International Journal of Engineering and Management Research
www.ijemr.net
e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-10, Issue-3 (June 2020)
https://doi.org/10.31033/ijemr.10.3.21

An Experimental Investigation of Material Removal Rate on H-13 Die Tool Steel on EDM Using Taguchi Techniques

Ankit Kumar[1] and Poshan Lal Sahu[2]
[1]M.Tech Student Department of Mechanical Engineering, Dronacharya College of Engineering, Haryana, INDIA
[2]Assistant Professor, Department of Mechanical Engineering, Dronacharya College of Engineering, Haryana, INDIA

[1]Corresponding Author: ankit.21832ggnindia@gmail.com

ABSTRACT

H-13 is die tool steel, it have widely applications in the Hot punches and dies for blanking, bending, swaging and forging, Hot extrusion dies for aluminum, cores, ejector pins, inserts, Nozzles for aluminum, tin and lead die casting, Hot shear blades etc. as the H-13 steel has widely applications so it is chosen for the present study. Presents works shows the effect of various process parameters like peak current, Pulse on Time and Feed rate on Material Removal Rate. EDM Drilling and Taguchi technique is used for the optimization of response variables.

Keyword-- EDM, H-13 Die Tool Steel, Pulse on Time, Peak Current and Feed Rate, Material Removal Rate, Taguchi Technique

I. INTRODUCTION

EDM machine was used as the experimental machine in this study. A Copper Tool with a diameter of 5 mm was used as an electrode to erode a work piece of h-13 Die Tool steel (flat plate). EDM is a non-traditional process based on removing unwanted material in the form of debris from a part by means of a series of recurring electrical discharges (created by electric pulse generators in micro seconds) between a tool called electrode and the work material in the presence of a dielectric fluid(kerosene, distilled water) . EDM is a cost-effective and important method of machining hard and brittle electrically conductive materials. In EDM, since there is no direct contact between the electrode and the work piece, hence it can eliminate mechanical stresses chatter and vibration problems during machining. All type of conductive material can be machined using EDM irrespectively the hardness of the material. Both tool and work piece are submerged in a dielectric fluid. Kerosene/EDM oil/de-ionized water is very common type of liquid dielectric medium. Ashok Kumar et. al. (2014) In this paper, an attempt has been made to machining the En-19 tool steel by using U-shaped copper electrode perform on electrical discharge machine. Where Diameter of U-shaped electrode, Current and Pulse on time are taken as process input parameters and material removal rate, tool wear rate, Overcut on surface of work piece are taken as output parameters. A set of eighteen experiments (Taguchi design) were performed on electronic a make smart ZNC electric discharge machine and relationships were developed between input and output parameters. The study indicates that, MRR increased with the discharge current (Ip). As the pulse duration extended, the MRR decreases monotonically. In the case of Tool wear rate the most important factor is discharge current then pulse on time and after that diameter of tool. In the case of over cut the most important factor of discharge current then diameter of the tool and no effect on pulse on time. Amit et. al. (2013) En-5 is a medium carbon steel , it have widely applications in the Axles, Connecting Rods, Guide Rods, Hydraulic Shafts, Motor Shafts, Rams, Spindles, Studs etc. as the en5 steel has widely applications so it is chosen for the present study. Presents works shows the effect of various process parameters like peak current, Pulse on Time, and Jet pressure on Material Removal Rate. EDM Drilling and L9 orthogonal array taguchi technique is used for the optimization of response variables. Result show that MRR is increase by increasing the peak current, MRR rises by increasing the value of pulse on time and MRR decreased by increasing the jet pressure. Nikhil Kumar et. al. (2012) Electrical discharge machining (EDM) is one of the nontraditional machining processes based on thermo electric energy between the work piece and an electrode. In this process, the material removal is occurred electro thermally by a series of successive discrete discharges between electrode and the work piece. The performance of the process, to a large extent, depends on the electrode material, work piece material manufacturing method of the electrodes. A suitable selection of electrode can reduce the cost of machining. So in this paper Die –Sinker EDM using copper and graphite electrode experiment has been done for optimizing performance parameters and reducing cost of manufacturing, finally it is found that a graphite electrode give better performance in certain characteristics but the cost become high for machining so keeping in mind cost and other some characteristics a graphite electrode is more suitable than copper electrode in case of both MRR and TWR. Pichai Janmance et. al. (2011) When a depth hole is drilled by EDM, taper is occurred which is

