OPTIMIZATION OF MATERIAL REMOVAL RATE IN ELECTROCHEMICAL MACHINING OF AISI 202 WITH MIXED ELECTROLYTES

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ABSTRACT

The Economic strength of a country is judged from the development of manufacturing industries. The manufacturing process begins with the product design, and materials specification from which the product is made. These materials are then modified through manufacturing processes to become the required part. Since the advent of new technologies such as electrical discharge machining, electron beam machining, ultrasonic machining, it is very difficult for machining the materials containing high chromium, carbon , super alloys and stainless steel . In order to overcome the challenges of above machining processes process is implemented which is used to produce complicated shapes with good surface finishing in machine materials.ECM process is more economical, fast, accurate and convenient when compared to conventional and traditional process.

Key words: ECM PROCESS, Composition of electrolytes, Material removal rate.

1. ECM PROCESS

Electrochemical machining is one of the best methods for removing metal by an electrochemical process. It is similar to the concept of (EDM) electrical discharge machining process. Unlike EDM, ECM has no tool wear (Tool wear describes the gradual failure of cutting tools due to regular operation) and possibility of creation of sparks at IEG is low. High metal removal rates are possible while using electrochemical machining because, no thermal, mechanical stress in ECM and minor surface finishing can be obtained.

2. RESEARCH ON ECM MACHINING

Recent developments in Electrochemical Machining (ECM) process are associated with the effect of process parameters such as material removal rate, roughness, microstructure, operating, tooling, maintenance cost, Quality, etc. The recent developments in EMM were highlighted by many researchers, they states that maintaining the proper inter electrode gap (IEG) leads to control over the material removal rate, power supply also minimize the formation of micro-sparks in IEG if 0.1mm is maintained.

MAJOR CHARACTERISTICS ELECTROCHEMICAL MACHINING (ECM)

S.NO	MAJOR CHARACTERISTICS	PARAMETERS
1	Applied Voltage	10 volts to 30 volts
2	Applied current	150A to 10000 A
3	Density (current)	20 A/cm^2 to 200 A/cm^2
4	Nature of Power supply	Direct current- Continuous and pulsed
5	Frequency range	Hertz–kilohertz range
6	Electrolyte flow rate	10–60 m/s
7	Type of electrolyte	Salt solution
8	Electrolyte temperature	24–65C
9	Concentration of the electrolyte	>20 g/l
10	Size of the tool	Large to medium
11	Operation	Mask/Mask less
12	Machining rate	0.2–10 mm/min
13	Side gap	>20 µm

3. ELECTROLYTES

In ECM Process, electrolyte plays an important role in Material removal rate (MRR) depends on selection of electrolytes, tool wear also varies with electrolytes. In Electro chemical machining processes, electrolyte is so chosen such that there is no deposition, whatsoever, on the cathode otherwise it will distort the shape of the tool and thus desired shape and surface finish on the work piece will not be attained. The properties of electrolytes should be high conductivity; toxicity of electrolyte should have low value and corrosive nature, and chemical and electrochemical stability. Some of the best electrolytes are NaCl, NaNO3, AgNO3, Na2Cr2O7, and NaClO4.

4. COMPOSITION OF ELECTROLYTES

In this work, sodium nitrate is used as an aqua electrolyte .In order to get better Material removal rate. Since sodium nitrate has better passivating characteristics, 15% of NaNO3 is used to obtain high surface roughness. 500ml of silver nitrate with normalities of 1/10 and 1/50 is mixed with sodium nitrate solution. Silver nitrate (AgNo3) is highly corrosive and its ionization rate is high-silvered ions results in improvement of MRR.

5. AISI 202 STAINLESS STEEL CHARACTERISTICS

AISI 202 stainless steel is comes under classification of austenitic stainless steel made of chromium manganese nickel steel prepared into wrought products. American Institute of Steel and Iron (AISI) has given designation for this material as 202.The cost of the AISI 202 steel is very low compared with other stainless steel in the same range. The main mechanical properties of the AISI 202 has high tensile strength. AISI 202 consists of 16-18% chromium, 0.5-4.0% nickel and carbon content of 0.12% in 202, content of manganese is 5.5-7.5% in 202, small quantities of silicon, phosphorus and molybdenum also presents.

