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Depassivation Method of Hard Passive Alloys by Electrochemical Machining

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ABSTRACT: *Recently numbers of materials are discovered for industrial applications. Those materials are having very high hardness and difficult to machining. Such materials are widely used in aerospace, automobile as well as in electronic industries. For mechanical machining purpose the first requirement for the cutting tool is its hardness must be higher than the workpiece. Therefore for machining of such materials non contacting non mechanical machining method or processes are used. In all non contacting methods electrochemical machining process is one of the best alternatives for machining hard passive alloys as well as composite materials. For electrochemical machining process the important requirement for the workpiece material is, 'it must be electrically conductive. Hard passive alloys such as Nickel base Superalloys and composite materials which are electrically conductive are machined by electrochemical machining process irrespective of their hardness. In this paper difficulty in machining hard passive alloys regarding the passivation effect and the economical method of depassivation is studied.*

Keywords*: Depassivation, Electrochemical machining process, hard passive alloys, passivation, pulse ECM*

I. INTRODUCTION

For industrial applications numbers of the materials are discovered having very high hardness. The materials such as Nickel base Superalloys and composite materials are having very high hardness as compared to traditionally used materials such as steel and cast iron. Traditionally the materials are machined by mechanical methods taking cutting tool of high hardness than the workpiece. While machining hard materials due to contact between the cutting tool and workpiece there is wear of the cutting tool as well as possibility of failure of cutting tool. Therefore to machine such hard materials non contacting machining method is used. Recently various non contacting machining processes are in use for machining hard materials. To machine hard material without affecting its properties is a big challenge. In all non contacting methods the electrochemical machining method is not changing the properties of workpiece and gives good machining characteristics. Hard materials such as Nickel base Superalloys widely used in precious applications such as turbine blades in airplanes. For cooling turbine blades during working is important for longer life of blades. For this purpose small cooling holes are required of very small diameters without changing the properties of blade material and without forming stress during machining. Electrochemical machining process (ECM) is one of the best suitable machining processes for machining such materials without formation of stress during machining. In this process cutting tool is not touching to workpiece and hence there is no tool wear alike mechanical machining methods [1-2]. As well as there is no stress formation during machining due to low heat generation and continuous flow of electrolyte. Electrochemical machining is reverse of the electroplating and works on principle of electrolysis in which the current is flowing between two electrodes. The positive pole of power source is connected to workpiece (anode) and negative pole to the cutting tool (cathode). The electric circuit is completed by supplying electrolyte continuously between the gap (Inter Electrode Gap). The electrolyte is normally aqueous solution of salt or acid or combination of both. The principle of electrolysis is shown on Fig.1.

In electrolysis process the ions are transferred from positive electrode i.e. workpiece (WP) to negative electrode i.e. cutting tool (TE) when voltage is supplied. In order to ensure the development of the chemical reactions that lead to the progressive erosion of the workpiece, i.e. oxidation (deelectronation) at the anode and reduction (electronation) at the cathode respectively, the applied voltage on the electrolytic cell must exceed the sum of the decomposition voltages at the two electrodes and the voltage drop across the interelectrode gap (IEG).Two energy conversion mechanisms are involved in electrochemical process: 1) Electro-chemical energy conversion and 2) Electro-thermal energy conversion. Electro-chemical energy conversion that occurs in the limit layer associated with the electrode-solution interface. Electro-thermal energy conversion, developed in the electrolyte, by Joule effect. The tool-electrode acts as an element designed to transfer the energy required to initiate and to maintain the erosive action. During the ECM process, the tool-electrode does not suffer any wear, while the electrolyte is subjected to some major alterations of its properties (impurities, heating, pH-changing, etc.), that imposes to take measures for reconditioning it.