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-10, Issue-3 (June 2020)
https://doi.org/10.31033/ijemr.10.3.21

not desired in the process. This research was focused on influence of EDM parameters on material removal rate (MRR), electrode wear rate (EWR) and tapered hole of martens tic stainless steel AISI 431. The considered factors consist of electrical current, on-time, duty factor and water pressure and servo rate. The experimental results reveal that MRR increases when increasing of servo rate. The taper of hole increases with increasing of electrical current and servo rate. However, it is reverse proportion to water pressure and duty factor. Andad Pandey et. al. (2010) Present manufacturing industries are facing challenges from these advanced materials viz. super alloys, ceramics, and composites, that are hard and difficult to machine, requiring high precision, surface quality which increases machining cost. To meet these challenges, non-conventional machining processes are being employed to achieve higher metal removal rate, better surface finish and greater dimensional accuracy, with less tool wear. Electric Discharge Machining (EDM), a non-conventional process, has a wide applications in automotive, defense, aerospace and micro systems industries plays an excellent role in the development of least cost products with more reliable quality assurance. Die sinking EDM, Rotating pin electrode (RPE), Wire electrical discharge machining (WEDM), Micro- EDM, Dry EDM, Rotary disk electrode electrical discharge machining (RDE-EDM) are some of the variants methods of EDM. The present paper review the state of the art technology of high-performance machining of advanced materials using Die Sinking EDM, WEDM, micro- EDM.

II. EXPERIMENTATION

The experiments were conducted using the Electric Discharge Machine, model ELEKTRA PULSPS 53 the polarity of the work piece was set as negative while that of electrode was positive. The dielectric fluid used was EDM oil. Various input parameters varied during the experimentation are Pulse on time, Current and Feed rate. The effect of these parameters is studied on Material Removal Rate. The work piece material H-13 die tool steel was used. The chemical composition of H-13 die tool steel is given in Table 1.

Table 1 Chemical Composition of H-13 die tool steel

Material	Percentage %
Carbon	0.3132
Manganese %	0.2930
Phosphorus	0.8432
Sulphur	0.0235
Silicon	0.0139
Chromium	5.169
Vanadium	1.159
Moly	1.433
Remaining	Iron

The results for various combinations of parameters were obtained by conducting the experiment as per the orthogonal array L_9. The calculated results were analysed using the commercial software MINITAB 19 specifically used for design of experiment applications and the graphs for various S/N (signal to noise) ratios and mean values for metal removing rate (MRR) were obtained by MINITAB R19.

To measure the quality characteristics, the experimental values are transformed into signal to noise ratio. The influence of control parameters such as current, pulse on time, and feed rate on metal removing rate (MRR) has been analysed using signal to noise response table. The control factors are statistically significant in the signal to noise ratio.

2.1. Select the Quality Characteristics

There are three types of quality characteristics in the Taguchi methodology such as:

1) Smaller-the-bette
2) Larger-the-bette
3) Nominal-the-best

The goal of this research was to analyse and determine maximum MRR. Therefore, a larger the-better quality characteristic was implemented because MRR is desirable property of material and our objective is to maximum MRR of H-13 die tool steel.

2.2. Select Noise Factor and Control Factor

From the literature survey, we conclude that current, pulse on time, and feed rate had significant effect on metal removing rate (MRR). These are controllable input factors.

