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PHONE: - + (91)-(11)-47026006

Journal of Electrical Engineering and Modern Technology

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ANALYSIS OF THE MERITS OF HOT RUNNER SYSTEM OVER COLD RUNNER SYSTEM IN MOULDING TECHNOLOGY

Sandeep Mathur[1‡], V. K. Mittal[1], Nitin Upadhye,[2] Vipul Mathur,[3] Kshitij Mathur[4]

[1]Amity School of Engineering and Technology, Amity University Noida,
sandeep_mathur66@yahoo.com, vkmittal@amity.edu
[2]University of Modern Sciences, Dubai
nupadhye@gmail.com
[3]Mechanical Engineering Department, NIT Kurukshetra, Haryana,
vipul95mathur@gmail.com
[4]Mechanical Engineering Department, BITS, Pilani Goa,
k.mathur68@gmail.com

Abstract

In the conventional moulding processes, the mould cavity is filled through the traditional cold runners in which plastic therein gets solidified along with the moulding parts produced. This method although cheap in terms of initial investment results in huge wastage of material, more operating cycle time and incurred regrinding costs. Hot runner technology is advancement over this traditional technique viz. cold runner technology and can be applied effectively to multi-cavity moulds in large scale and flexible production. The extensive analysis of the advantages and limitations of the two methods in this study will help in taking prudent industrial decisions regarding production, profit and infrastructure required.

Keywords- hot runner; cold runner; supply chain, injection moulding.

Introduction

In Injection molding, the thermoplastic resin is pushed into the mould cavity under pressure to attain the configuration of the product to be formed. The process control is best established in injection molding by using simulation models for improving observability through decoupled gating [1]. A runner is employed which acts as a pathway for the resin to fill the mould. The runner plays a crucial role in the entire process affecting the cooling time, maximum section thickness of the casting and coloration. The systems in which the material in the runner and the gates are solidified along with that in mould cavity are termed as Cold Runner systems and are widely used in all molding applications such as fast moving electrical goods (FMEG).

Cold runner systems, although cheap, suffer from some limitations namely- material wastage, degrading complexity, regrind costs and increased molding cycle. For assembly line productions comprising two or more moulding components in which the output may vary from few thousand to lakhs of pieces at a time, these losses become substantial and result in additional burden on supply chain systems. Also, the runner thickness and length is sometimes even greater than the maximum cross section of the product, making these losses even more uneconomical for similar situations.

The runner-less systems i.e. hot runner systems were evolved to tackle these issues in injection molding. The advantage of having the plastic in the runner, gates and nozzles continuously heated via electric heating coils leaves no extraneous material. Although design and analysis of nozzles and pressure valves are critical in hot runner system, present study does not deal with these aspects and only focusses on the complete hot runner system vis a vis cold runner system [2, 3]. In hot runner system, cycle time is reduced and less injection pressure/force is required. The structure of hot runner systems consists of a heated manifold which houses the runner, gating section and nozzles and is quite complex as compared to cold runner technology. The large investment for hot runners is not justified for small scale production and it is an important aspect while considering the installation of hot runner systems. In this work, an electrical assembly comprising of two functionally dependent parts is manufactured with both cold and hot runner processes to generate a comparative study of both systems to provide options for improving productivity and efficiency of a supply chain.

2. Description

While there are several case studies related to quality and productivity improvements in the injection molding processes [4], the present study deals with manufacturing of two parts using two distinctive mould making technology which are modeled as shown in the Fig. 1 and 2 with the respective CAD orthographic views alongside it.

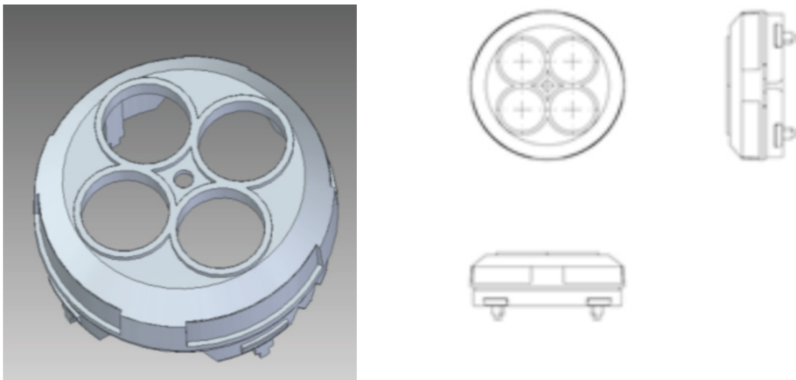

Fig. 1 Part 1

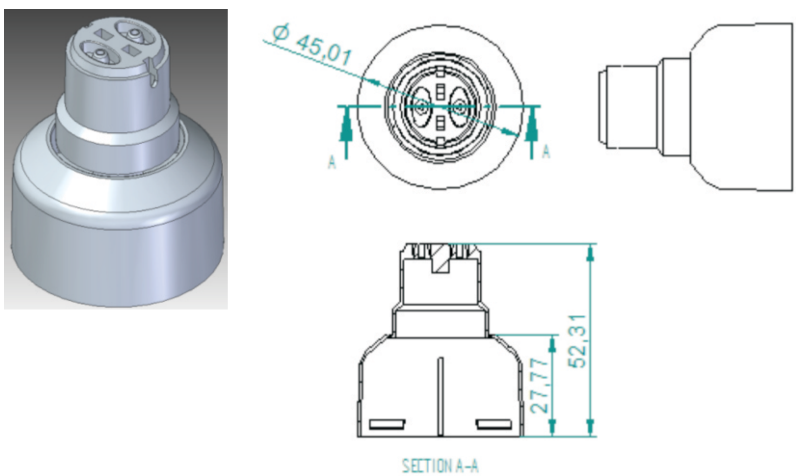

Fig. 2 Part 2

2.1 Part Properties For Cold Runner Mould:

The part properties are provided in the Table 1 with the shot weight as it would be required for a cold runner mould. Thus, it includes the runner weight and also the shrinkage and draft allowances. This data is projected from the mass properties in the 3D model. The material for the parts is PBT-20% which stands for Poly Butylene Terephthalate (density=1.38 g/cc). Since the type of polymer is critical in melt flow characteristics, the simulation model for visualization of hot runner design could not be employed as it was unrelated to this work [5].

Property	Part 1	Part 2
Weight (grams)	4.407	9.200
Shrinkage %	0.9	0.9
No. of cavities	16	08
Shot weight required (grams)	162.	120.
Material	PBT-20% GLASS FILLED	PBT-20% GLASS FILLED
Mold Base	C 45 material	C 45 material

2.2 Machine Specifications:

For Hot runner experiment, the valve type hot runner automated injection mould is used whereas, for the Cold runner experiment, a 200 ton 580 mm x 580 mm semi-automatic injection mould is used for both the parts. Fig. 3 shows the cold runner machine with the injection mechanism and Fig. 4 shows the Valve Gate (VG) hot runner machine with the mould open for injection. The machines are pneumatically actuated and are capable of producing 16 pieces at a time. The parts are produced at the rate of 16 and 8 pieces per shot respectively. The thermoplastic is fed from an overhead hopper which is injected into the mould cavity at the preset pressure. The temperatures inside the mould are recorded through sensors.

