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Research paper

Empirical modeling and optimization of kerf width in abrasive water jet machining – a short review

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Abstract

Changing demands of the industries require advanced materials to meet the demands of the industries researchers are constantly creating newer materials such as alloys, metal matrix composites and hybrid materials these metal materials are tailored either ferrous or non-ferrous, due to different compositions material properties are altered with respect to physical and mechanical properties, some of them are malleabil-ity, ductility, hardness and toughness, to machine these materials conventional methods of machining using lathe, milling, drilling may not be suitable due to low productivity and poor in accuracy and surface finish because of the boosted material properties. A capable method of machining would be unconventional machining methods such as wire EDM, Laser beam machining, chemical machining, electro chemical machining, water jet machining and abrasive water jet machining. In this paper the implication of abrasive water jet machining is emphasized based on the valuable research carried out by various researchers across the globe. This paper put forward the materials used, parameters considered, and design of experiments emphasized by researchers.

Keywords: *Abrasive Water Jet Machining; Kerf Width; Modeling; Optimization; Response Surface Methodology; Genetic Algorithm.*

1. Introduction

Abrasive water jet machining is one of the non-conventional machining processes which are the combination of both the abrasive and water with jet machining process. The abrasive material and the water are subjected to certain pressure to cut the work piece. The high-speed water combines with the abrasive material and flow through the nozzle. This jet water which passes through the nozzle will make a neat cut on the work piece.

From reservoir through pump water flow to the intensifier their water accumulates control valve controls the flow through its regulator to the nozzle.

Abrasive feed is added through abrasive tube in the nozzle and mixture of water and abrasive makes the clean cut on the work piece. Abrasive water jet machining a newly developed manufacturing technology. It has advantage of absence of thermal effects, flexible in manufacturing and machining with little force. [1]. Aluminum metal matrix composites show superior qualities over aluminum alloys. Water jet pressure influences kerf taper. [2]. Conducted experiments using abrasive Water Jet Machining of aluminum - tungsten carbide composite, results obtained from experiments and multi response optimization obtained are recorded for having a database for the industry. [3]. Studied the effects of pulsating water jets using circular and flat nozzles. [4]. Investigated the consequence of jet traverse speed on reinforced metal matrix composite (MMC) generated by Abrasive Water Jet Machining (AWJM). Surface morphology, surface topography, and surface roughness of the abrasive water jet surface were analyzed. [5].

2. Materials used for machining using abrasive water jet machining expertise

Authors carried out experimentations on materials like hybrid aluminium 7075 metal matrix composites [6]. $A359/Al_2O_3/B_4C$ composite material is fabricated by electromagnetic stir casting process by the researchers [7-8]. AA6061-B_4C-hBN hybrid metal matrix composite is used by the researchers [9]. Aluminium-tungsten carbide composite with varying percentage of tungsten carbide reinforced composite from 2 to 10 wt. % [10]. Grade 5 titanium alloy, (Ti6Al4V) is utilized by the researchers [11]. Mg-based nanocomposite is used for the investigation [12]. Aluminium alloy 5083 is machined by AWJM [13]. 718 alloy is milled by abrasive water jet [14]. AISI 304 austenitic stainless steel [15]. abrasive jet machining is carried out on nickel 233 alloy [16]. AISI 304 is cut by pulsating water jet [17]. Inconel718 [18]. Abrasive water jet machining of TiB_2 particles reinforced Al7075 composite [19]. Abrasive waterjet machining is carried on the surface of graphite and aluminium alloy [20]. Aluminium 6061-T6 alloy is machined by water jet [21]. Copper CW004A [22]. Hastelloy C276 sheet is drilled by AJM [23]. Redmud with banana-sisal and sisal-glass FRP (fiber reinforced polyester) composite [24]. Aluminium metal and its composites and alloys are widely developed and machined by using abrasive water jet machining. Above few materials ferrous, nonferrous alloys, composites and hybrid metals and FRP composites listed are the materials considered by the researchers whose work is published in the year 2018.

3. Parameters

In this section the various process parameters considered and reported by the researchers is mentioned, input parameters and output responses are given, Transverse speed, standoff distance and mass flow rate as input and kerf width and taper angle as response [25]. Rotational speed, water pressure, surface roughness parameters, stand-off distance, abrasive mass flow rate and surface roughness and residual stress are measured [26]. Water jet pressures and jet impact angles on surface topography and roughness profiles on AISI D2 steel kerf wall cut surfaces [27]. The effect of air and abrasive mixture pressure, stand-off distance, nozzle diameter and abrasive size on surface roughness [28]. Surface roughness after AWJM [29]. The following are the parameters considered water pressure, (AFV)abrasive flow volume, (SOD) standoff distance and table feed and material removal rate (MRR) [30]. Feed rate, water pressure, (SOD) standoff distance and abrasive flow rate are considered and surface and kerf-angle as responses. Traverse rate, water pressure and SOD stand-off distance is considered for machining 16 mm PZT-5H lead zirconate titanate ceramic and kerf as response [32]. Feed rate, water pressure, (SOD) standoff distance and abrasive flow rate on the responses surface roughness and kerf-angle [33]. Authors concluded that in abrasive water jet machining (AWJM) process kerf and surface values are decreased when compared with EDM output parameters [34]. $LaPO_4/Y_2O_3$ ceramic composite is machined by abrasive water jet, material removal rate, kerf angle and surface finish are examined the influence of water jet pressure, SOD (stand of distance) and traverse pressure [35]. Al–NiTi–SiC reinforced hybrid composite is used by the researchers to know the values of surface roughness and kerf angle when abrasive water jet pressure, (SOD) standoff distance and feed rate are considered [36].

4. Optimization of abrasive water jet machining process using algorithms

In this section various optimization algorithms used by researchers is discussed in accordance with abrasive water jet machining, cohort intelligence algorithm is based on artificial intelligence a socio inspired algorithm is used for the abrasive water jet machining process parameter optimization of surface roughness and kerf [37]. Researchers used multi-objective cuckoo algorithm and concluded that the model developed for abrasive water jet machining is superior than experimental data [38]. Authors used multi-objective optimization artificial bee colony algorithm for improving the quality characteristics of abrasive water jet machining [39]. Jaya Algorithm is employed for the formulation of process parameters optimization models [40]. Multi Objective Optimization by Ratio Analysis (MOORA) is used by researchers [41]. Taguchi-DEAR Methodology is used by the authors [42]. Evolutionary algorithm, grey wolf optimizer (GWO), is applied for finding out the optimal parametric groupings of abrasive water jet machining processes [43]. Gravitational search algorithm (GSA) is used to categorize the finest likely grouping of abrasive water jet machining parameters [44]. Authors used response surface methodology and artificial neural network for optimization of abrasive water jet machining [45].

5. Conclusions

In this paper the following conclusions are drawn about abrasive water jet machining,

- Abrasive water jet machining is substantial technology available for machining both electrically conductive and nonconductive materials where traditional methods of machining possess some limitations.
- Effective machining performance of abrasive water jet machining depends on the selection of process parameters, water jet pressure, standoff distance, traverse speed.
- Type of material and material dimensions are also deciding factors for efficient machining.
- Evolutionary algorithms, meta heuristic algorithms and hybrid algorithms are promising optimization software tools developed by the researchers for developing empirical models and optimization of responses such as kerf, surface roughness.
- Newer algorithms are developed by the researchers to employ for abrasive water jet machining

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