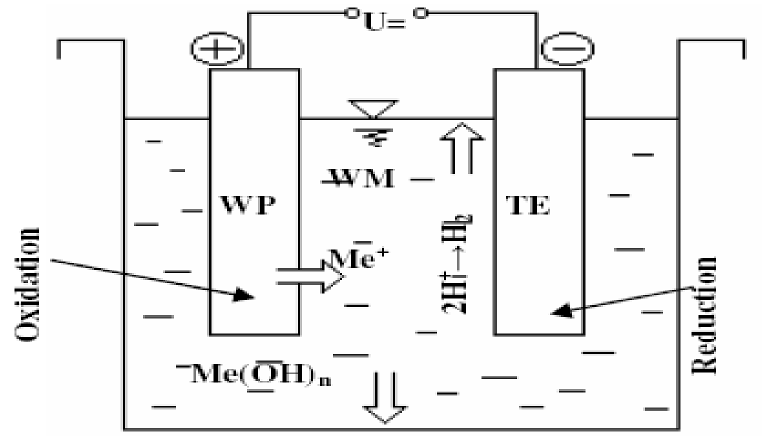

Fig.1 Electrolysis [3]

The physical and chemical transformations that occur in the electrochemical cell result in a passivation while machining Nickel base Superalloys. A metal can be considered as electrochemically passive, when it cannot be difussed by means of positive ions into the solution, although it's positive potential greater than its decomposition potential. The passivation effect can negatively influences the productivity of the ECM process. Therefore machining of hard passive alloys such as Nickel base Superalloys is challenging. Depassivation is done by means of various techniques/methods such as 1) Chemical 2) Electrical 3) Mechanical 4) Hydrodynamic 5) Hybrid etc. [3]

II. METHODS OF DEPASSIVATION

Depassivation or removal of the thin film is done by the following methods such as 1) Chemical 2) Electrical 3) Mechanical 4) Hydrodynamic 5) Hybrid etc. Each method is having different methodology of depassivation.2.1.

2.1 Chemical depassivation

In this method of depassivation some chemicals are added into the electrolyte to avoid the formation of thin film. Thin film or passivation effect is because of the chemical reaction between ions of workpiece, electrolyte and tool material. If the ions which are forming film are reacted with some other ions which are not dissolving into the electrolyte can be easily flushed away by the electrolyte. Sometimes the chemical added into the electrolyte may change the properties of the electrolyte such as electrical conductivity, pH, etc. If the properties of the electrolyte are changed e.g. decrease or increase in conductivity changes the current density as well as breakdown voltage.

2.2 Electrical depassivation

The passive film is broken by changing form of current. Generally in electrochemical machining process direct current is supplied to erode the workpiece. When direct current is supplied continuously, possibility of formation of passive film is more because of continuous current supply and possibility of decrease in current density as machining proceeds. Therefore for avoiding the formation of passive film the current is modulated i.e. pulsed. The schematic of the pulse wave form is shown in Fig 2. As shown in figure 2 during pulse off-time no current is available for the reaction between tool electrode and wrokpiece. Hence the removed material is flushed away by the flowing electrolyte which is formed during pulse on time. This current on-off cycle is repeated continuously to form pulse and thus formation of passive film is avoided. In this process at the pulse off time there is no material removed and hence decrease in material removal rate but increase in surface finish. The material removal rate (MRR) is increased by reversing the current during pulse off time. During pulse off time the polarity is changed i.e. positive voltage supply is changed to negative voltage (positive voltage supply of workpiece is changed into negative supply and vice-versa). During reverse current the flow of ions removed during anodic duty cycle is reversed and thus formation of passive film is avoided.

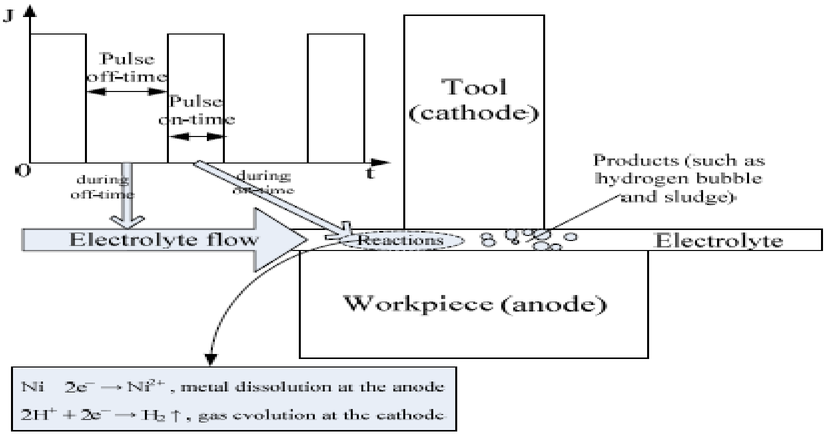

Fig.2.Schematic of Pulse wave form [4]

2.3 Mechanical/Mechanic depassivation

In mechanical depassivation the passive film is broken by adding abrasive particles in the electrolyte. Abrasives attacking on the workpiece surface and remains in inter electrode gap for some time and thus break the passive film to increase material removal rate.