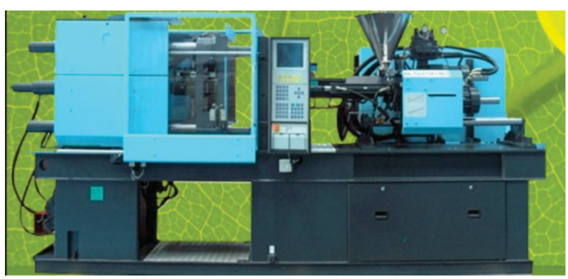

Fig. 3 Cold Runner injection Mould

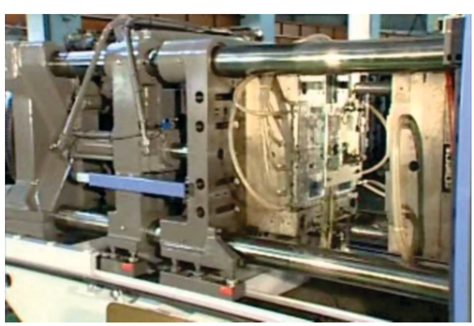

Fig. 4 Hot Runner injection Mould

The typical stages in a molding cycle are explained in Fig. 5 as a block diagram:

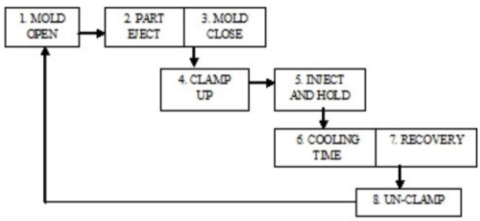

Fig.5.Stages in molding cycle

In the beginning of the cycle, the mould opens (1) and the solidified part is ejected from the cavities by the help of several ejector pins (2). The mould then closes (3) to prepare for the next shot and is clamped up (4) by applying high hydraulic or pneumatic pressure specified usually as tonnage of the machine. Then the molten thermoplastic is injected into the mould cavity (5) and the mould is retained in this configuration till the resin fills it completely. Subsequently, the cooling begins (6) and the resin starts to solidify. During this time, the screw or plunger moves, create a new shot, and returns to its original position. This is termed as Recovery period (7) and as soon as recovery is completed, the mould unclamps (8) and opens again. This entire process is then repeated.

In this work, the Hot and Cold runner designs are compared on the following criteria:

1) Machine Performance And Maintenance: The thermoplastic resin must flow through the profiles, curves and sections for each cavity in the mould so as to ensure that it enters at same pressure and thermal distribution [6].To achieve this, the machines performance is checked by identifying the intermittent maintenance operations which facilitates the production of consistent parts.

2) Part Quality: The parts are checked for flaws and shortcomings and tested in their field of application. The two designs are checked for defects such as-Short Shot, Sink marks, Voids and flashes.

3) Cycle Time and Maximum Capacity Of Production: Cycle time is the total time in which all the operations from injection of resin to ejection of part are satisfactorily completed. From Fig. 5

Cycle time= total time of operations (1+2+3+4+5+ 6+7+8)

In hot runner system injection time (5) is reduced as the plastic is already available in molten form in gates and runners.

4) Return of Investments In Batch Production: For this study, the efficiency of production is estimated by comparing the initial investment in the infrastructure of systems with the savings per day.

Certain **precautions** are to be kept in mind in the manufacturing process:

- The injection pressure is carefully monitored so that it is within the optimum range. Too low pressure will not fill the cavity completely while a higher pressure will result in degradation of material for the next shot and may cause ceasing of the machinery.
- Regular maintenance of hot runner machinery and its components like the electric heating arrangement and nozzles is essential. In cold runner setup, the waste solidified in runners need to be disposed off efficiently.
- The gating mechanism and runner design plays a pivotal role in deciding the properties of the part produced. Gate selection should be made considering molded product shape, number, looks, economic efficiency, and moldability [7].

3. Experimental Study

The criteria of comparing the two systems are elaborated in this experimental study carried for one month.

Machine Performance and maintenance: For this test, the machine performance is evaluated on the basis of the maintenance operations which are required to ensure the similarity or consistency of parts. In cold runner systems, it is observed that for both part 1 and part 2, the mould life was around **5 lakh** shots after which, the parts showed deviations from the others in terms of quality, thermal history and defects. Whereas in Hot runner systems, the discrepancies and quality degradation arrived only after **10 lakhs** shots which is significantly more than those in the cold runner system. Fig. 6-9 shows the runner arrangements in the mould and the resin flow pathway:

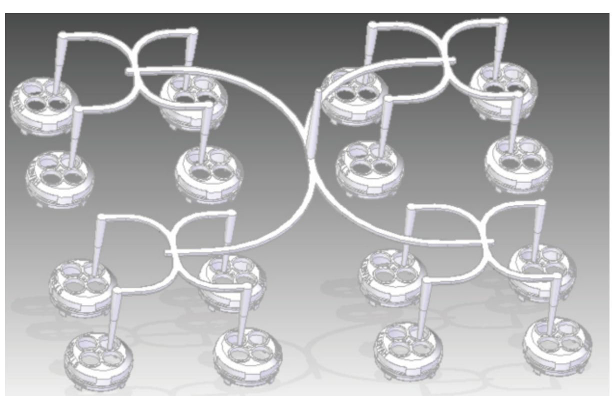

Fig. 6 Cold runner gating (Part 1)

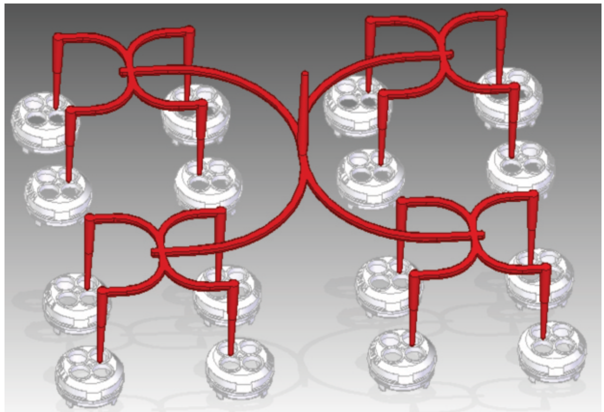

Fig. 7 Hot runner gating (Part 1)

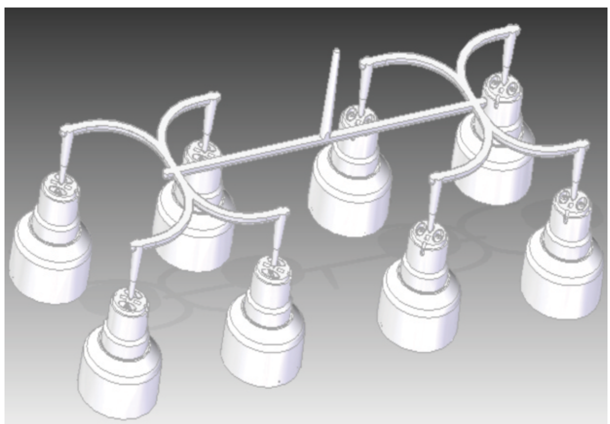

Fig. 8 Cold runner gating (Part 2)

