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FUTURISTIC RESEARCH TRENDS IN SPARK ASSISTED ABRASIVE GRINDING

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ABSTRACT

The grinding of advanced materials is still a challange for manufacturing industries. Electrical discharge machining is more acceptable among available processes to achieve better machined surface quality for electrically conductive difficuilt-to-machine materials, but the productivity of such materials is very low. In reacent years, the focussed area for researchers is abrasive grinding with electrical spark assistance for machining these materials. Spark assisted abrasive grinding (SAAG) is form of EDM with rotating wheel electrode for grinding using abrasives. It gives better performance as this process employs combined effect of electrical spark and abrasion action to inhance the rate of machining and surface quality. The aim of this paper is to summarize a review on development in the area of SAAG process alonwith focus on the future research scope in the discussed area as well.

Keywords: *Hybrid Machining, Electrical Discharge Grinding, Electrical Discharge Diamond Grinding, Abrasive Grinding*

INTRODUCTION

Electrical discharge grinding (EDG) is an unconventional process for finishing of difficult-to-machine electrically conductive materials. In this process, material-removal occurs by melting, vaporization and ejection as in EDM. The stationary tool electrode used in EDM is replaced by a continuously rotating electrically conductive wheel about its axis in EDG process. The rotationa wheel-speed has been transfered to the flowing dielectric in the machining gap. The rotational motion of wheel caused enhanced flushing capability of the process. Better surface finish and increased material removal rate has been as compare to the EDM process due to the proper flushing [1, 2]. EDG gives better performances during machining extremely hard materials (2-3 times) [3]. The spark becomes instable and produces affect adversely the performance with increase in wheel speed after a certain value [4]. The process is found more advantageous for finishing electrically conductive thin and brittle orkpieece because of no direct physical contact between wheel and workpiece [3, 4].

The schemetic view of EDG process has been shown in Fig 1. A rotating eclectically conductive metallic wheel is used in place of stationary tool electrode known as grinding wheel. The grinding wheel continuously rotates at its horizontal axis and has no abrasive particles. The rotating wheel is separated from workpiece by dielectric fluid. The dielectric fluids used are mainly de-ionized water, Transformer oil, Paraffin oil or Kerosene oil. To achieve and maintain the required constant inter electrode gap the servo control mechanism is applied in the range of 0.013-0.075 mm and to maintain the pulsed DC supply a pulse generator is used [3]. The spark takes place into gap when pulsed power supply is applied due to the ionization and colision of electrons and ions the corresponding electrodes and finally high temperature of the range of 8000°C to 12000°C is generated [5] or upto 20000°C [6]. The molten material flushes away in form of debris particles from machining zone and form the crater on workpiece surface due to the high flushing efficiency [7].

METHODOLOGY

In EDG the mild steel wheel is used due to its reduced wheel wear rate as compare to brass and copper wheel due to high wear resistance. With the research development in EDG process researchers are using metal bonded abrasive wheel in place of bare metallic wheel electrode. Such type of grinding wheel is named as composite grinding wheel. The main role of abrasive particles in composite wheels is to enhance the MRR, to achieve better surface quality and lowering the grinding forces. Spark assisted abrasive grinding (SAAG) is the considerable innovation in the area of EDG with introduction of abrasive wheel. SAAG is again developed in different machining modes *ie.* spark assisted abrasive face grinding (SAAFG), spark assisted abrasive cut-off grinding (SAACG), and spark assisted abrasive surface grinding (SAASG). In modern era researchers are using Spark assisted abrasive surface grinding in both the orientations of abrasive grinding wheel ie Spark assisted abrasive face surface grinding (SAAFSG) and Spark assisted abrasive peripheral surface grinding (SAAPSG).

RESEARCH IN SAAG

To improve the process capability of EDG, a metal bonded abrasive grinding wheel electrode is applied in place of the bare metallic or graphite wheel electrode and the process developed is named as spark assisted abrasive grinding (SAAG) [8-11]. The material removal is performed by the joint effect of spark-erosion of EDM and abrasion action of abrasive grinding process as illustrated in Fig. 2 and the resulting performances of the newly developed SAAG process have been inhanced. This process is more usefull when machining engineering ceramics, super-hard materials, metal composites and sintered carbides [9, 10]. The self dressing of metal bonded abrasive grinding wheel has been carried out by electrical spark interactions during the process. The experimental investigation and theoretical analysis of self-dressing of SAAG process has been performed by Kozak [10] and claimed that spark-erosion process could be usefull in profiling of metal bonded super-hard wheel.

