© 2017 IJSRST | Volume 3 | Issue 6 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Review on Machining of Nickel Based Alloy Using EDM and WEDM

M. Mahalingam
Department of Manufacturing Engineering, Annamalai University, Annamalainagar, Tamilnadu, India

ABSTRACT

The aim of this review paper is to present the consolidated information on processing of nickel based alloy using electrical discharge machining (EDM) and wire electrical discharge machining process (WEDM) and subsequently identify the research gaps. Electrical Discharge Machining (EDM) is a widely accepted process for machining of Nickel based alloy. This material is important in high-temperature applications; they are also known as heat-resistant material. They are extremely useful in gas turbine, aircraft, nuclear reactors, petrochemical equipment's. Nickel based alloy is the only materials to retain high strength even after continuous exposure to extremely high temperatures. Due to these properties the machining of this material is difficult. New and alternate method of machining propelled research to develop and use new processes of machining which promoted the use of electric discharge machining and wire electric discharge machining process. The process is widely accepted by the researchers to machine the Nickel based alloy. This paper has been concluded by giving some suggestion for future researcher from the literature survey.

Keywords: EDM, WEDM, Nickel based alloy, Review.

I. INTRODUCTION

Electrical Discharge Machining (EDM) is an important manufacturing process for machining harder material and its alloys. This process is capable of getting required metal removal rate and surface finish by controlling the process parameters. The important process parameters which influence are pulse on time, pulse off time, wire tension and wire feed on response such as Material removal rate (MRR), Tool Wear Rate (TWR) and Surface Roughness (SR).

The review presented in this paper is machining of nickel based alloy using electrical discharge machining & Wire EDM process which is also widely used in many applications including aeronautics and petrochemical equipment's. Where this material is required to retain high hardness, strength, wear resistance and corrosion resistance even after continuous exposure to high temperatures.

II. LITERATURE SURVEY

Name & Year	Contribution	Workpiece Material	Tool Material	Machining Parameters	Response
Muthu Kumar, V. et al. (2010) [1]	Optimization of the WEDM Parameters on Machining Incoloy800 Super alloy with Multiple Quality Characteristics	Incoloy 800	Brass wire.	Gap Voltage, Pulse On-time, Pulse Off-time, Wire Feed.	MRR, Ra , Kerf
Prabhu, S. et al. (2011) [2]	AFM surface investigation of Inconel 825 with multi wall carbon nano tube in EDM process using Taguchi analysis	Inconel 825	Copper, Carbon nanotube(graphite)	Pulse current, Pulse duration, Pulse voltage.	Ra,
Dinesh Kumar, et al. (2011) [3]	Study of Overcut During EDM of Hastelloy Steel With Different Electrodes Using the Taguchi Method.	Hastelloy	Sintered tool of copper tungsten , copper	Polarity, tool material, current, pulse on time, duty cycle, gap voltage	Overcut
Harshit Dave, et al. (2012) [4]	Experimental investigations on orbital EDM of Inconel 718 using Taguchi technique	Inconel 718	Copper	Orbital Radius, Orbital Speed, Current , Gap Voltage, Pulse on time, Duty Factor	MRR, Ra
Beri,N et al.(2012) [5]	To Study the Effect of Polarity and Current during EDM of Inconel 718 with CuW Powder Metallurgy Electrode	Inconel 718	Copper tungsten (PM)	Polarity, current.	MRR, Ra , TWR
Saeed Daneshmand., et al.(2012) [6]	Investigation of WEDM of Nickel-Titanium Shape Memory Alloys on Surface Roughness and MRR	NiTi60.	Copper wire	Current , Pulse on-time, Wire speed	MRR, Ra.
Vinod Kumar., et al.(2012) [7]	Effect of WEDM parameters on machinability of Nimonic-90	Nimonic 90	Brass wire	Peak current, Pulse-on time, Pulse-off time, Servo voltage, Wire feed rate .	Cutting speed
Goswami Amitesh., et al. (2012)[8]	An investigation into the machining Characteristics of Nimonic 80A using CNC WEDM	Nimonic 80A	Brass wire	Pulse -on-time, peak current, pulse-off-time, spark gap, set voltage.	Cutting speed, MRR
Rajyalakshmi,G. et al. (2012)[9]	Simulation, Modelling and Optimization of Process parameters of Wire EDM using Taguchi –Grey Relational Analysis	Inconel 825	Brass wire	pulse on time, pulse off time, servo voltage, wire feed, wire tension, dielectric flow rate, spark gap voltage, servo feed	MRR, Ra.

