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Wire EDM Process: A Review

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Abstract - In this paper Exhaustive review of various research paper has been carried out to find the advancement for the future application of wire EDM process. It is one of the material removal processes which is non- convectional and widely used. It is used for manufacturing difficult shape and profile of hard materials which is a distinctive variation of the usual EDM process, to upgrade productivity and quality; need of rate cutting speed and high accuracy machine working on the same principle is growing fast. A thin copper, brass or tungsten wire of diameter 0.05–0.3 mm electrode wire is used in wire electrical discharge machining process. It is strictly controlled by a CNC system. CNC plays a very important. It unrolls the wire from first spool and connects work-piece to take it to a second spool. Usually wire velocity can be from 0.1 to 10 m/min, and feed rate can be 2 to 6 mm/min, to generate high frequency pulse within work piece and wire; direct current is used. In order to reduce the chance for production of inaccurate parts, wire is held in tensioning device. There is a lower stress within the work piece and electrode because there is no direct contact between them during machining.

Keywords: Wire EDM, High Frequency Pulse, Irregular Shaped Work Piece, CNC Machining, Spool

I. INTRODUCTION

In 1960, manufacturing industries developed WEDM. The developed technique is now replaced by machine electrodes used in electrical discharge machining. Optical line follower system in 1974 was introduced by D.H. Dulebohn, which automatically controlled the part shapes machined in wire electrical discharge machining process. In 1975itspotential was accepted by manufacturing industry making it popular. Introduction of computer numerical control system in WEDM process has led to the phenomenal development in machining process. However, the ability of WEDM process was widely ill- used for those machine process which are used to make holes completely through the substance.

Various features of wire electrical discharge machining process are:

- Fabricating the stamp
- Extrusion tools and dies
- Fixtures and gauges
- Prototypes
- Aircraft and medical parts
- Grinding wheel form tools

The Structured Diagram of WEDM is as Shown Fig. 1.1.

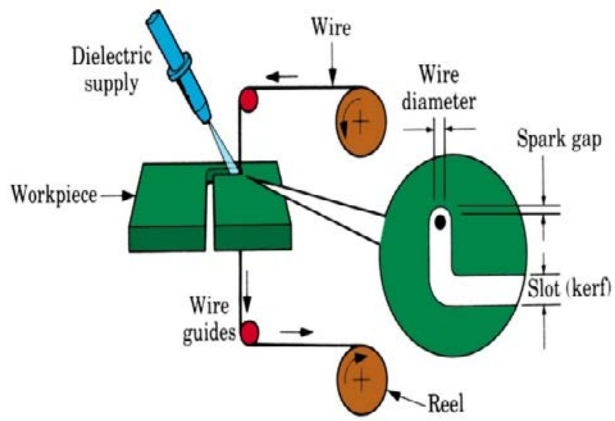

Fig. 1.1 WEDM Process

Removal method of wire electrical machining is comparable to the conventional electrical discharge machining process where, erosion effect on work piece by the spark was done. Through the series of spark material is eroded from work piece, happening between workpiece and wire and is segregated by dielectric liquid, and is regularly used in machining zones. In recent years, a wire electrical discharge machining process is commonly conducted in a container which is filled with dielectric liquid and is completely submerged in it.

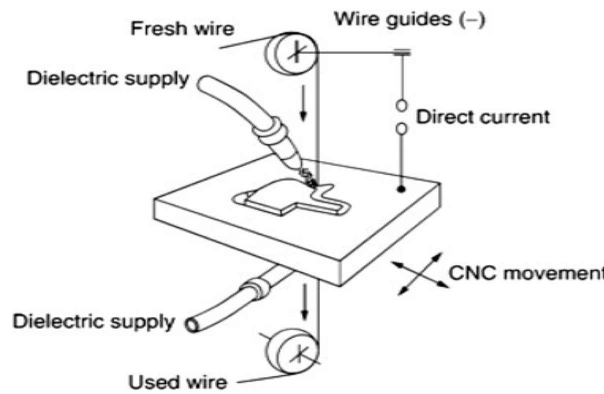

Fig. 1.2 WEDM Machining Process

Through this method of wire electrical discharge machining, it supports the stabilization of temperature and further, effective flushing when there is difference in thickness of workpiece. It usually uses electrical energy to produce the plasma channel within the cathode and anode and also to build thermal energy within the temperature range of 8,000^{0}C to 12,000^{0}C or higher which can be, 20,000^{0}C. This produces significant amount of heat and melts the material on each pole surface. If the oscillating DC supply between 20,000 and 30,000 Hz is turned off, it will lead to breakdown of plasma channel, causing the abrupt decrease in temperature and allowing to move dielectric liquid to support the plasma channel and movement of particles which are molten to each poles surface as microscopic debris. The WEDM machining process is shown in fig. 1.2.