Table 5.1 Constituent of AISI 202

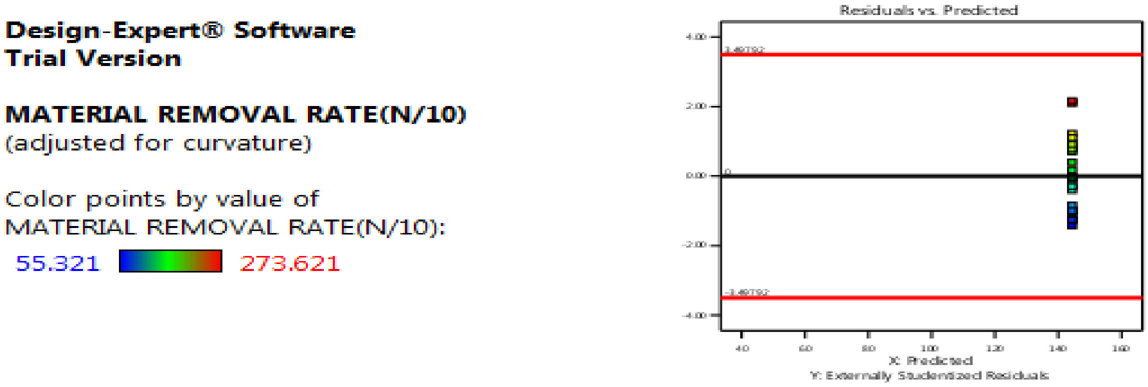
Elements	Fe	Cr	Mn	Ni	C	Co	P	Mo	S
Weight %	73.7	13.98	9.75	0.189	0.107	0.033	0.052	0.016	0.005

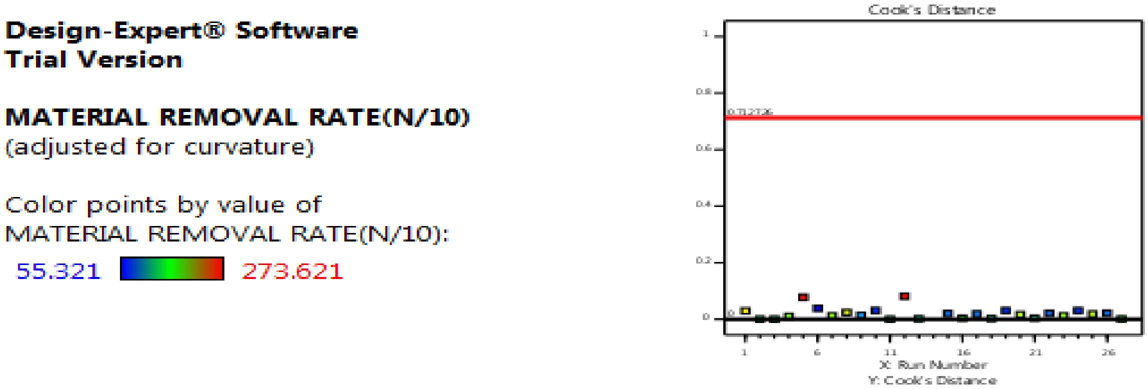
6. MAXIMIZATION OF MRR

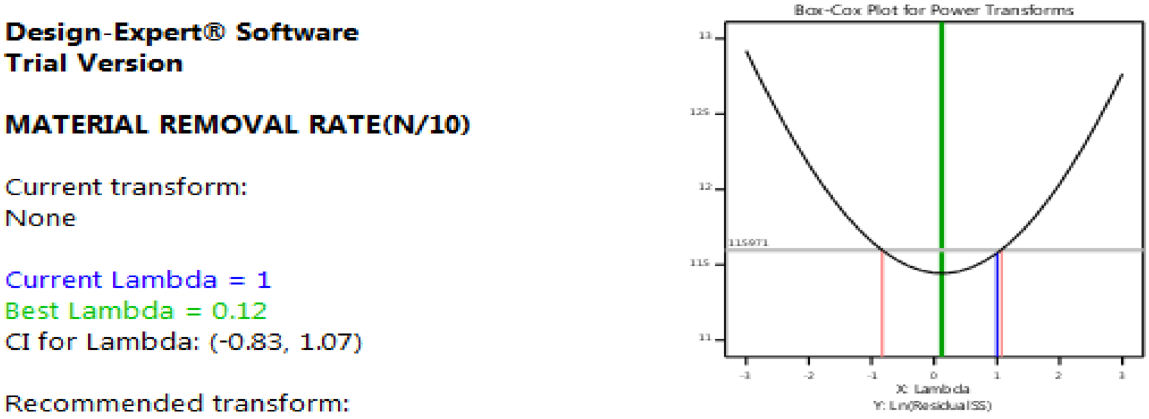
The optimization of MRR is performed is Design expert 10 software. It usually used to perform design of experiments. This software provides robustness, maximization, and combined designs. The abnormalities in the data are revealed using these graphical tools. By analyzing the variance, it is possible to establish its statistical significance . Design Expert is software designed to simulate the interpretation of multi-factor experiments. It creates computer generated D-optimal designs for cases where standard designs are not possible, or where we try to augment an existing design.