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-10, Issue-3 (June 2020)
https://doi.org/10.31033/ijemr.10.3.21

Table 2 Selected Factors and Levels

Controllable factors	I_p	T_{on}	Feed Rate
Level 1	30	40	5
Level 2	40	50	7
Level 3	50	60	9

2.3. Select Orthogonal Array

- The selection of Orthogonal array depends on three items in order of priority, viz., the number of factors and their interactions, number of levels for the factors and the desired experimental resolution or cost limitations.
- A total of nine experiments were performed based on the run order generated by the Taguchi model. The response for the model is metal removing rate (MRR).
- In Orthogonal array, first column is assigned to current, second column is assigned to pulse on time and third column is assigned to feed rate and the remaining columns are assigned to their interactions and errors associated with them.
- The objective of model is to maximize the metal removing rate (MRR). The Signal to Noise (S/N) ratio, which condenses the multiple data points within a trial, depends on the type of characteristic being evaluated.
- The S/N ratio characteristics can be divided into three categories, viz. nominal is the best, larger the better and smaller the better characteristics. In this study, larger the better characteristics was chosen to analyze the

For the present experimental work the three process parameters each at three levels have been decided. It is desirable to have three minimum levels of process parameters to reflect the true behaviour of output parameters of study. MRR test was performed with three parameters: and varying them for three levels. Degree of freedom for an orthogonal array should be greater than or equal to sum of those parameters, a L_9 Orthogonal array. As per above parameters we select L_9 orthogonal array in the Taguchi parameter design. The general layout of L_9 orthogonal array is shown in Table 3.

Table 3 L_9 orthogonal array for experiment

Expt. No.	Column 1	Column 2	Column 3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

III. CONDUCT THE EXPERIMENTS

The work piece material used was H-13 die tool steel. These specimens were cut in the nine pieces by hacksaw. Metal removing rate (MRR) values were collected with the help of EDM machine. S/N ratio was calculated with the help of following Eq. (1).

$$\text{S/N } (\eta) = -10 log \frac{1}{n} \sum_{i=1}^{n} y_i^2$$

Where y_1, y_2...y_i are the response of MRR and n is the number of observations.

The result of L_9 orthogonal array MRR of the investigated material obtained by the testing on EDM machine is shown in table 4. Three responses were taken from each experiment e.g. R_1, R_2 and R_3 responses for each experiment. The signal-to-noise ratio calculated for the output responses. For MRR, the signal-to-noise ratio should be large e.g. larger the S/N ratio, better will be the MRR.

The response table for signal to noise ratios shows the average of selected characteristics for each level of the factor. This table includes the ranks based on the

International Journal of Engineering and Management Research
www.ijemr.net
e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-10, Issue-3 (June 2020)
https://doi.org/10.31033/ijemr.10.3.21

delta statistics, which compares the relative value of the effects. S/N ratio is a response which consolidates repetitions and the effect of noise levels into one data point.

Table 4 Result of L_9 orthogonal array

Sr No.	Ip	Ton	FR	W_I (g)	W_f (g)	W_L (g)	Time Taken (s)	MRR (mg/s)
1	30	40	5	27.850	27.460	0.308	293	1.05
2	30	50	7	27.450	27.155	0.295	310	0.95
3	30	60	9	27.680	27.370	0.310	341	0.91
4	40	40	7	27.390	27.081	0.309	359	0.86
5	40	50	9	27.540	27.209	0.331	372	0.89
6	40	60	5	27.880	27.602	0.278	331	0.84
7	50	40	9	27.810	27.488	0.322	329	0.98
8	50	50	5	27.490	27.166	0.324	315	1.03
9	50	60	7	27.380	27.021	0.359	362	0.88

Fig. 1 Workpiece after working

Table 5 Response Table for Signal to Noise ratios

Level	I_p	T_{on}	FR
1	0.9700	0.9633	0.9733
2	0.8633	0.9567	0.8967
3	0.9633	0.8767	0.9267
Delta	0.1067	0.0867	0.0767
Rank	1	2	3

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-10, Issue-3 (June 2020)
https://doi.org/10.31033/ijemr.10.3.21