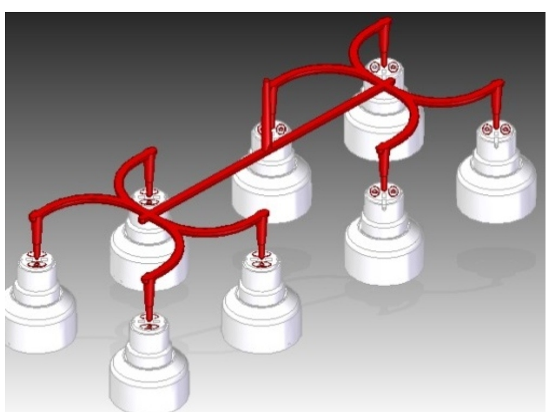

Fig. 9 Hot runner gating (Part 2)

Table 2 shows the operations which are required to keep the mould in running condition alongside their frequency.

Operation	Cold runner frequency (no of shots)	Hot runner frequency (no of shots)
1) Need to replace core / cavity insert	3 lakh	5 lakh
2) Need to replace pillar bush of mould	3 lakh	5 lakh
3) Need to place tip insulator	N/A	5 lakh
4) Need to replace valve stem to prevent from wear tear	N/A	5 lakh
5) Need to replace all seal in mould to prevent from water leakage because leakage can damage heater	N/A	2 lakh
6) Need to purge from plastic material after production to prevent from blockage in hot runner	N/A	yes
7) Need to clean air channel for proper flow of air	N/A	2 lakh
8) Need to clean the solenoid valve after 1lakh shot	N/A	1 lakh
9) Need to clean valve stem	N/A	1 lakh
10) approx. mould life	5 lakh	10 lakh

1) Part Quality*:* The quality of the parts is analyzed by checking for the following defects:

· *Short Shot*- Failure to completely fill the mold or cavities of the mold is called short shot. Edges may appear melted in this defect [8].

· *Sink marks*- An indentation on the surface of the part as a result of significant local change in wall section is a sink mark. The mark will occur in the thicker area.

· *Voids*- These are the unfilled spaces within a solid material.

· *Flash*- Flash refers to any excess material that is formed with and attached to the component along a seam or mold parting line.

In this experiment, the total rejections in a month were recorded and they were classified into various defects. Table 3 shows the respective rejections. Care was taken to use fresh raw material to prevent any aging effect on polymer to interfere in the findings [9].

3) Cycle Time And Speed Of

Table 3. Rejection status

Operated Machine	Part 1		
	Average Rejections (parts/hour)	Total (parts/hour)	Rejections (percentage)
Hot Runner	6	2880	0.208
Cold Runner	10	1296	0.772
Operated Machine	Part 2		
	Rejections (parts/hour)	Total (parts/hour)	Rejections (percentage)
Hot Runner	5	1440	0.347
Cold Runner	7	648	1.080

The relative proportions of the different defects are shown by the graphs (Fig. 10 and 11).

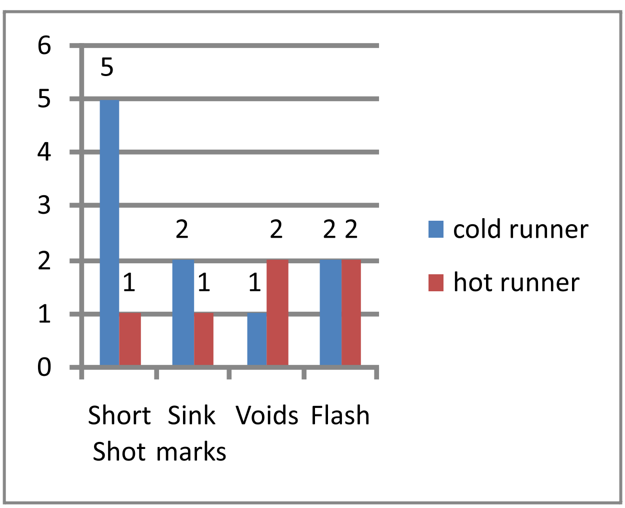

Fig. 10 Part Quality chart (Part 1)

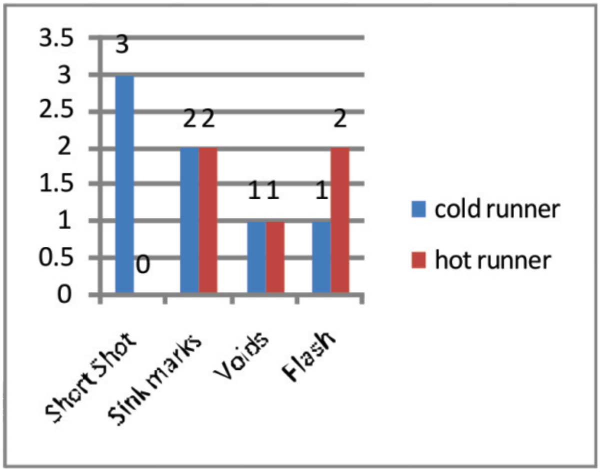

Fig. 11 Part Quality chart (Part 2)

production: In calculation of cycle time, the time (in seconds) for the molding operation and the production of 22 hours per day is calculated and the results are tabulated. Table 4 shows the time taken by the machines for both components and Table 5 gives the respective production per day.

4) Return of Investments in batch

Table 4.Cycle time

Operated Machine	**Time for Part 1 (sec)**	**Time for Part 2 (sec)**
Hot Runner m/c	18	20
Cold Runner m/c	40	40

Table 5. Max. Production Capacity

Operated Machine	Part 1 production/day	Part 2 production/day
Hot Runner	63360	31680
Cold Runner	28512	14256

production: The production study is carried out for a time period of 22 hours with the actual cost per piece calculated by using raw material cost, machine running cost, mould maintenance cost and the special hot runner maintenance cost. This is given as in table 6.

4. Results

Table 6.Cost analysis

Costing Factor	Hot Runner		Cold Runner	
	16 drop H/R (Part 1)	8 drop H/T (Part 2)	16 drop C/R (Part 1)	8 drop C/T (Part 2)
No of Shots/hour	200	200	90	90
Net WT. (Shot) (grams)	80.00	72.00	80.00	72.00
Runner Wt./shot (grams)	0.00	0.00	82.40	84.00
Gross Wt./Shot (grams)	80.00	72.00	162.40	156.00
RMC cost/ Piece (Rs) (A) @ Rs 135.0/kg	0.68	1.22	1.37	2.63
M/C Running cost @ Rs 200/Hours) (B)	0.09	0.17	0.19	0.39
Labor Cost @ Rs9000/Month/12Hours (C)	0.26	0.26	0.26	0.26
Mould Maintenance Cost/Piece (Rs) (D)	0.03	0.03	0.03	0.03
Hot Runner Maintenance cost/Piece (Rs) (E)	0.05	0.05	0	0
Actual Cost/Piece (Rs)(A+B+C+D+E)	1.11	1.73	1.85	3.31
Actual Cost per Day(@50K pcs per day)	55,500	86,500	92,500	1,65,500
Saving per day with Hot runner Mould	92,500+1,65,000-55,500-86,500=1,15.500			

From each criteria considered, the results are collected which depict the performance of the two molding machines.