2.4 Hydrodynamic depassivation:

When electrolyte is flowing through the gap its speed is changing at different points of inter electrode gap due to hydrodynamic effect. Passive film formed in the gap is removed by supplying electrolyte at high speed or increasing electrolyte flow rate. This requires fluctuation in flow rate. Change in flow rate may decrease the material removal rate due very short contact of electrolyte with workpiece. For reaction between the ions of workpiece and tool i.e. +ve ions and –ve ions requires sufficient time. If flow rate of the electrolyte is increased, electrolyte will be flushed away from the gap at high speed without contacting the workpiece. If the flow rate is decreased then the electrolyte will be in contact with surface of workpiece and the surface finish is affected.

2.5 Hybrid depassivation

Depassivation is also done by combining electrochemical machining process with other machining processes such as ultrasonic machining process, electric discharge machining process. When electrochemical machining process is combined with ultrasonic machining process then the passive film formed in the inter electrode gap is removed by the ultrasonic waves. For this purpose separate ultrasonic wave generator is required along with electrochemical set up.

Electric discharge machining process is combined with electrochemical machining process to avoid passivation. In this process the sparks generated by electric discharge machine break the passive film and thus increases material removal rate and hence productivity. For this purpose total setup of electric discharge machining is coupled with electrochemical machining process. When such types of combinations are done the cost of machining process increases as well as there is formation of stress in the machined surface of workpiece due to heat generation during machining.

III. CONCLUSION

While machining hard materials such as Nickel base Superalloys (Inconel, Hastelloy etc.) by electrochemical machining process, ‘passivation effect’ is big problem. The depassivation or breaking of film or avoiding formation of thin film is done by above mentioned methods. The electric depaasivation method is best as compared to other depassivation methods. It requires only change of voltage/current from direct to pulse. Other methods such as hybrid depassivation such as ECM with electric discharge machining are forming stress at machined area and it requires separate set up of electric discharge machining and thus increases cost.

REFERENCES

[1] American Society for Metals, MACHINING-HANDBOOK, Page No.149-155 VOL- 3,9th Edition.

[2] American Society for Metals, MACHINING-HANDBOOK, Page No.147-155, VOL-16,8th Edition.

[3] D. Nicoara, A. Hedes, I. Sora, Ultrasonic Enhancement of an Electrochemical Machining Process, *Proceedings of the 5th WSEAS International Conference on Applications of Electrical Engineering, Prague, Czech Republic, March 12-14, 2006.*

[4] Y. Zhang, Investigation Into Current Efficiency For Pulse Electrochemical Machining Of Nickel Alloy, *M.S. Thesis*

[5] C.D. Zhou, E.J. Taylor, J. J. Sun, L. Gebhart, E.C. Stortz, and R.P. Renz , Electrochemical Machining of Hard Passive Alloys With Pulse Reverse Current, Faraday Technology, Inc., *Transactions of NAMRI/SME, Volume XXV, 1997*

[6] Electrochemical Machining Using Modulated Reverse Electric Fields, US Patent 6402931B1, Jun 11, 2002

[7] J. J. Sun Larry E. Gebhart Robert P. Renz E. Jennings Taylor Maria E. Inman, The Applications of CM-ECM Technology to Metal Surface Finishing, Faraday Technology, Inc. *Transactions of NAMRI/SME Volume XXVIIII, 2000*.

[8] J. McGeough, ELECTROCHEMICAL MACHINING (ECM), Electrochemistry, Encyclopedia,http://electrochem.cwru.edu/encycl/art-m03-machining.htm

[9] Amitabh Ghosh, Asok Kumar Mallik, Manufacturing science, 1985, 354-383,

[10] P. N. Rao, Manufacturing Technology, Metal Cutting & Machine Tools, 2008, 282-289.

[11] E.Paul Degarmo, J.T.Black, Ronald A.Kohsher, Materials & Processes in Manufacturing,8, 1997,947.

[12] V. D. Kodgire, S.V. Kodgire, Material Science & Metallurgy, Evrest Publishing House, 21st Edition.

[13] http://www.unl.edu/nmrc/ecmreferences.htm, 18/6/2004