- Spark Erosion and Its Concept

The concept behind the spark erosion is direct. Tools and Workpiece are arranged in such a manner that they don't touch each other and is divided by dielectric fluid. Further the process of cutting happens in a container, direct current flows between a workpiece and tool. An Electrical potential is used between workpiece and a tool when the switch; which is one lead is closed. At First, dielectric do not conduct current between the workpiece and tool making it as an insulator. Spark can come across when it is of minute size and also when the gap is small, electrical energy converts to produce plasma channels. Extreme surface heating of material is observed at discharge channel. Irregularity in current flow can easily break discharge channel. That is why the metal is melted to form molten which is evaporated combustlyon the surface of the material and takes the molten liquid material down along with it to a limited depth, forming small crater. If discharge is continuous a new crater is formed near to the old ones and the workpiece is continuously eroded. Process of sparking in WEDM Process is shown in figure 1.3.

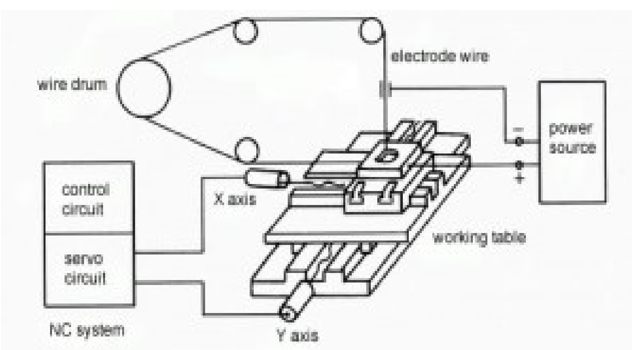

Fig. 1.3 Process of Sparking in WEDM Process

- Used Labels in WEDM Process

Spark Gap: Gap between electrode and workpiece, where voltage is applied and electric field is formed in the space among it.

Kerf Width: It is defined as the addition of diameter of wire and double of spark gap. This is commonly measure using the Infinite Focus Alicona Machine.

- Various usage of Dielectric in WEDM Process

Insulation: It provide the insulation to the workpiece from electrode, which is one of the important use of it.

Cooling: Dielectric maintains the normal temperature of workpiece and electrode. As overheating can occur of electrode because of high temperature.

Waste Particles Segregation: It helps by removing the particle from the area of erosion in order to avoid the trouble caused during process.

- Basic Features of Wire EDM

a) It is used for manufacturing difficult shape and profile of hard materials which is a distinctive variation of the usual EDM process.

b) To upgrade productivity and quality; need of rate cutting speed and high accuracy machine working on the same principle is growing fast.

c) A thin copper, brass or tungsten wire of diameter 0.05–0.3 mm electrode wire is used in wire electrical discharge machining process.

d) It is strictly controlled by a CNC system.

II. LITERATURE REVIEW

Kunieda et al. [1] defined the progress in a new dry wire electrical discharge machining method. They conducted an experiment using gas atmosphere instead of dielectric liquid. For improving the accuracy of finish cutting, the oscillation of the wire electrode is required so that it can minimize the minor small process reaction force. Elevated accuracy and finish cutting may be recognized in dry-wire electrical discharge machining. But, some disadvantages of dry-wire electrical discharge machining like lower material discard rate compared to conventional wire electrical discharge machining and lines are more likely to be generated over the finish surface.

Okada et al. [2] introduced a fine wire electrical discharge machining using thin wire electrode. In wire electrical discharge machining process, proper distribution of spark location is essential to achieve the stable machining performance. But, it is difficult to accurately measure the division in spark location by the traditional branched electric current method where workpiece is considered as thin. Hence, they introduced a new method to analyse the distribution of spark location using a high-speed video camera. From this camera, locations of sparks are identified and analysed through the recorded images. The machining criterion such as servo voltage, pulse interval time and wire running speed are significantly effects on the distribution of spark location.

Cabanesa et al. [3] introduced a methodology which facilitated to avert breakage of wire and unsteady situations as both of them reduces the performance of machining process and also causes reduction in the quality of components in wire electrical discharge machining. The given approach establishes the technique to be followed in an order for understanding the causes of breakage of wire and its unsteadiness. A series of pointers are provided in relation to discharge energy, ignition delay time, and peak current, so that we can evaluate the patterns of its unsteadiness or instability in a machining. With comparing the series of pointers with the previously calculated threshold values; breakage of wire risk can be seen, which is used to develop tactics for the better performance of WEDM process.