In **Machine Performance and Maintenance** test, it is found that there are many maintenance operations of replacing and cleaning in hot runner moulds which are not required in the simple construction of cold runner moulds. However, the expected working life of hot runner moulds is nearly double as compared to the old runner moulds which accounts for their high productivity and endurance.

In **part quality** test, the production of one month duration was taken to account for all types of variations in the moulding processes. It is clearly established from the process data that the rejection rate is approximately one third of the rate evidenced in the case of cold runner systems.

Under the **Cycle time** criteria, it took 18 sec and 20 sec to produce part 1 and part 2 respectively in the hot runner machine. For the cold runner machine, the cycle time is 40 sec for both parts. This, it is clear that hot runner technology is almost twice as fast as its counterpart.

For the purpose of return on investment calculations, the additional investment is calculated as given in table 7 and divided by the total savings with hot runner worked out in table 6. The resultant number shows the ROI in days which in this case has come about 90 days that is 3 months.

These four criteria put together make

Table 7. Actual cost

	Hot runner	Cold Runner
Mould Cost part-1	50 Lakhs	5 Lakhs
Mould Cost part-2	50 Lakhs	5 Lakhs
Total investment	100 Lakhs	10 Lakhs

hot runner a resource efficient injection moulding with low environmental impact [10].

5. Conclusions

In this work, a four criteria analysis is used to study the hot runner and cold runner injection molding systems to facilitate sound supply chain management decisions. Two functionally interdependent parts of an electrical assembly are manufactured using the two types of molding systems and the data on their performance and their properties is collected. This was done in an industrial environment and setting to simulate real life and dynamic conditions during production. The study has achieved its prime objective of highlighting the various advantages and limitations of hot runner and cold runner technologies and comes to the conclusion that for the considered part and parts of similar dimensions, hot runner moulds are more effective in mass production. While there is no appreciable difference in the quality of parts produced by the two systems, lower injection pressures, rapid production and no material wastage in hot runner moulds make them ideal for such situations. The material and time savings can amount to over 50 to 100 percent. The study also suggests from experimental observations that the product formed through hot runner systems shows enhanced properties than its counterpart in melt flow and coloration. But the cold runner moulds are very cheap as compared to hot runner ones and for supply chains involving small scale industries, the hot runner technology is not feasible due to their large initial costs.

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REPRODUCTION AND ACHIEVEMENT APPRAISAL OF LEE MODEL BELOW THE URBAN, SUBURBAN AND RURAL ATMOSPHERE

Vimal Patel

[1]Student, L.D.College of Engineering, Ahemdabad, Gujarat- India
vimalme2510@gmail.com

Abstract

Mobile radio conversation in mobile radio take place between a fixed base station (bs) and mobile stations (ms). From the research that have been taken place over the years, those involving characterization an modeling of the radio procreation channel are amongst the most important and fundamental. The procreation channel is the principal contributor to many problems and limitations the best mobile radio systems. One obvious example is multipath procreation which is the major characteristic of mobile radio channels. It is caused by diffraction and scattering from terrain features and buildings, that leads to distortion in analogue communication systems and severely affects the achievement of digital systems by reducing the carrier –to-noise and carrier-to interference ratios. A physical below standing on mathematical modeling of the channel is very important because it facilitates more accurate prediction of system achievement and provides the mechanism to test and evaluate methods to see the effects caused by the radio channel. The main objective of this paper to develop LEE procreation prediction model (GUI based) to interface using MATLAB software. With this reproduction, hope that this interface can be one of the friendly interface to the user.

Keywords: FSPL, Okumura Model, Cost 231 Model, SUI Model, ECC-33 Model, Cost 231 W-I Model, Ericsson Model

I: Introduction

By connecting examine and empirical methods the procreation models are derived. Procreation models are used for arithmetic of electromagnetic field courage for the purpose of wireless system planning during prior deployment. It describes the signal attenuation from transmitter to receiver antenna as a function of distance, carrier frequency, antenna heights and other significant parameters like terrain profile (e.g. urban, suburban and rural).

II: Path Loss

*A*free Space Path Loss Model (FSPL):. Free Space Path Loss Model (FSPL):Path loss in FSPL defines how much courage of the signal is lost during procreation from transmitter to receiver. FSPL is diverse on frequency and distance. The arithmetic is done by using the

$$PLfs = 32.45 + 20\log10(d) + 20\log10(f)\,[dB] \quad (1)$$

following equation. where *d* is in km and *f* is in MHZ

B. Okumura Model

Okumura's model is used to predict the path loss in suburban and rural

$$PL = PLfs + Amn(f,d) - G(hb) - G(hm) - Garea \quad (2)$$

atmosphere

where, Amn(f,d) is the median attenuation relative to free space,

$$G(hb) = 20 \cdot \log10\left(\frac{hb}{200}\right) \quad for\ 10m < hb < 1km \quad (3)$$

$$G(hm) = 20 \cdot \log10\left(\frac{hm}{3}\right) \quad for\ hb \leq 3m \quad (4)$$

$$G(hm) = 10 \cdot \log10\left(\frac{hm}{3}\right) \quad for\ 10m < hb \leq 1000m \quad (5)$$

Garea is the gain due to the type of environment, extracted as in [1][2]

c*COST-231 Hata Model*

This model is derived by modifying the Hata model, and is used in urban, suburban and rural atmosphere

$$PL = 46.3 + 33.9 \cdot \log10(f) - 13.8 \quad (6)$$
$$+ (44.9 - 6.55 \cdot \log10(hb)) \cdot \log(d) + s - a(hm)$$

.Scenario 1: Urban Cost-231 Path loss (7)

$$PL = PLUrban - 2 * (\log\left(\frac{f}{28}\right)^2 - 5.4$$

Scenario 2: Suburban Cost-231 Path loss

Scenario 3: Rural Cost-231 Path loss

PL =PLUrban
4.78(log10(f))²+18.33log10(f)- 40.98
(8)

MS antenna correction factors a(hm) for all is:
a(hm)=(1.11log10(f) -0.7)hm-(1.56 log10(f) - 0.8) *(9)*

The path loss exponent for the predictions done by COST-231Hata model is given by:

α = (44.9 - 6.55log10 (hb)) / 10 *(10)*

D. Stanford University Interim (SUI) ModelIEEE 802.16 Broadband Wireless Access working group proposed the standards for the frequency band below 11 GHz containing the channel model developed by Stanford University, namely the SUI models. This prediction model comes from the extension of Hata model with frequency larger than 1900 MHz. The correction parameters are allowed for (11) 900 MHZ band.