Rajyalakshmi,G. et al. (2012)[10]	A parametric optimization using Taguchi method: effect of WEDM parameters on surface roughness machining on inconel825	Inconel 825	Brass wire	pulse on time, pulse off time, corner servo voltage, wire feed, wire tension, dielectric flow rate, spark gap voltage,	Ra, Spark gap
Ahmada,S.et al. (2013) [11]	EDM of Inconel 718 by using copper electrode at higher peak current and pulse duration	Inconel 718	Copper	Peak current, Pulse duration	MRR, EWR, Ra.
Skrabalaka G, et al. (2013)[12]	Optimization of dry EDM milling process	Inconel 617, hardened tool steel	Copper	Tool rotations, Gas flow, Composition of gas mixture.	MRR, TWR, Ra.
Ayesta, I. et al. (2013) [13]	Influence of EDM parameters on slot machining in C1023 Aeronautical alloy	C1023	Graphite	Current, Pulse time, Servo voltage.	Erosion time, Electrode wear
Lohithaksha M Maiyara, et al. (2013)[14]	Optimization of machining parameters for end milling of Inconel 718 super alloy using Taguchi based grey relational analysis	Inconel 718	Tungsten carbide	Cutting speed, Feed rate, Depth of cut	MRR, Ra.
Uhlmann,E. et al. (2013) [15]	Development and optimization of the die-sinking EDM-technology for machining the Nickel-based alloy MAR-M247 for turbine components	MAR-M247	Graphite	Current, Discharge duration, Pause duration, voltage , Duty factor.	MRR, TWR, Ra.
Dhanabalan,S. et al. (2013)[16]	Optimization of Machining parameters of EDM while machining Inconel 718 for form tolerance and orientation tolerance.	Inconel 718	Copper	pulse current, pulse on time, pulse off time	MRR, TWR.
Saeed Daneshmand et.al. (2013)[17]	Influence of machining parameters on EDM of NiTi Shape Memory Alloys.	NiTi	Copper	Current, Pulse on time, Voltage	MRR, TWR.
Shah,C.D. et al. (2013) [18]	Optimization of Process Parameter of Wire EDM by Response Surface Methodology on Inconel-600	Inconel -600	Molybdenum wire.	Peak Current, Pulse-On time, Pulse-Off time, Wire Feed rate.	MRR
Rajyalakshmi,G. et al. (2013) [19]	Optimization of Process Parameters of Wire EDM Using Fuzzy Logic Integrated with Taguchi Method	Inconel 825	Brass wire	pulse on time, pulse off time, corner servo voltage, wire feed, wire tension, dielectric flow rate, spark gap voltage ,servo feed	MRR, Ra, Spark gap