7. MATHEMATICAL DESIGN FOR AQUA ELECTROLYTE WITH 0.01 NORMALITY

By using design, expert software analysis of variance is applied for analyzing the MRR. The result of ANOVA is significant.MRR model has better tool feed rate and its voltage and electrolyte discharge rate is high. The immediate correlation is formed with regression model by selecting its variables and responses. The value of R^2 is 92.67% and model F-value is 78.28%.this values shows that MRR model is highly significant.







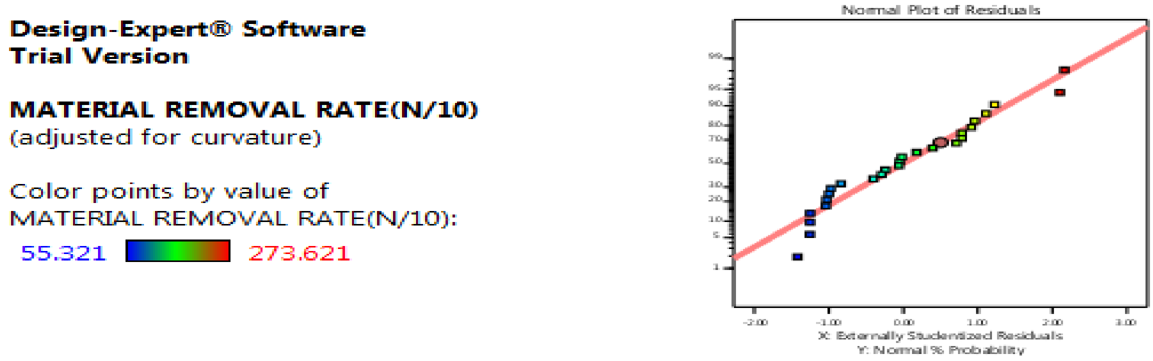


Figure 7.1 **Material removal rate 3D surfaces with mixed electrolyte ($NaNO_3$ with $AgNO_3$ (0.1N)**

The input variables on MRR are varied between factors as if tool feed rate, voltage and discharge rate. If the discharge rate of electrolyte increases, MRR of AISI 202 is also increases. The slope of surface increases when applied voltage increases from 12 v to 18v, which shows that MRR is clear at higher voltage when compared to lower voltage.