Saha et al. [4] made a simple FE model and a modern approach to foretell the thermal distribution in the wire which is equal and precise. The model can be used to enhance the various parameters in the system in order to avoid wire breakage. At any instantaneous of time, we can plot the spatial heat distribution profile and can also be transient analysis at any point on wire passing through all the heat zones from the top to bottom spool. Models and controlled principles are used to conclude the heat generated that mainly responsible for wire breakage. The model successfully predicted the thermal distribution profile accurately for various wire materials, for increased wire velocity and for reduction in heat transfer coefficient. This simple model was a precursor of development for 3-D finite element models which can be described the cross-sectional wire erosion as the workpiece cutting progresses. The modeling may lead to the development of a smart electro-discharge machining system with a sensor and feedback control to increase the cutting speed and minimize breakage.

Hou et al. [5] developed the prototype which is a double layer structure and can analysed consequences of temperature fields and thermal stress on removal of insulated ceramics Si_3N_4 during the wire electrical discharge process. These patterns of temperature filed in conductive layer and Si_3N_4 and prototype of double layer structure, it was related with single electrical discharge. Its outcomes i.e. effects on peak current, pulse duration and the movement speed of wire electrode to discharge craters were analysed. Given model shows that conductive layer on insulating ceramics creates a major effect on thermal transmission in the radius direction when it occurs. It reports that removal of material while single discharge increases with the increase of peak current and pulse duration but reduces with the increase of wire electrode movement speed.

Hada et al. [6] investigated the suitable machining conditions in which wire electrical discharge machining wire-EDM. Discharge current is affected (even if the pulse conditions are same) by the various factors of the wire and workpieces. Those factors include; double of radius of the wire, height of the workpiece and material of which wire and workpiece is made off. Hence, they developed a simulator to analyse the patterns of the current density, and magnetic flux density in and area close to wire so they, obtain the impedances of the wire and workpiece electrodes by applying the electromagnetic field which is analysis of finite element method FEM. After analysing the impedance with LCR meter it matches with the analysed results, supporting the experiment that it is useful to acquire the discharge current waveform. It can also varies based upon on the magnitudes and material-based properties of the electrodes, which act as tool to optimize the machining conditions.

Cabanes et al. [7] talks about the analysis of a through experimental data base that creates the unusual disturbances; which are noticed during normal operations. The results allow one to guess the wire breakage. During the increase in peak current, ignition delay time, discharge energy and decrease in ignition delay time, symptoms can be seen. Various difference in the thickness of workpiece, led to difference of symptoms. Among the aspects of writing this paper is to gather the analyses of the distribution of the anticipation time for different validation tests. Based on the results of that written paper contributes for the betterment of the process performance through a common wire breakage monitoring and diagnosing system. It consists of two well defined systems one is the virtual instrumentation system called as VIS which measures relevant magnitudes. Second is the diagnostic system called as DS which can detects low quality in cutting regimes and also can predicts the breakage of wire. It was approved successfully, by the various amount of experiment tests done on the working of WEDM process and its work piece thickness. Its working ability was tested through an efficiency rate.

Cheng et al. [8] determined an approach through which you can measure the heat transfer coefficient in wire electro-discharge machining process. This is done by measuring the increase in average temperature, through a special device. The thermal load enforced on wire was calculated and recorded, on this calculated basis the convective coefficient can be measured correctly. In order to note the impact of kerf width on convective coefficient, calibrated experiment is performed in already cut profile. The convective coefficient shows the fluctuation by 30%, when the wire is cut into workpiece. The effect of the coolant flushing pressure on convective coefficient can be measured with same mentioned method. Value of convective coefficient can be increased by 20% if we raised the pressure from 0.2 to 0.8 Mpa, which improves the cooling condition in WEDM process.

Yan et al. [19] presented the advancement and significance of fine-finish power supply in WEDM. Various components of it contains full- bridge circuit, 2 snubber circuits and a pulse control circuits. It was designed in a way to so that it provides the hold on anti-electrolysis, high frequency and very-low-energy pulse control. Examined values showed that pulse duration of discharge current may be minimized by arranging the capacitance in parallel with the sparking gap. Maximum capacitance value provides maximum discharge duration whereas, maximum current-limiting resistance leads to decrease in discharge current. The thickness of recast layers can be increased by increase in Peak current and pulse on-time. These values give us the ideas that fine-finish power supply can be useful in various ways like eliminating titanium's bluing and rusting effect and reducing micro-cracking in tungsten carbide which is because of electrolysis and oxidation. At 0.22 μm Ra the system can achieve fine surface finish.