Rajyalakshmi,G. et. al. (2013) [20]	Multiple process parameter optimization of WEDM on Inconel 825 using Taguchi grey relational analysis	Inconel 825	Brass wire	pulse on time, pulse off time, servo voltage, wire feed, wire tension, spark gap voltage, servo feed	MRR, Ra, Spark gap
Gagan Goyal et al. (2013)[21]	Performance Evaluation of WEDM Machining on Incoloy800 by Taguchi Method	Incoloy 800	Coated wire	pulse on time, pulse off time, spark voltage, peak current.	Kerf width, Gap current
Saeed Daneshmand et. al. (2013)[22]	Experimental Investigations into EDM of NiTi Shape Memory Alloys using Rotational Tool	Nickel Titanium	Copper	pulse current, pulse on time, voltage ,pulse off time.	MRR, Ra, TWR
Muthukumara,V. et al.(2014) [23]	Mathematical Modeling for Radial Overcut on EDM of Incoloy 800 by Response Surface Methodology	Inconel 800	Copper	Current, Pulse-on time, Pulse-off time, Voltage	Radial over cut
Saeed Daneshmand, et al. (2014)[24]	Optimization of EDM parameters for NiTi Shape memory alloy by using the Taguchi method	NiTi60	Brass	Pulse on time, Pulse off time, Voltage, current.	MRR, Ra.
Karthikeyan,P. et al. (2014) [25]	Machining characteristics analysis on EDM for Inconel 718 material using copper electrode	Inconel718	Copper	Peak current, Pulse on time, Pulse off time, Flushing pressure with the tool shapes.	MRR, TWR, Ra.
Mahendra G. Rathi, et al. (2014) [26]	Study on Effect of Powder Mixed dielectric in EDM of Inconel 718	Inconel 718	Copper	Duty cycles, Current, Pulse on time, Powder media in that Silicon carbide, , Graphite powder	MRR, TWR.
Chandramouli, S. et al. (2014)[27]	Optimization of EDM Process Parameters Using Taguchi Method	RENE 80 Nickel Super alloy	Aluminum	Current, Pulse on time, Pulse off time.	MRR, TWR Ra.
Sabareesaan,K.J. et al. (2014)[28]	Analysis of the Effect of Process parameters in EDM of Inconel X750 using brass Electrode	Inconel X750	Brass	Pulse peak current, Pulse on time, Gap voltage.	MRR, EWR, Ra.
Masoud Azadi Moghaddam, et al. (2014)[29]	An Empirical Study on Modeling and Optimization of EDM Process Parameters for Inconel 718 Super Alloy Using D- optimal approach and Genetic Algorithm	Inconel 718	Copper	Voltage, pulse on time.	MRR, Ra.
Dhakar, K., et al. (2014) [30]	Optimization and comparison of near-dry EDM and dry EDM of Inconel 718	Inconel 718	Copper tube	Current, Pulse on time, Pulse off time, Gap control	MRR, TWR.

Sabareesaan,K.J. et al. (2014)[31]	Evaluation of Process parameter ranks in EDM of Aerospace super alloy using copper Electrode	Inconel X750	Copper	Pulse peak current, Pulse on time, Gap voltage.	MRR, TWR Ra.
Amitesh Goswami, et al. (2014) [32]	Optimization in wire-cut EDM of Nimonic-80A using Taguchi's approach and utility concept	Nimonic-80A	Brass wire	Pulse-on time, Pulse-off time Voltage, current, Wire feed, Wire tension.	MRR, Ra.
Amitesh Goswami, et al. (2014) [33]	Investigation of surface integrity, material removal rate and wire wear ratio for WEDM of Nimonic 80A alloy using GRA and Taguchi method	Nimonic-80A	Brass wire	Pulse-on time, Pulse-off time, Voltage, Peak current, Wire feed, Wire tension.	Surface integrity , MRR, WWR.
Chinmaya P Mohanty, et al. (2014) [34]	An Experimental Investigation of Machinability of Inconel 718 in EDM	Inconel 718	Copper, Brass , Graphite	Voltage, Discharge current, Pulse-on-time, Duty factor, Flushing pressure,	MRR, Ra.
Anshuman Kumara, et al.(2014) [35]	Numerical Modeling of WEDM of Super alloy Inconel 718	Inconel 718	Brass wire	Voltage, current, pulse on time.	MRR.
Sabareesaan, K J. et al. (2014) [36]	MRR Prediction Model for EDM of Inconel X750 by Response Surface Methodology Using MINITAB Software	Inconel X750	Brass	Pulse peak current, Pulse on time, Gap voltage.	MRR
Jasvinder Pal, et al. (2014) [37]	Parameters optimization of WEDM for surface roughness using Taguchi Technique	Nimonic-80	Wire	pulse on time, servo voltage, pulse off time, wire tension,	Ra.
Taha Chowdry (2014) [38]	Improvement of surface roughness of Nickel alloy specimen by removing recast layer in WEDM	Inconel 600	Brass wire	Pulse-On time, Pulse-Off time, Peak Current, Bed speed	Recast layer, Ra.
Md.karim Baig, et al (2014) [39]	Parametric optimization of WEDM for Hastelloy C276, using GRA method	Hastelloy C276	Zinc coated brass wire.	Pulse on time, pulse off time, discharge time ,servo voltage	MRR, Kerf
Kasim,M.S. et al (2014)[40]	The effect of WEDM cutting parameter on Inconel 718 subsurface micro hardness	Inconel 718	Brass wire	Voltage , Feed rate, Current	Micro-hardness
Manjaiah M, et al (2014) [41]	Optimization of WEDM parameters to achieve better MRR and surface finish.	$Ti_{50}Ni_{40}Cu_{10}$	Brass wire	Peak current , Pulse-on time, Pulse-off time, Wire feed .	MRR, Ra.
Ashok Kumar Choudhary, et al (2014) [42]	Performance evaluation on parameter optimization of WEDM for super alloy Incoloy-800	Incoloy-800	Brass wire.	pulse on time, pulse off time, spark gap voltage, peak current ,wire feed rate	Kerf width, Ra. MRR, Gap