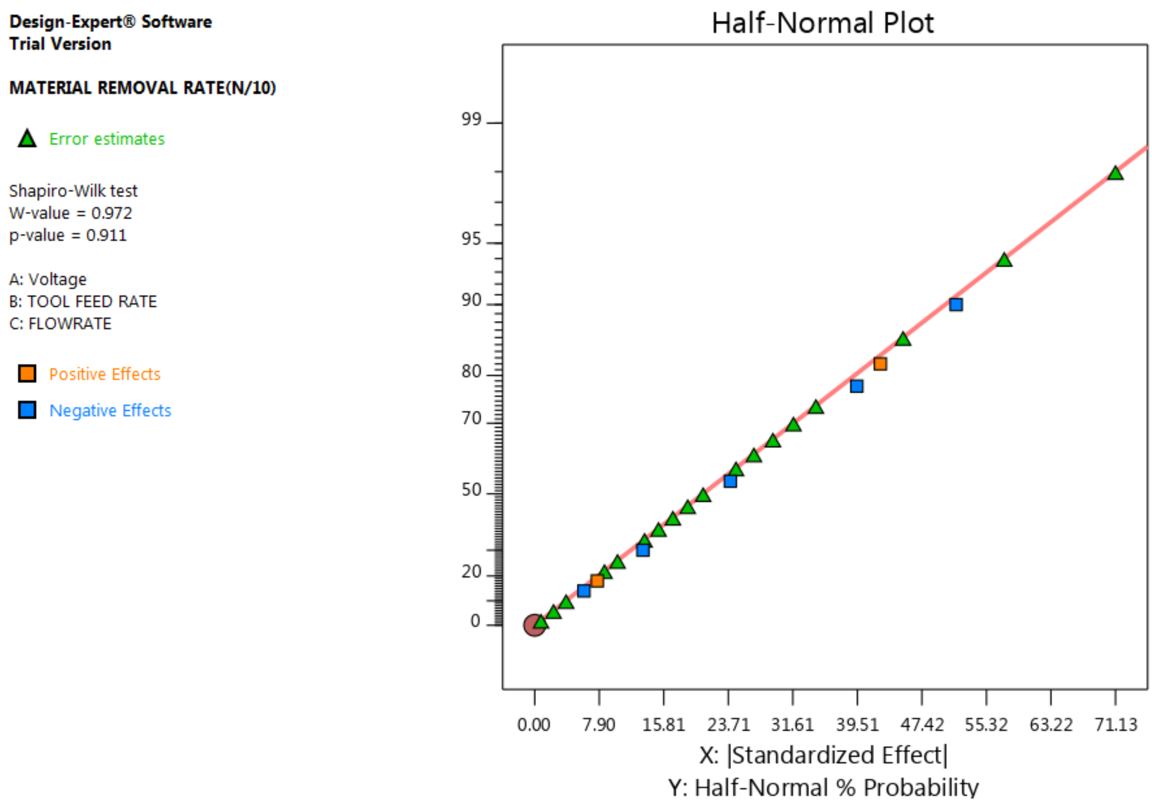
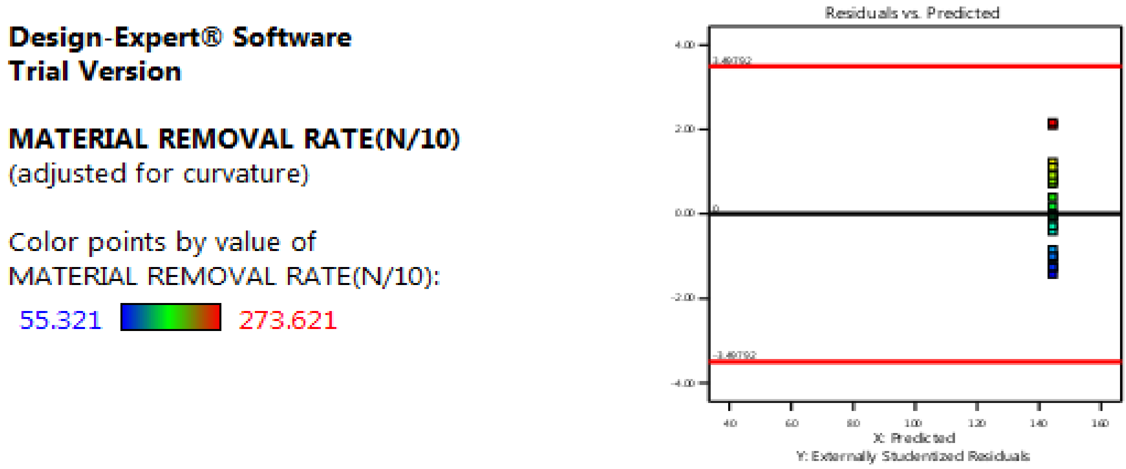
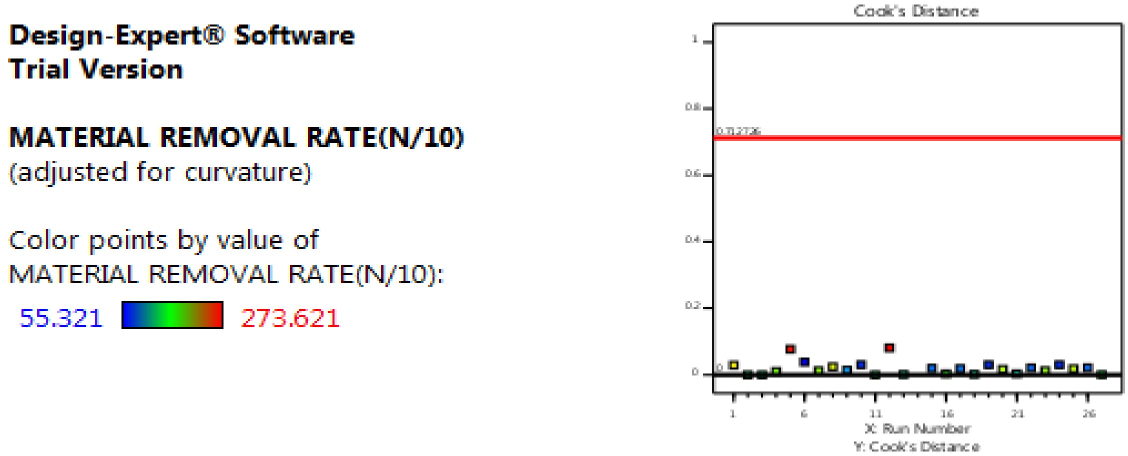


