context with thermo physical properties of the suspended particles deserves a thorough investigation. Secondly, the difficulty in operation of dielectric interchange, the high amounts of powder consumption, the environmental requirements of fluid disposal and its higher initial cost (two to three times higher than the one required for a conventional EDM system)

Future Scope:

This paper presents a detailed summary of research results reported in the area of powder mixed EDM It can be concluded from this review that SS304,He30, Powdered EDM holds a bright promise in application of EDM, particularly with regard to process productivity and surface quality of workpiece. As such, extensive study is required to understand mechanics of machining and other aspects of PMEDM

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