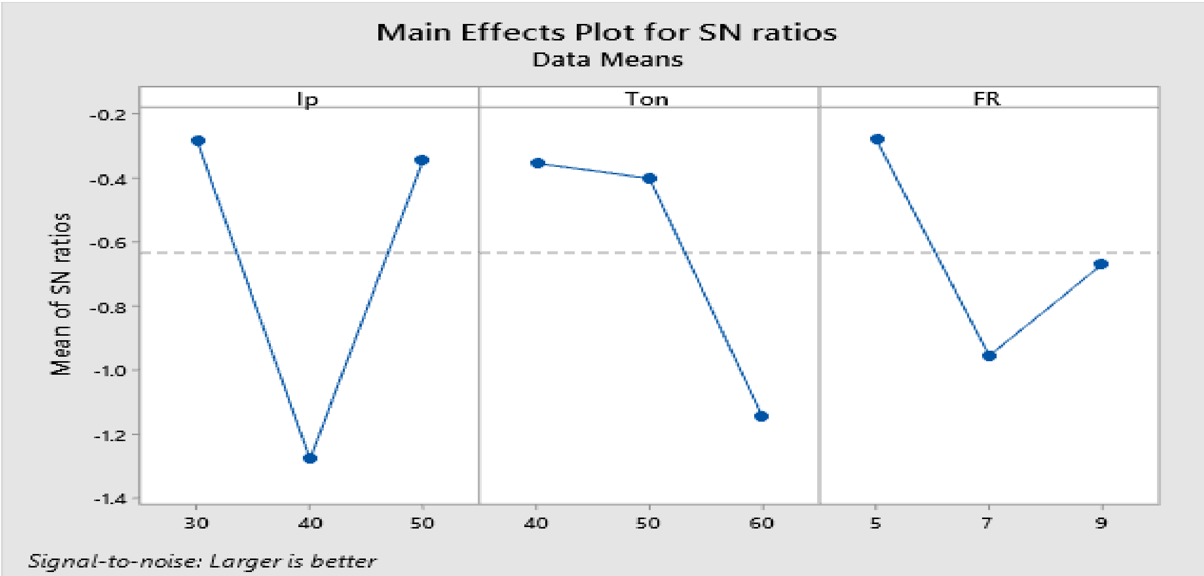

Fig.2 Main Effects Plot for SN ratios

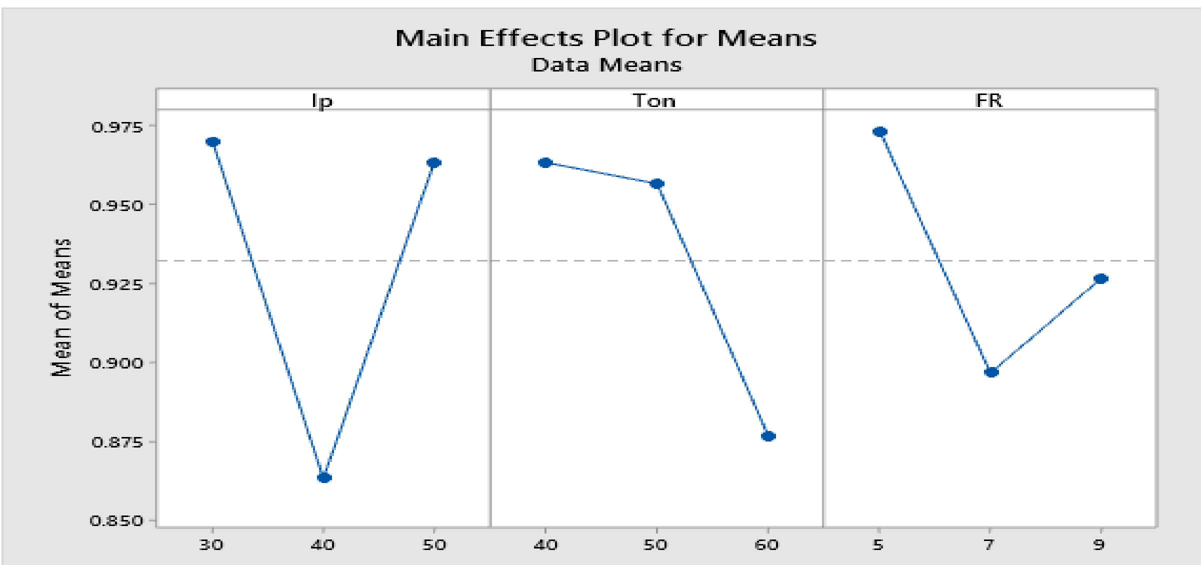

Fig.3 Main Effects Plot for Means

Table 6 Response Table for Means- Larger is better

Level	I_p	T_{on}	FR
1	-0.2803	-0.3539	-0.2780
2	-1.2789	-0.4003	-0.9553
3	-0.3430	-1.1480	-0.6690
Delta	0.9986	0.7941	0.6773
Rank	1	2	3