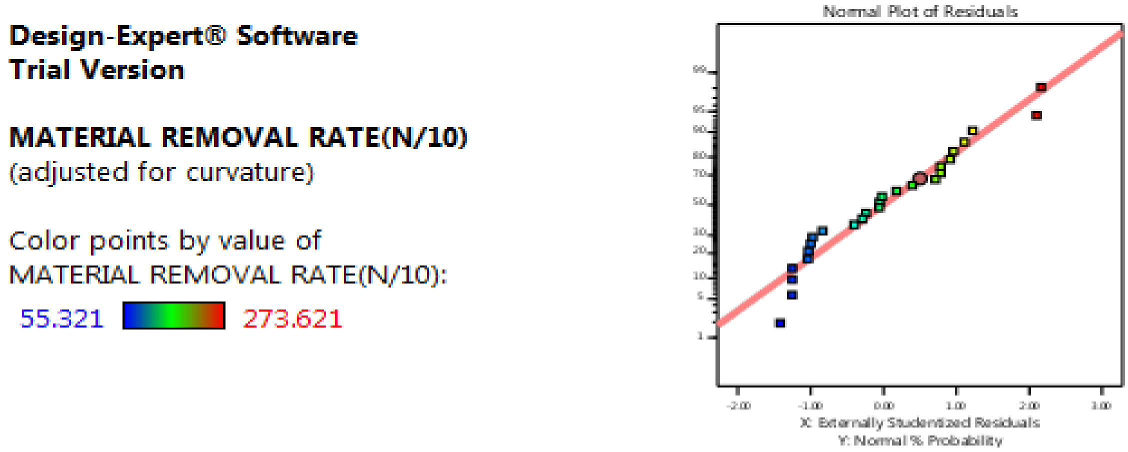
Figure 7.2 **MRR Normal plot of residuals with $AgNO_3$ (0.1N)**

8. MATHEMATICAL DESIGN FOR AQUA ELECTROLYTE WITH 0.02 NORMALITY

By using ANOVA, the quadratic model is done for analyzing the MRR. By implementing quadratic and regression model AISI 202 has better significant tool feed rate, voltage on electrolyte and high discharge rate. Its regression value is 93.57% and 64.83-selectedresponse. From the values, it concludes that MRR response increases by its input variables like varying voltage feed and flow rate.







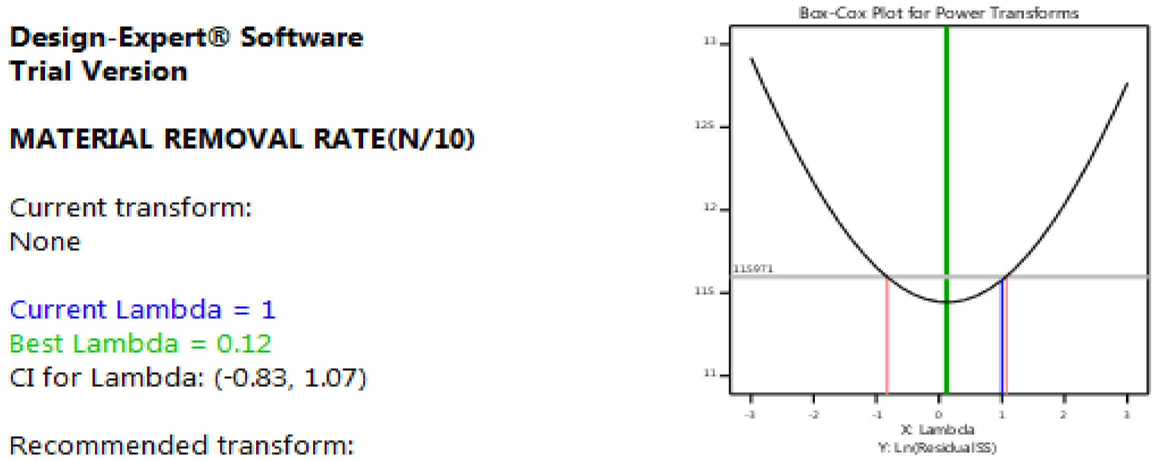


Figure 8.1Material removal rate 3D surfaces with mixed electrolyte ($NaNO_3$ with $AgNO_3$ (0.02N)