					current
Manjaiah, M. et al (2014) [43]	Wire EDM characteristics of titanium nickel shape memory alloy	TiNi	Brass wire	Peak current , Pulse-on time, Pulse-off time, Wire feed .	MRR, Ra.
Sivaprakasam,P. et al (2014) [44]	Modeling and Analysis of Micro-WEDM Process on Inconel Super Alloy through Response Surface Methodology	Inconel 718	Zinc coated copper wire	voltage, capacitance, feed rate.	MRR
Satyanarayana,B. et al (2014) [45]	Multi- response optimization of CNC WEDM process parameters for machining Inconel 718 using Taguchi grey relational analysis	Inconel 718	Brass wire	Pulse-on time, Pulse-off time, Wire feed, Wire tension, water flow rate.	MRR, Kerf width, WWR

III. SUMMARY& CONCLUSION

From the above literature review the following can be pointed out:

Many research works have been reported in literature on machining using EDM &WEDM processes of Inconel materials. Some works on Nimonic material [7,8,32,33,37] and NiTi shape memory alloy [6,41,43,17,22,24], as well as Hastelloy [3,39] materials have also been reported. However, very less work has been reported on WEDM of Monel material. This paper has presented significant contributions of the researches on EDM and WEDM on machining of nickel based materials. The study of this paper reveals the research gaps, which may be useful for carrying out research by future researchers.

The literature survey reported in this paper revealed that, researchers are concentrating on many machining parameters. However, the study of surface integrity of the advanced materials has not been investigated by many researchers. The study of the effect of parameters on machining of nickel based alloys with major concentration on the electrical and non-electrical parameters such as pulse-on - time, pulse - off- time, peak current, discharge voltage, polarity, wire material, wire diameter and wire tension and wire feed is another thrust field.

IV. REFERENCES

[1]. Muthu Kumar,V.,Suresh Babu,A.,Venkatasamy,R.,and Raajenthiren,M. (2010). Optimization of the WEDM Parameters on Machining Incoloy 800 Super alloy with Multiple Quality Characteristics. International Journal of Engineering Science and Technology,Vol. 2(6), pp.1538-1547.

[2]. Prabhu,S.,and Vinayagam,B.K. (2011).AFM surface investigation of Inconel 825 with multi wall carbon nano tube in electrical discharge machining process using Taguchi analysis. Archives of Civil and Mechanical Engineering,Vol. XI(1), pp. 149–170.

[3]. Kumar,D.,Beri,N. and Kumar,A.,(2011). Study of overcut during electric discharge machining of hastelloy steel with different. International Journal of Advanced Engineering Technology,Vol.2(1),pp.306-312.