The basic path loss expression of The SUI model with correction actors is presented as:

PL=A+10 γ log10(d/do)+Xf+ Xh+S for d > do

The random variables are taken through a statistical procedure as the path loss exponent γ and the weak fading standard deviation S is defined. The log normally distributed factor s, for shadow fading because of trees and other clutter on a procreations path and (12) its value is between 8.2 dB and 10.6 dB

$$\gamma = a - b \cdot hb + \left(\frac{c}{hb}\right)$$

The parameter A is defined as

A=*20log10(4πdo/ λ)*

and the path loss exponent

Table 1: The parameter values of different terrain for SUI model

The value of parameter γ = 2 for free

Model	Terrain	Terrain	Terrain
a	4.6	4.0	3.6
b(1/m)	0.0075	0.0065	0.005
c(m)	12.6	17.1	20

space procreation in an urban area, 3 < γ < 5 for urban NLOS environment, and γ > 5 for indoor procreation

The frequency correction factor Xf and the correction for receiver antenna height X*h* for the model are expressed in [3]:

Xf=6.0log10(f/2000) (14)

Xh=-10.8log10(hr/2000) for terrain type A and B (15)

*Xh=-20*log10(hr/2000) for terrain type C (16)*

For the above correction factors this model is extensively used for the path loss prediction of all three types of terrain in rural, urban and suburban atmosphere.

E. *Hata-Okumura extended model or ECC-33 Model*

One of the most extensively used empirical procreation models is the Hata-Okumura model [3], which is based on the Okumura model. This model is a well-established model for the Ultra High Frequency (UHF) band.The tentatively proposed procreation model of Hata-Okumura model with report [3] is referred to as ECC-33 model. In this model path loss is given by:

PL=Afs + Abm –Gb- Gr (17)

Where

Afs : Free space attenuation in dB

Abm: Basic median path loss in dB

Gb : Transmitter antenna height gain factor

Gr : Receiver antenna height gain factor

These factors can be separately described and given by as:

$$Afs = 92.4 + 20\log_{10}(d) + 20\log_{10}(f) \quad (18)$$

$$Abm = 20.41 + 9.83\log_{10}(d) + 7.894\log_{10}(f) + 9.56[\log_{10}(f)]^2 \quad (19)$$

$$Gb = \log_{10}(hb/200)\{13.958 + 5.8[\log_{10}(d)]2\} \quad (20)$$

Gr = [42.57 + 13.7log10(f)] [log10 (hr)-0.585] (21)
for large city
Gr = 0.759hr-1.862 (22)
where,
d: Distance between transmitter and receiver antenna in m
f: Frequency in GHz
hb: Transmitter antenna height in m
hr : Receiver antenna height in m
In our analysis, we consider the medium city model is appropriate for European cities.

F COST 231 Walfish-Ikegami (W-I) Model

This model is a combination of J. Walfish and F. Ikegami model. The COST 231 project further developed this model. Now it is known as a COST 231 Walfish-Ikegami (W-I) model. This model is most suitable for flat suburban and urban areas that have uniform building height .The equation of the proposed model is expressed in [3]:

For LOS condition
Pllos =42.6 + 26 log10(d) +20log10(f) (23)

and for NLOS condition
PLnlos= Lfsl+ Lrts + Lmsd for urban and suburban (24)

PLnlos= Lfs if Lrts + Lmsd > 0 (25)

Where, Lfs*l* = Free space loss
Lrts = Roof top to street diffraction
Lmsd = Multi –screen diffraction
free space loss [4];
Lrts = -16.9 -10log(w) + 10log(f) +20 log(hmobile)+ Lori for hroof > h mobile (27)
Lrts =0 (28)
where
Lori = 10 + 0.354φfor 0 <= φ < 35 (29)
=2.5 + 0.075(φ-35)for 35 <= φ < = 55 (30)
= 4-0.114(φ -55) φ for 55 <= φ <= 90 (31)

G. Ericsson Model

To predict the path loss, the system planning engineers are used a software provided by Ericsson company is called Ericsson model. This model also stands on the modified Okumura-Hata model to allow room for changing in parameters according to the procreation environment. Path loss according to this model is given by

*PL=ao+a1*log10(d)+a2*log10(hb) +a3*log10(hb)log10 (d)-3.2(log10(11.75*hr) 2)+g(f) (32)*
G(f) = 44.49 log10(f)–4.78(log10(f)) ^{2} *(33)*

Table2:Values of parameters for Ericsson model

The value of parameter ao and a1 in suburban and rural area are based on the Least Square (LS) method

Environment	ao	a1	a2	a3
Urban	36.2	30.2	12.0	0.1
Suburban	43.20*	68.93*	12.0	0.1
Rural	45.95*	100.6*	12.0	0.1

H.Lee Model

Named after W.C.Y. Lee, Lee model is relatively simple and intuitive to use and it is characterized by its aptitude to achieve good prediction accuracy. In addition, its prediction can be significantly improved by the incorporation of measurement data. In the beginning, the Lee model was developed for use at 900 MHz and has two modes: area-to-area and point-

(A)path Loss in Urban Area

to-point. The Lee model is a modified power law model with correction factors for antenna heights and frequency and has the ability to be easily customized to the local environment. A typical application involves taking measurements of the path loss in the target region and then adjusting the Lee model parameters to fit the model to the measured data. This empirically derived path loss model is parameterized by Pr_0, the power at the 1-mile point of interception, and γ, an experimentally determined path loss slope

$$Pr = 10\log_{0}[Pr_0(r/r_0)^{-\gamma}(f/f_0)^{-n}\alpha_0] \text{ [dBm]}$$

Where:

Pr= field courage of the received signal at a distance r from the transmitter

Pr_0: received power at 1 mile (1.6 km)

r:distance between MS and BS antennas

r_0:1 mile (1.6 km)

γ:path loss slope (experimentally determined)

f: actual carrier frequency

f_0: nominal carrier frequency,(= 900 MHz)

n:empirically derived exponent depends on geographical locations and operating frequency ranges. $2 \leq n \leq 3$

α_0:correction factor accounts for antenna heights, transmit power and antenna gains which differ from nominal values

n=3 for an urban area with f > 450 MHz and n=2 is recommended for a suburban or open area with f < 450 MHZ.

III: **Reproduction of Models**

In our computation, LEE established empirical mathematical relationships to describe the graphical information given by W.C. Y. LEE formulation is limited to certain ranges of input parameters.