In recent past years, many reseaechers have attempted for exploring the feasibility of SAAG process with several names *ie.* electrical-discharge diamond grinding (EDDG) and abrasive electrical-discharge grinding (AEDG). The improvement in MRR on introducing abrasive abrasion has been compared with treditional EDM as well as EDG with continuously rotating graphite wheel electrode by Rajurkar et al. [9] during machining of Al/SiC composite as well as Ti-alloy. They claimed that MRR increased during SAAG process by five times as compared with EDM and about doubled than that of EDG process. Aoyama and Inasaki [11] have investigated that the tangential and normal woking forces during grinding has been reduced with an increase in the applied voltage. The joint effect of spark and abrasive grinding of SiC with slotted wheel is proposed by Ji et al. [12]. They found that the developed process is effective during machining of large surface with improved material removal and better surface quality.

For improvement in performance of SAAG process Koshy et al. [13] suggested that the abrasive protrusion height is 30% approximately of the grain size is preffered. It was investigated that the electrical spark softens the machining zone, and soft material is easily removed by abrasion action decreasing the normal forces [13, 14]. Choudhury et al. [15] experimentally found that tangential forces during grinding has been reduced with increase in duty factor and voltage for a specific current. Jain and Mote [16] explored that less requirement of specific energy in SAAG process as compared to EDG. It has been claimed by Yadav et al. [17] that the most considerable factors are wheel speed and current affecting performance of SAAG. Yadav and Yadava [18-21] studied the effects of process parameters on self-developed setup. Singh et al. [22-26] developed SAAG process for finishing the end surface of cylindrical workpiece in face grinding mode and explored the effects of process parameters. Agrawal and Yadava [27, 28], Modi and Agrawal [29] developed SAAG process for machining flat surface and studied the influences of process parameters in surface grinding mode. Yadav and Yadava [30] investigated the influence of process parameters on MRR and grinding forces during electrical discharge diamond peripheral surface grinding (EDDPSG) during hybrid metal matrix composite. It was claimed that thermal softening of workpiece eliminates the problem of wheel glazing. Yadav and Yadava [31, 32] have investigated the effect of process parameters on performance parameters by self developed process of slotted- electrical discharge diamond grinding and claimed that such innovative process gives better machined surface quality.

PARAMETERS DURING SAAG

The important parameters during SAAG are categorized into two groups such as EDM parameters and abrasive grinding parameters. EDM parameters are pulse current, discharge voltage, pulse off-time, pulse on-time, pulse frequency, duty factor and electrode polarity while abrasive grinding parameters are like conventional grinding. The considerable performance parameters are MRR, wheel wear rate (WWR), and average surface roughness (Ra).

CONCLUSIONS

In this paper an attempt has been made to summarize the published research papers in the area of SAAG process along with the input parameters and their influence on performances measures. The slotted-EDDG is the innovative development in the field of EDG for machining difficuilt-to-machine materials with electrically conductivity adding the abrasives into metallic wheel. This study will be helpful for researchers and developers, who are interested to work in the field of advanced machining as well as making efforts for finishing difficult to machine materials with good surface quality.

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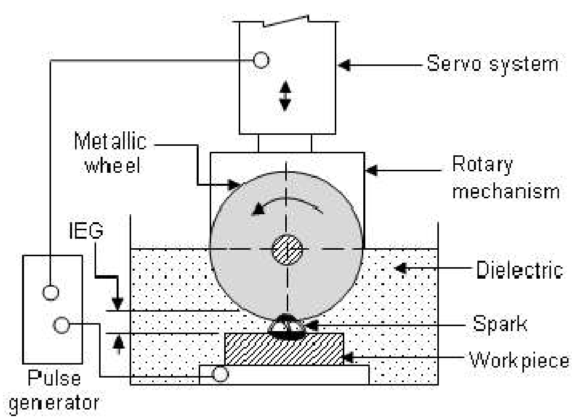

Figure 1:*Schemetic view of EDG*

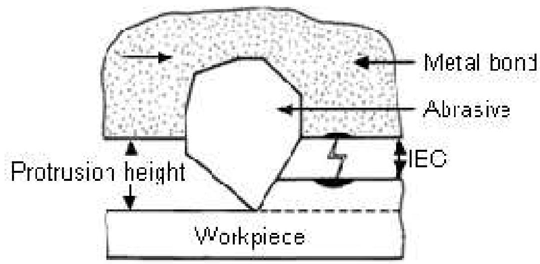

Figure 2: *Spark-erosion and abrasive abrasion in SAAG [15]*