[4]. Harshit Dave.,Keyur Desai.,and Harit Raval. (2012).Experimental investigations on orbital electro discharge machining of inconel 718 using taguchi technique. International Journal

of Modern Manufacturing Technologies,Vol. IV(1),pp. 53–58.

[5]. Naveen Beri.,Harish Pungotra.,and Anil Kumar. (2012).To Study the Effect of Polarity and Current during Electric Discharge Machining of Inconel 718 with CuW Powder Metallurgy Electrode. Proceedings of the National Conference on Trends and Advances in Mechanical Engineering,Oct 19-20,pp. 476–481.

[6]. Saeed Daneshmand.,Reza Hessami.,and Habib Esfandiar. (2012).Investigation of Wire Electro Discharge Machining of Nickel-Titanium Shape Memory Alloys on Surface Roughness and MRR. Life Science Journal,Vol. 9(4), pp.2904-2909.

[7]. Kumar,V.,Jangra,K.,and Kumar,V.(2012). Effect of WEDM parameters on machinability of Nimonic-90. .Proceedings of the National Conference on Trends and Advances in Mechanical Engineering (TAME),YMCA University of Science and Technology,pp.511-516.

[8]. Amitesh,G.,and Jatinder,K.,(2012). An investigation into the machining characteristics of nimonic 80A using CNC wire-EDM. International Journal of Advanced Engineering Technology,Vol.3(1),pp.170-174.

[9]. Rajyalakshmi,G. and Ramaiah,D.P.V.,(2012). Simulation,Modelling and Optimization of Process parameters of Wire EDM using Taguchi–Grey Relational Analysis. IJAIR,ISSN,pp.2278-7844.

[10]. Rajyalakshmi,G.,and Venkata Ramaiah,P. (2012).A parametric optimization using Taguchi method: effect of WEDM parameters on surface roughness machining on Inconel825.Mechanical Engineering,Vol. 43,pp. 6669-6674.

[11]. Ahmada,S.,and Lajisbi,M.A. (2013).Electrical discharge machining (EDM) of Inconel 718 by using copper electrode at higher peak current and pulse duration. Materials Science and Engineering,Vol. 50 ,pp. 1–7.

[12]. Skrabalaka,G., Kozaka,J.,and Zyburaa,M. (2013).Optimization of dry EDM milling process. Procedia CIRP, Vol. 6 ,pp.332 – 337.

[13]. Ayesta,I.,Izquierdo,B.,Sáncheza,J.A., Ramos,J.M., Plazaa,S.,Pombo,I.,Ortegaa,N., Bravoe,H., Fradejase,R., and Zamakonae,I. (2013). Influence of EDM parameters on slot machining in C1023 aeronautical alloy. Procedia CIRP,Vol. 6 ,pp.129 – 134.

[14]. Lohithaksh M Maiyar.,Ramanujam.R.,Venkatesan,K. and Jerald,J. (2013).Optimization of Machining Parameters for End Milling of Inconel 718 Super Alloy Using Taguchi Based Grey Relational Analysis. Procedia Engineering,Vol.64,pp.1276 – 1282.

[15]. Uhlmann,E. and Domingos,D.C. (2013). Development and optimization of the die-sinking EDM-technology for machining the nickel-based alloy MAR-M247 for turbine components. Procedia CIRP,Vol. 6,pp.180 – 185.

[16]. Dhanabalan,S., Shivkumar,K., and Narayanan,C.S. (2013).optimization of machining parameter of EDM while machining inconel 718 for form tolerance and orientation tolerance. Indian Journal of Engineering and Materials Science,Vol. 20, pp.391-397.

[17]. Saeed Daneshmand.,Farahmand Kahrizi,E.,Abedi,E.,and Mir Abdolhosseini,M. (2013).Influence of Machining Parameters on Electro Discharge Machining of NiTi Shape Memory Alloys. International Journal of Electrochemical Science,Vol. 8,pp.3095 – 3104.