The mathematical expression and their ranges of applicability are as follows:

Carrier Frequency: 1 MHz ≤ fc < 900 MHZ

BaseStation(BS)AntennaHeight:1m≤ hb < 30.8 m

Mobile Station (MS)AntennaHeight:1 m ≤hm < 3 m

Transmission Distance: 1 km ≤d < 20 km

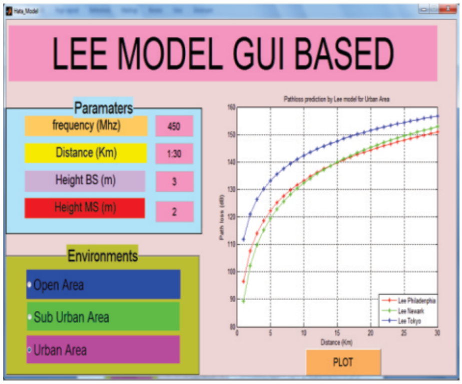
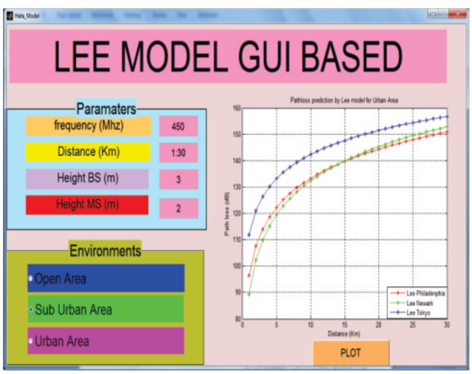


Figure1.Path loss in urban environment

(B) Path Loss in Suburban Area

Figure2.Pathloss in suburban environment



© Path Loss in Open Area

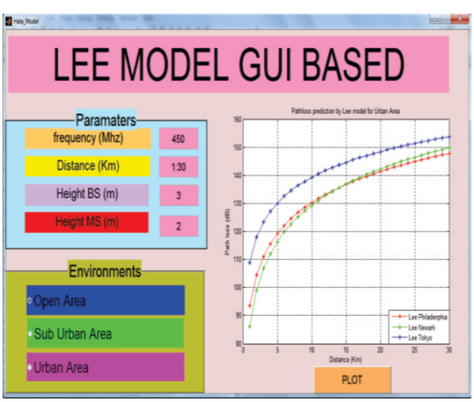


Figure 3 Path loss in open environment

IV: Conclusions

Several predictions method has been described in his paper. They all aim to predict the median signal courage either at a specified receiving point or in a small area. Receiving point methods are needed for point-to-point links whereas small area methods are useful for base-to-mobile paths where the precise location of the receiver is not known. All of these methods have been available for many years and have stood the test possibly with modification and updating. They differ widely in approach, complexity and accuracy. But sometimes, when it comes to accuracy, no one method outperforms all others in all conditions. Statistical methods are based on measured and average losses along typical classes of radio links. Deterministic methods based on the physical laws of wave procreation are also used Ray Tracing is such one method. These methods are expected to produce more accurate and reliable predictions of the path loss than the empirical methods. However they are significantly more expensive in computational effort and depend on the detailed and accurate description of all objects in the procreation space such as buildings, roofs, windows, doors and walls. For these reasons they are used predominantly for short procreation paths. Every procreation models has its own advantage and disadvantage. Choosing a method appropriate to the specific problem below consideration is a vital step in reaching a valid prediction.

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THE STATE OF ART ANALYSIS ON ELECTRONIC LICENSE PLATE ACCEPTANCE

Rinku Solanki
(M. Tech in Digital Communication, N.R.I. Collage, Bhopal, India)
rinkusolanki86@gmail.com

Abstract:

Every country uses their own way of crafty and apportions number plates to their country vehicles. This license number plate is then used by many government offices for their specific regular administrative task like- traffic police recording the people who are contravening the traffic rules, to analyze the theft cars, in toll collection and parking allocation management etc. In India all motorized vehicle are assigned unique numbers. These numbers are assigned to the vehicles by district-level Regional Transport Office (RTO). In India the license plates must be kept in both front and back of the vehicle. These plates in general are easily readable by human due to their high level of intelligence on the contrary; it becomes an extremely difficult task for the computers to do the same. Many attributes like illumination, blur, background color, foreground color etc. will pose a problem.

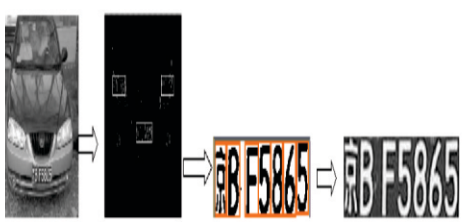
Nowadays vehicles play a very big role in transportation. Also the use of vehicles has been increasing because of population growth and human needs in recent years. Therefore, control of vehicles is becoming a big problem and much more difficult to solve. The presence of noise, blurring in the image, uneven illumination, dim light and foggy conditions make the task even more difficult. Nowadays, intelligent transportation systems (ITSs) have a significant impact on people's lives. ITSs include intelligent infrastructure systems and intelligent vehicle systems. In the current information technology era, the use of automations and intelligent systems is becoming more and more widespread. Vehicle number plate acceptance (VNPR) has turned out to be an important research issue. VNPR has many applications in traffic monitoring system, including controlling the traffic volume, ticketing vehicles without the human control, vehicle recording, policing, security, and so on. In this paper categorize different ELPA techniques according to the features they used for each stage, and compare them in terms of pros, cons, acceptance accuracy and processing speed.

Keywords— Electronic license plate acceptance (ELPA) system, literature analysis, reference.

Introduction

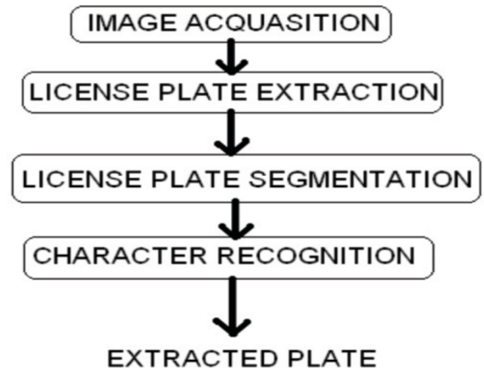
The purpose of this paper is to provide researchers a systematic survey of existing ELPA research by categorizing existing methods according to the features they used, by analysing the pros/cons of these features, and by comparing them in terms of acceptance performance and processing speed, and to open some issues for the future research.

Basic block diagram of the ELPA system is shown in **fig 1**.for above steps different techniques used by different author which are studied in literature analysis. An example of the number plate extraction is given by figure (2).by this figure block diagram is easily understand, in this figure all steps of block diagram is shown by indicating number A,B,C,D,E.



Figure(2)an Example of Extraction of Number Plate

Electronic license plate acceptance (ELPA) applies image processing and character acceptance technology to analyze vehicles by electronically reading their number plates. and this system mainly divide in three steps:



Figure(1)basic blockdiagram of elpa System

Step(1)image Acquisition, in image acquisition explained that from where images are acquire Image can be input to the system by different methods by analog camera, or by digital cameras, but nowadays digital technology has their advantages so better input method is by digital cameras or by direct digital photos.

figure(a)captured image

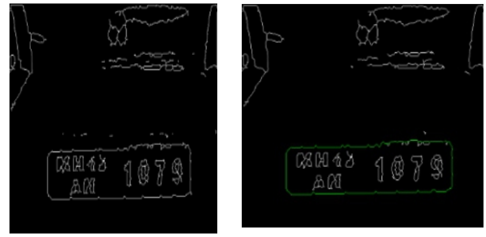
Step(2)licensePlate Area Extraction by whole capturing image we having license plate covered by background of vehicle body,so by this step only plate are is extracted from whole body. our task now is to analyze the region containing the license plate. In this experiment, two features are defined and extracted in order to decide if a candidate region contains a license plate or not , these features are

1. Aspect Ratio: The aspect ratio is defined as the ratio of the width to the height of the region.

Aspect Ratio = width/height

Since the minimum enclosing rectangle(MER) of the object region can be computed via rotating the region in previous section, the dimension of the objects MER can be taken as the width and the height of the region