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-10, Issue-3 (June 2020)
https://doi.org/10.31033/ijemr.10.3.21

IV. MRR

Table 7 Analysis of Variance MRR

Source	D F	Seq SS	Adj SS	Adj MS	F	P	%
Current	2	0.021422	0.021422	0.010711	50.74	0.019	47.86
Pulse on time	2	0.013956	0.013956	0.006978	33.05	0.029	31.18
Feed rate	2	0.008956	0.008956	0.004478	21.21	0.045	20.01
Residual Error	2	0.000422	0.000422	0.000211			0.943
Total	8	0.044756					

From this ANOVA table, we give the results those following parameters such as current [47.86%], Pulse on time [31.18%] and feed rate [20.01%] which are influencing metal removing rate (MRR). MRR is influenced by current, Pulse on time and feed rate respectively. We know that MRR which is volumetric loss of H-13 die tool steel is highly influenced by current.

V. CONCLUSION

The following conclusions are drawn from the experimental study

1. It is observed that current is the main influence parameters on MRR followed by pulse on time and feed rate.
2. MRR increase with increase in the value of current.

REFERENCES

[1] Anand Pandey & Shankar Singh. (2010). Current research trends in variants of Electrical Discharge Machining: A review. *International Journal of Engineering Science and Technology*, *2*(6), 2172-2191.
[2] Ashok Kumar, Kuldeep Singh Bedi, Karaj Singh Dhillo, & Rashpal Singh. (2004). Experimental investigation of machine parameter for EDM using U-shaped electrode of EN-19 tool steel. *International Journal of Engineering Research and Application*, *1*(4), 1674-1684.
[3] Harpreet Singh & Amandeep Singh. (2012). Effect of pulse on/pulse off time on machining of AISI D3 die steel using copper and brass electrode in EDM. *International Journal of Engineering and Science*, *1*(9), 19-22.
[4] Jai Hindus. S, Prasanna Rajendra Kumar. R, Oppiliyappan. B, & P. Kuppan. (2013). Experimental investigations on electrical discharge machining of SS 316L. *International Journal on Mechanical Engineering and Robotics (IJMER)*, *1*(2), 39-45.
[5] Kuldeep Ojha, R. K. Garg, & K. K. Singh. (2011). Parametric optimization of PMEDM process with nickel micro powder suspended dielectric & varying triangular shape electrode on EN -19 steel. *Journal of Engineering & Applied Science*, *6*, 152-156.
[6] Kuwar Mausam, Mohit Tiwari, Kamal Sharma, & Ravindra Pratap Singh. (2014). Process parameter optimization for maximum material removal rate in high speed electro-discharge machining. *International Journal of Current Engineering and Technology*, 239-244.
[7] K.S.Banker, A.D. Oza, & R.B. Dave. (2013). Performance capabilities of EDM machining using aluminum, brass and copper for AISI 304L material. *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, *2*(8).
[8] Karan Chopra, Gautam Kocher, & Sandeep Kumar. (2012). Investigation of surface integrity of AISI D3 tool steel after EDM. *International Journal of Emerging Technology and Advanced Engineering*, *2*(4), 160-162.
[9] Lee, S.H. & Li, X.P. (2001). Study of the effect of machining parameters on the machining characteristics in electrical discharge machining of tungsten carbide. *Journal of Materials Processing Technology*, *115*(3), 344-358.
[10] M.M. Rahman, Khan M.A.R., Kadirgama K., Noor M.M., & Bakar R.A. (2011). Experimental investigation into electrical discharge machining of stainless steel 304. *Journal of Applied Sciences*, *11*, 549-554.
[11] Nikhil Kumar, Lalit Kumar, Harichand Tewatia, & Rakesh Yadav. (2012). Comparative study for MRR on die sinking EDM using electrode of copper & graphite. *International Journal of Advanced Technology & Engineering Research and Studies*, *II*(I), 148-150.
[12] M.A. Ali, M. Samsul,N.I.S. Hussein, M. Rizal, R. Izamshah, M. Hadzley, M.S. Kasim, M.A. Sulaiman, & S. Sivarao. (2013). The effect of EDM die-sinking parameters on material removal rate of beryllium copper using full factorial method. *Middle-East Journal of Scientific Research* *16*(1), 44-50.
[13] Narendra Sharma & Ajeet Bergaley. (2013). Optimization of electrical and non electrical factors in EDM for machining die steel using copper electrode by adopting taguchi technique. *International Journal of Innovative Technology and Exploring Engineering*, *3*(3), 44-48.