III. CONCLUSION

Review of various papers indicate that there is a wide scope of study in the wire EDM process. FEA modeling at different pulse rate may be carried out. By changing material type and its thickness several important data can be computed. With change of pulse rate stress distribution and temperature can be measured**.**

REFERENCES

[1]. Datta S. and Mahapatra S.S, "Modeling, simulation and parametric optimization of wire EDM process using response surface methodology coupled with grey-Taguchi technique" International Journal of Engineering, Science and Technology, Vol. 2, pp. 162-183, 2010.

[2]. Kunieda, K. and Furudate, C, "High Precision Finish Cutting by Dry WEDM" Journal of Materials Processing Technology, Vol. 149 pp. 77–82, 2001.

[3]. Okada, O. Uno, Y., Nakazawa, M. and Yamauchi, T. "Evaluations of spark distribution and wire vibration in wire EDM by high-speed" Manufacturing Technology, Vol.59, pp. 231–234, 2010.

[4]. Cabanesa, I., Portilloa, E., Marcosa, M. and Sa´nchezb, J.A. "An industrial application for on-line detection of instability and wire breakage in wire EDM" Journal of materials processing technology, Vol. 1 9 5, pp. 101–109, 2008.

[5]. Saha, S., Pachon, M., Ghoshal, A.and Schulz d, M.J. "Finite element modeling and optimization to prevent wire breakage in electro-discharge machining Mechanics" Research Communications, Vol. 31, pp. 451–463, 2004.

[6]. Hou, P.J., Guo, Y.F., Sun, L.X. and Deng G.Q. "Simulation of temperature and thermal stress filed during reciprocating traveling WEDM of insulating ceramics" Procedia CIRP Vol. 6 PP. 410 – 415, 2013.

[7]. Hada, K. and Kunieda, M. "Analysis of wire impedance in wire-EDM considering Electromagnetic fields generated around wire electrode" Procedia CIRP Vol.6 245 – 250, 2013.

[8]. Cabanesa, I., Portilloa, E., Marcosa, M. and Sa´nchezb, J.A. "On-line prevention of wire breakage in wire electro-discharge machining, Robotics and Computer-Integrated Manufacturing" Vol. 24, pp. 287-289, 2008.

[9]. Cheng, G., Zhijing, H.and Feng "Experimental determination of convective heat transfer coefficient in WEDM" International Journal of Machine Tools & Manufacture, Vol. 47, pp. 1744–1751, 2007.

[10]. Yan, M.T. and Lai, Y.P. "Surface quality improvement of wire-EDM using a fine-finish power supply" International Journal of Machine Tools & Manufacture, Vol.47, pp. 1686–1694, 2007.

[11]. Yuana, J., Wangb, K., Yua, T. and Fanga, M. "Reliable multi-objective optimization of high-speed WEDM process based on Gaussian process regression" International Journal of Machine Tools & Manufacture, Vol. 48, pp. 47–60, 2008.

[12]. Hana, F., Chenga, G., Fenga, Z. and Isagoc, S. "Thermo-mechanical analysis and optimal tension control of micro wire electrode" International Journal of Machine Tools & Manufacture, Vol. 48, pp. 922–931, 2008.

[13]. Sanchez, J.A., Plaza, S., Ortega, N. Marcos, M. and Alizarin, J. "Experimental and numerical study of angular error in wire-EDM taper-cutting" International Journal of Machine Tools & Manufacture, Vol. 48, pp. 1420– 1428, 2008.

[14]. Izquierdo, B., Sa, J.A., Nchez, Plaza, S., Pombo, I., Ortega, N. "A numerical model of the EDM process considering the effect of multiple discharges" International Journal of Machine Tools & Manufacture, Vol. 49, pp. 220–229, 2009.

[15]. Shichun, Di. Xuyang, C., Dongbo, Zhenlong, W.and ChiLiu, Y. "Analysis of kerf width in micro-WEDM" International Journal of Machine Tools & Manufacture Vol. 49 pp. 788, 2009.

[16]. Liao Y.S. and Yub, Y.P. "The energy aspect of material property in WEDM and its application" Journal of Materials Processing Technology Vol. 149 pp.77–82, 2004.

[17]. Tani, T., Fukazawa, Y., Mohri, N. Saito, N., Okadaa, M. "Machining phenomena in WEDM of insulating ceramics" Journal of Materials Processing Technology Vol. 149 pp. 124–128, 2004.

[18]. Aliasa, A., Abdullaha, B. and Mohd, A "Influence of machine feed rate in WEDM of titaniumti-6Al-4V with constant current (6A) using brass wire" Procedia Engineering, Vol. 41 pp.1806 – 1811, 2012.

[19]. Dodun, O., Slătineanu and Lorelei, G. “Improving the WEDM process acting on the tool electrode” Procedia Technology, vol.12 pp. 427 – 432, 2014.

[20]. http://eidetec.com/wire-edm-diagram