2. Edge Density: Applying the above feature to filter the segmented regions, a lot of no license plate regions can be removed. However, there are still many candidate regions left which take similar rectangularity and aspect ratio features as the license plate regions do, such as often the head lights. Considering that the license plate regions generally take higher local variance in its pixels‟ values due to the presence of characters, an important feature to describe license plate region is local variance, which is quantized using the edge density.so extracted plate region example shown in figure(b).



figure(b)licenseplate area extraction

Step(3)character Segmentation: by this step characters on license plate are segmented and analyze. This step is the most important step in license plate acceptance because all further steps rely on it. This is the second major part of the License Plate detection algorithm. There are many factors that cause the character segmentation task difficult, such as image noise, plate frame, rivet, space mark, plate rotation and illumination variance. We here propose the algorithm that is quite robust and gives significantly good results on images having the above mentioned problems. for the segmentation pre-processing is required by conversion to gray scale and binarization. Different algorithms are used for segmentation which are explained further later in literature analysis. segmented license plate example is given in figure©

.figure(c)segmented License Plate

Step(4)license Plate Number Recognize: by number plate extraction step final result is founded. Consider figure(d) as an final extracted license plates

Figure(d) License Plate Number Recognize

The **variations of the plate types** or environments cause challenges in the detection and acceptance of license plates. They are summarized as follows:

1) Location: Plates exist in different locations of an image.
2) Quantity: An image may contain no or many plates.
3) Size: Plates may have different sizes due to the camera distance and the zoom factor.
4) Colour: Plates may have many characters and background colours due to different plate types or capturing devices.
5) Font: Plates of different nations may be written in different fonts and language.
6) Occlusion: Plates may be obscured by dirt.
7) Inclination: Plates may be tilted.
8) Other: In addition to characters, a plate may contain frames and screws.

Environment Variations:

1) Illumination: Input images may have different types of illumination, mainly due to environmental lighting and vehicle headlights.
2) Background: The imagebackground may contain patterns similar to plates, such as numbers stamped on a vehicle, bumper with vertical patterns, and textured floors.

Literature Analysis

In the literature, many license plate detection algorithms have been proposed. Although license plate detection has been studied for many years, it is still a challenging task to detect license plates from different angles, partial occlusion, or multiple instances. License plate detection investigates an input image to analyze some local patches containing license plates. Since a plate can exist anywhere in an image with many sizes, it is infeasible to check every pixel to locate it. Generally, it is preferable to extract some features from images and focus only on those pixels characterized by the license plate. Based on the involved features, traditional license plate detection methods can be classified into three categories: colour-based, edge-based, and texture-based. In what follows, we will analysis the related work in each category Colour-based approaches are based on the observation that some countries have specific colours in their license plates. It is intuitive to extract license plates by locating their colours in the images the collocation of license plate colour and character colour is used to generate an edge image. Then, it checks neighbours of pixels with a value within the license plate colour range to find candidate license plate regions Edge-based approaches are the most popular, with reliable performance in license plate detection. Generally, as a prior, license plate is characterized by a rectangular shape with a specific aspect ratio, and can be extracted by checking all possible rectangles in the image kinds of traditional locating methods, some other approaches based on local features have been proposed recently. A brief description of some of previous works is demonstrated in section of literature introduction.

In[1],license plate acceptance methods are:(1)Image Acquisition: By digital camera (2) License Plate Extraction: *vertical edge detection by sobel algorithm *filtering by seed filling algorithm *vertical edge matching(3)Segmentation: (4) Character Acceptance: * Normalization * Template matching using hamming distance approach. and by this paper referenced getting the result like: License Plate Extraction: 587/610, 96.22% License Plate Segmentation: 574/610, 94.04% License Plate Acceptance :581/610, 95.24%,and over all system efficiency: 95%.this approach having some problem in extracting the plate, diplomatic cars and military vehicles, are not addressed since they are rarely seen. Detection only for white, black, red, and green color plate or numbers.

By[2], (1)Extraction of plate region: edge detection algorithms and smearing algorithms (2)segmentation of Characters: smearing algorithms, filtering and some morphological algorithms (3)acceptance of plate characters : template matching. Final output it is proved to be %97.6 for the extraction of plate region, %96 for the segmentation of the characters and %98.8 for the acceptance unit accurate, giving the overall system performance %92.57 acceptance rate .it having some limitation like it acceptance of car license plate only, and This system is designed for the identification of Turkish license plates.

In[3],acceptance steps are as follow:(1)Image Enhancement: by histogram equalization method (2)Structuring Elements : by thickening, (3) Hat transformations: which is use for contrast, enhancement(top has & bottom has)setting (4) Morphological Operations like dilation and erosion (5) Plate region confirmation (6) Character Segmentation and Acceptance by neuron implementation model .by this reference 250 color images were used for testing the technique, These results report a high accuracy rate of above 95%.Although the technique is quite efficient enough to work very well in the real time environment but currently the technique proposed lays more emphasis on the accuracy of the overall system, while the some more work is to be done to make the technique more efficient.

In[4],acceptance by(1) Target acceptance: by using feature-salience theory, features of license plates(include shape, symmetry , height-to-width ratio , colour, texture, and spatial frequency, Character features include lines, blobs , aspect ratio of characters, distribution of intervals between characters ,and alignment of characters) (2license plate locating by Hough transform (HT). (3) recognizing license characters by different steps like binarization, noise removal, and orientation adjustment, Optical Character Acceptance. in this paper , the success rate for the identification with the set of 1144 license plates is 95.7%. Combining this rate with the location success (97.3%), the overall rate of success for our LPR algorithm is 93.1%.As pointed out in the preceding sections, although this system is intended for the acceptance of Chinese license plates only .

By[5], mainly focused on Edge Detection(Sobel Edge Detection)technique and then filtering of noise by Median Filter, Smoothing, Connector, Masking, ,and then Colour Conversation is done. we can see that the detection is not that clear and proper, which we find , is due to improper light segment or varying illumination effects. and all over system result is not mention in this paper.

In the reference[6], The proposed algorithm consists of three major parts: Extraction of plate region, segmentation of characters and acceptance of plate characters. For (1)extracting the Plate region, edge detection algorithm and vertical projection method are used.(2) in segmentation part filtering, thinning and vertical and horizontal projection are used. And finally, (3)chain code concept with different parameter is used for acceptance of the characters. The performance of the proposed algorithm has been tested on real images. Total Vehicles Images 150(tested under sunny, cloudy, daytime, nigh time, rainy days...etc atmosphere), Extracted license plates147 Unsuccessful Extraction 3 .and final system Efficiency : 98%. The proposed method is mainly designed for real-time Malaysian license plate, and can be readily extended to cope with license plates of other countries, especially those using Latin characters.

By[7],involve three approaches: (1)in plate localization Noise alleviation, Changing colour space, Intensity dynamic range modification, Edge detection ,Separating objects from background, Finding connected component ,Candidate selection, all above process are used (2) in segmentation part multistage model re used.(Improvement,Rotation,Binarization,SegmentationSegmentation,Preparation,)(3)for the acceptance artificial l1Feed forward neural network is used.