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-10, Issue-3 (June 2020)
https://doi.org/10.31033/ijemr.10.3.21

[14] Pichai Janmance & Apiwat Muttamara. (2011). A study of hole drilling on stainless steel AISI 431 by EDM using brass tube electrode. *International Transaction Journal of Engineering, Management, & Applied Sciences, & Technologies, 2*(4), 471-481.

[15] Parmod Malhotra & Amit Kohli. (2013). Performance study of electrical discharge machining with H-11 tool steel using one variable at a time approach. *International Journal for Science and Emerging Technologies with Latest Trends, 12*(1), 15-20.

[16] Pravin R. Kubade, & V. S. Jadhav. (2012). *An experimental investigation of electrode wear rate (EWR), material removal rate (MRR) and radial overcut (ROC) in EDM of high carbon-high chromium steel (AISI D3)*. Available at: http://journaldatabase.info/articles/experimental_investigation_electrode.html.

[17] Ram.R.Wayzode, Dr. S. V. Deshmukh, & Prof. N. G. Alvi. (2012) Mathematical modeling of EDM hole drilling using response surface methodology. *Review of Research*, *1*(VIII), 1-4.

[18] Saha, S.K. & Choudhury, S.K. (2009). Experimental investigation and empirical modeling of the dry electric discharge machining process. *International Journal of Machine Tools and Manufacture*, *49*(3-4), 297-308.

[19] Saeed Daneshmand, Ehsan Farahmand Kahrizi, Esmail Abedi, & M. Mir Abdolhosseini. (2013). Influence of machining parameters on electro discharge machining of NiTi shape memory alloys. *Int. J. Electrochem. Sci., 8*, 3095-3104.

[20] Singh Jaspreet, Singh Mukhtiar, & Singh Harpreet. (2013). Analysis of machining characteristics of cryogenically treated die steels using EDM. *International Journal of Modern Engineering Research (IJMER), 3*(4), 2170-2176.

[21] Sohani, M.S., Gaitonde, V.N., Siddeswarappa, B., & Deshpande, A.S. (2009). Investigations into the effect of tool shapes with size factor consideration in sink electrical discharge machining (EDM) process. *International Journal of Advanced Manufacturing Technology*, 1-15.

[22] Vishnu D Asal, Prof. R.I. Patel, & Alok B. Choudhary. (2013). Optimization of process parameters of EDM using ANOVA method. *International Journal of Engineering Research and Applications (IJERA), 3*(2), 1119-1125.

[23] Crookall J.R. & Heuvelman. (1971). Electro-discharge machining-the state of the art. *Annual of the CIRP*, *20*, 113-120.

[24] Singh, S. Kansal & H.K. Kumar. (2005). Parametric optimization of powder mixed electrical discharge machining by response surface methodology. *Journal of Materials Processing Technology*, *169*(3), 427-436.

[25] Mohan, B. Rajadurai, A., & Satyanarayana, K.G. (2004). Electric discharge machining of Al–Sic metal matrix composites using rotary tube electrode. *Journal of Materials Processing Technology*, *153–154*, 978–985.

[26] Krishna Mohan Rao, G. Satyanarayana, & S. Praveen, M. (2008). *Influence of machining parameters on electric discharge machining of maraging steels-An experimental investigation*. Available at: https://www.researchgate.net/publication/44262193_Influence_of_Machining_Parameters_on_Electric_Discharge_Machining_of_Maraging_Steels_-_An_Experimental_Investigation.

[27] Kansal, H.K, Singh,S., & Kumar, P. (2007). Effect of silicon powder mixed EDM on machining rate of AISI D2 die steel. *Journal of Manufacturing Processes*, *9*(1), 13-22.