[18]. Shah,C.D., Mevada,J.R., and Khatri ,B.C. (2013).Optimization of Process Parameter of Wire Electrical Discharge Machine by Response Surface Methodology on Inconel -600. International Journal of Emerging Technology and Advanced Engineering,Vol. 3(4),pp. 260-267.

[19]. Rajyalakshmi,G.,and Venkata Ramaiah,P. (2013).Optimization of Process Parameters of

Wire Electrical Discharge Machining Using Fuzzy Logic Integrated with Taguchi Method. International Journal of Scientific Engineering and Technology,Vol.2(6), pp.600-606.

[20]. Rajyalakshmi,G.,and Venkata Ramaiah,P. (2013).Multiple process parameter optimization of wire electrical discharge machining on Inconel 825 using Taguchi grey relational analysis. International Journal of Advance Manufacturing Technology,Vol. 69, pp.1249–1262.

[21]. Gagan Goyal.,and Ashok Choudhary. (2013). Performance Evaluation of Wedm Machining on Incoloy 800 by Taguchi Method. International Journal of Latest Trends in Engineering and Technology,Vol. 2 (4), pp.93-99.

[22]. Saeed Daneshmand.,Ehsan Farahmand Kahrizi.,Ali Akbar Lotfi Neyestanak.,and Mehrdad Mortazavi Ghahi. (2013).Experimental Investigations into Electro Discharge Machining of NiTi Shape Memory Alloys using Rotational Tool. International Journal of Electrochemical Science,Vol. 8,pp.7484 – 7497.

[23]. Muthukumar,V.,Rajesh,N.,Venkatasamy,R.,Sureshbabu,A.,and Senthilkumar,N.(2014).Mathematical Modeling for Radial Overcut on Electrical Discharge Machining of Incoloy 800 by Response Surface Methodology. Procedia Materials Science,Vol. 6,pp.1674 – 1682.

[24]. Saeed Daneshmand.,Ehsan Farahmand Kahrizi.,Ali Akbar LotfiNeyestanak.,and Vahid Monfared. (2014).Optimization of electrical discharge machining parameters for NiTi shape memory alloy by using the Taguchi method. Journal of Marine Science and Technology,Vol. 22(4), pp.506-512.

[25]. Karthikeyan,P.,and Arun,J. (2014). Machining characteristics analysis on EDM for Inconel 718 material using copper electrode.International Journal of Research in Engineering and Technology,Vol. 03(11) , pp.309-311.

[26]. Mahendra G. Rathi.,and Deepak V. Mane. (2014).Study on Effect of Powder Mixed dielectric in EDM of Inconel 718. International Journal of Scientific and Research Publications,Vol. 4(11),pp.1-9.

[27]. Chandramouli,S.,Shrinivas Balraj,U.,and Eswaraiah,K. (2014).Optimization of Electrical Discharge Machining Process Parameters Using Taguchi Method. International Journal of Advanced Mechanical Engineering,Vol. 4(4), pp.425-434.

[28]. Sabareesaan,K.J.,Varahamoorthi,R.,and Habeeb Al Ani. (2014).Analysis of the Effect of Process parameters in Electric Discharge Machining of Inconel X750 using brass Electrode. International Journal of Engineering Research and Technology,Vol. 3(9).

[29]. Masoud Azadi Moghaddam.,and Farhad Kolahan. (2014).An Empirical Study on Modeling and Optimization of EDM Process Parameters for Inconel 718 Super Alloy Using D- optimal approach and Genetic Algorithm.third International Engineering Materials and Metallurgy Conference ,I Mat 2014,pp.1-10.

[30]. Dhakar,K.,Pundir,H.,and Dvivedi,A. (2014).Optimization and comparison of near-dry EDM and dry EDM of Inconel 718. Journal of Production Engineering,Vol.17 (02),pp. 25-29.

[31]. Sabareesaan,K. J.,Varahamoorthi,R.,and Habeeb Al Ani. (2014).Evaluation of Process parameter ranks in Electric Discharge Machining of Aerospace super alloy using copper Electrode. 2nd International Conference on Current Trends in Engineering and Technology," ICCTET'14,IEEE Conference Number – 33344,pp.556-560.