Figure 8.1 states the increased effect on input variable , when varying the applied voltage, tool feed rate and electrolyte flow rate on the comeback of material removal rate is AISI 202. Also when higher tool feed the material removal rate goes low with increasing electrolyte flow rate. At the higher voltage material removal rate is very sharp. Higher voltage because of incline of surface when voltage increases from 12volt to 18volt .

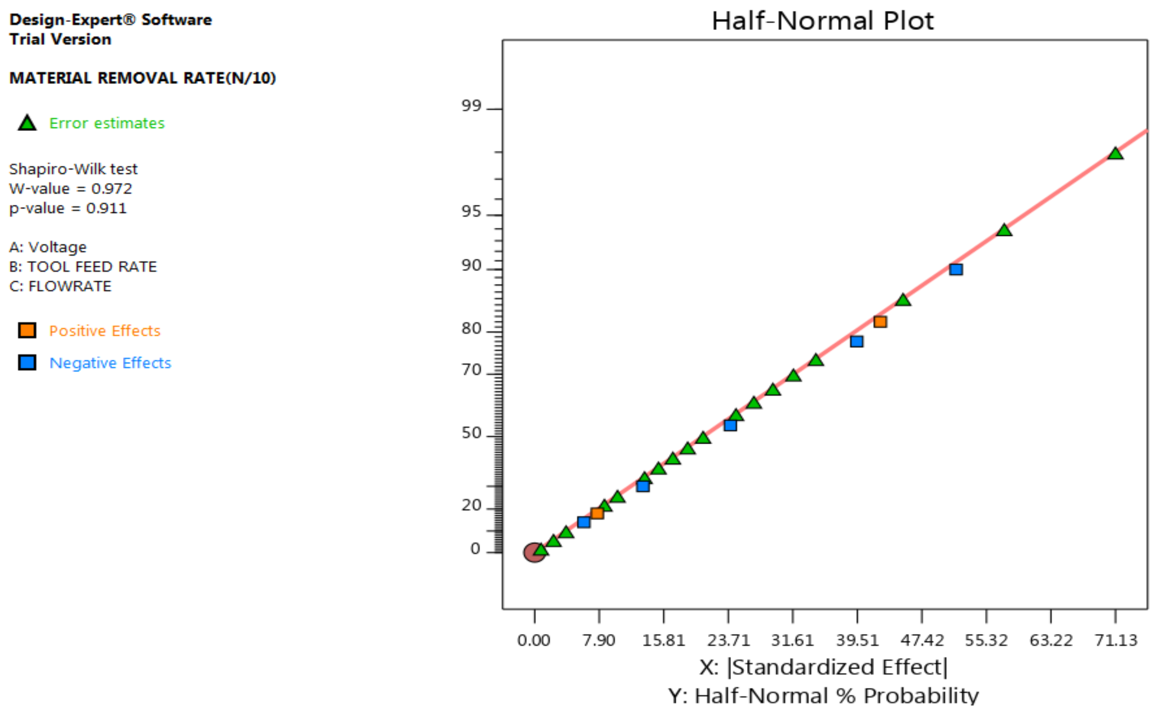


Figure 8.2 MRR Distribution of Normal probability of residuals with$AgNO_3$ (0.02N)

Figure 8.2 indicates the distribution of probability of residuals for MRR. It is stated that residuals follows a point to point straight line. It indicates models are matched with experimental results values.

CONCLUSION

From the above analysis, the study states that optimization of MRR is done efficiently using the electrolytic solutions. This study carries out two different procedures for analyzing the material removal rate. By using silver nitrate 1/10 normality with sodium nitrate aqua solution the MRR increases linearly with increase in applied voltage when compared to 1/50 normality. Also by using N/50 normality, it is possible to obtain MRR of order 308.034mm^3/min at 15v, also its IEG is 0.1mm, which helps to attain high MRR.

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