[32]. Amitesh Goswami.,and Jatinder Kumar. (2014).Optimization in wire-cut EDM of Nimonic-80A using Taguchi's approach and

utility concept. International Journal of Engineering Science and Technology, Vol.17, pp.236-246.

[33]. Amitesh Goswami.,and Jatinder Kumar. (2014).Investigation of surface integrity,material removal rate and wire wear ratio for WEDM of Nimonic 80A alloy using GRA and Taguchi method. International Journal of Engineering Science and Technology,Vol.17,pp.173-184.

[34]. Mohanty Chinmaya,P.,Mahapatra Siba Shankar.,and Singh Manas Ranjan. (2014).An Experimental Investigation of Machinability of Inconel 718 in Electrical Discharge Machining. ICMPC,Procedia Materials Science,Vol. 6 ,pp. 605 – 611.

[35]. Anshuman Kumar.,Dillip Kumar Bagal.,and Maity,K.P. (2014).Numerical Modeling of Wire Electrical Discharge Machining of Super alloy Inconel 718 GCMM 2014. Procedia Engineering,Vol. 97 ,pp.1512 – 1523.

[36]. Sabareesaan,K. J.,Varahamoorthi,R.,Habeeb Al Ani.,and Jaya,J. (2014).MRR Prediction Model for Electrical Discharge Machining of Inconel X750 by Response Surface Methodology Using MINITAB Software. European Journal of Advances in Engineering and Technology,Vol.1(1), pp.1-6.

[37]. Jasvinder Pal.,and Nishant. (2014).Parameters optimization of wire EDM for surface roughness using Taguchi technique. International Journal of Technical Research,Vol. 3(1),pp. 23-28.

[38]. Taha Chowdry.,(2014). Improvement of Surface Roughness of Nickel Alloy Specimen by Removing Recast Layer in Wire Electric Discharge Machining. International Journal of Modern Engineering Research,Vol. 4(11), pp.54-62.

[39]. Karim Baig,M.D. and Venkaiah,N.,(2014). Parametric optimization of WEDM for HastelloyC276,using GRA method. International Journal of Engineering Development and Research,Vol.1(2),pp.1-7.

[40]. Kasim,M.S., Zahudi,M.S.M., Haron,C.H.C., Ghani,J.A., Izamshah,R., Isa,M.H., Saedon,J.B., Taufik., and ITO,T. (2014).Effect of WEDM cutting parameter on Inconel 718 subsurface micro hardness. Journal of Advanced Manufacturing Technology,Vol. 8(2).

[41]. Manjaiah,M.,Narendranath,S.,and Javad Akbari. (2014).Optimization of WEDM parameters to achieve better MRR and surface finish. Procedia Materials Science,Vol. 5 ,pp. 2635-2644.

[42]. Ashok Kumar Choudhary.,and Chhabra,K.K. (2014).Performance evaluation on parameter optimization of wire electro-discharge machining for super alloy Incoloy-800. International Journal of Engineering and Science Research,Vol.4(10),pp.587-597.

[43]. Manjaiah,M., Narendranath,S.,Basavarajappa,S.,and Gaitonde,V.N. (2014).Wire electric discharge machining characteristics of titanium nickel shape memory alloy. Trans. Nonferrous Met. Soc. China,Vol. 24,pp.3201–3209.

[44]. Sivaprakasam,P.,Hariharan,P.,and Gowri,S. (2014).Modeling and Analysis of Micro-WEDM Process on Inconel Super Alloy through Response Surface Methodology. 5th International and 26th All India Manufacturing Technology,Design and Research Conference (AIMTDR 2014) December 12th–14th, IIT Guwahati,Assam,India,443,pp.1-5.

[45]. Satyanarayana,B.,and Srikar,G. (2014).Multi-response optimization of CNC WEDM process parameters for machining Inconel 718 using Taguchi grey relational analysis. International Journal of Mechanical and Production Engineering,Vol. 2(10), pp.35-41.