The method achieved accuracy over 91% for localizing plates. The acceptance system implemented by neural networks after segmentation of characters in image plate analyze alphabets and numbers separately and achieve an accuracy over 97% and 94% specificly for each. Advantage of this approach is The image database includes images of many vehicles with different background and slop under varying illumination condition and the disadvantage is detection only for English and Parisian number plate.

In[8] For the Number plate acceptance first image conversion in binary and apply to neural network, and apply mpl algorithm, then detection individual symbol, by matrix mapping, and Training by this approach obtained 96.53% average acceptance rate using double hidden layer and 94% using single hidden layer. The captured image 2-3 meters taken away from the cameras.

By[9] (1)Pre-processing of Image by histogram equalization(2)Extraction of plate region by edge detection algorithm(canny operator) and Plate Area Detection by many morphological operations (3)Segmentation of characters by *connected component *bounding box method , *Median filter, all above methods. and observed final result as Extraction :71/78 which gives 91.02% efficiency ,Segmentation 69/78 which gives 88.46%efficiency. overall accuracy of ursystemis 74%.proposed method is sensitive to the angle of view, physical appearance and environment conditions.

By[10] Given All 3 process by 2D Haar after the discrete wavelet Transform technique : (1)locate and extract the license-plate (2)train of the license-plate (3)real time scan recognize of the license-plate .by this paper result shown are as given, Ve hicle acceptance number:100,Acceptance number of successful:93 ,Acceptance number failed :7 ,Acceptance rates (%) :93.0%.advantage of this approach is Haar Discrete Wavelet Transform are that it each time transform only needs 1/4 of the original image. Hence, this method can fast execution speed. and the Disadvantage is that in this paper only specified cameras used like Using the CASIO EXILIM, 10.1 MEGA PIXELS DIGITAL CAMERA EX-S10, adjusting the resolution 480 x 640 for photography vehicle license plates, In[11] detection steps are :(1)Image acquisition by capturing an image of a vehicle from video (2)License plate detection extraction, by Spectral Analysis Approach and Connected Component Analysis (3)extract the region of license plate process use spectral analysis (4)Character segmentation use Connected component analysis approach and SVM feature extraction techniques. the advantage of this approach is success full acceptance of a moving vehicle.

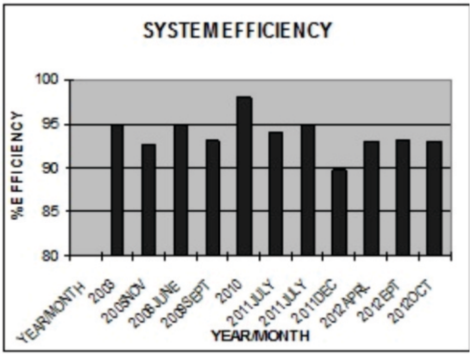
By[12] (1)PVW approach is used in this orientation, ratio of scale to character height, and relative position in the character region are done by clustering (2)visual word matching by comparing the extracted SIFT features and histogram approach is used (3) for license plate location A bounding box will be estimated to encompass license plate by determining the upper, lower, left, and right bounding lines sequentially. This technique achieves a 93.2% “true” detection rate. This approach can also be extended to the detection of logos and trademarks .The weakness of this approach is that it may fail when the license plate resolution is too low, or when the distortion from the observation angle is too severe.
Approach explained in[13] that, (1) detect a license plate region by vertical or a horizontal edge based method (2) pre-processing: is also needed in this approach .so first converted in to binary image then eliminate noise using morphological operation (3) character segmentation by thresholding method (4) feature extraction and character acceptance by Euler number formation .Advantage of this approach that skew ness is not present in the detected vehicle number plate compare to other methods and Disadvantage is it limits the efficiency of the total system.

By[14] (1)plate extraction by Mathematical Morphology approach and then ,Dilation and Erosion is apply to image,(2)segmentation by Structuring Elements approach, Meredian Filter technique and Edge Detection Methods are use,(3)character extraction by Preprocessing, Text/non-text classification approach .result derived by this paper is as given, Real Time Data:100,Images correctly Detected:93,Results Accuracy 93%.and it says that Very much damaged plate can not be recognize.

YEAR/MONTH	% EFFICIENCY
2003	95
2005NOV	92.57
2008JUNE	95
2009SEPT	93.1
2010	98
2011JULY	94
2011JULY	95
2011DEC	89.74
2012APRL	93
2012EPT	93.2
2012OCT	93

Figure(3)tableof%efficiency/month Or Year

As per literature study all over system efficiency per month/year as given by chart figure(4) which is vary according to methods for different steps for reconditioning of license plate.by the given plot we can observe percentage efficiency of system as per given data.As per given data in studied references making of table which shows %efficiency per month/year ,so consider the table for plot



Figure(4)overAllSystem%Efficiency/year

Conclusion:

In general, an ELPA system consists of four processing stages. In the image acquisition stage, some points have to be considered when choosing the ELPA system camera, such as the camera resolution and the shutter speed. In the license plate extraction stage, the license plate is extracted based on some features such as the colour, the boundary, or the existence of the characters. In the license plate segmentation stage, the characters are extracted by projecting their colour information, by labelling them, or by matching their positions with template. Finally, the characters are recognized in the character acceptance stage by template matching, or by classifiers such as neural networks and fuzzy classifiers. Electronic license plate acceptance is quite challenging due to the different license plate formats and the varying environmental conditions. There are numerous ELPA techniques have been proposed in recent years.

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EXPERIMENTAL ASSESSMENT OF WASTE VEGETABLE OIL AS ALTERNATIVE DIELECTRIC FLUID IN ELECTRIC DISCHARGE MACHINING

Nitesh Kμmar [1*], Manoj Kumar [2]

(Assistant professor, Department of Mechanical and Automation Engineering,
HMR Institute of Technology and Management, Delhi
nitesh.kmr.sngh@gmail.com *, manozme@gmail.com

Abstract:

Electric-Discharge Machining (EDM) process has seen major development in terms of quality and quantity in recent time. The dielectric fluid plays an important role in concentrating the plasma channel over the machining area and removes debrises from the machining area. This dielectric although important for the process still it is a major source of pollution to the environment and causes carcinogenic problem to the operator in long term usage. The castoff edible vegetable oil is discarded into environment after series of cooking cycles once the oil double bonds starts breaking into single bonds leading to its saturation. Similarly, waste vegetable oils such as jatorpha, linseed, etc. obtained from forest tree and plants can be found from local markets and have limited usage. The EDM electric properties required like viscosity and breakdown strength are in the range for these oils also but rare studies have been done in using such oils as EDM dielectric. This work reports, a comparative study of use of conventional hydrocarbon oil, waste vegetable oil, and castoff edible vegetable oil in EDM of Inconel 718. The effects of various parameters viz. current, pulse-on-time, and duty factor on volumetric removal rate, electrode wear rate, and surface finish are analyzed.
Preliminary experimental result shows that waste vegetable oil or cast off vegetable oil could be an alternative dielectric for green EDM process.

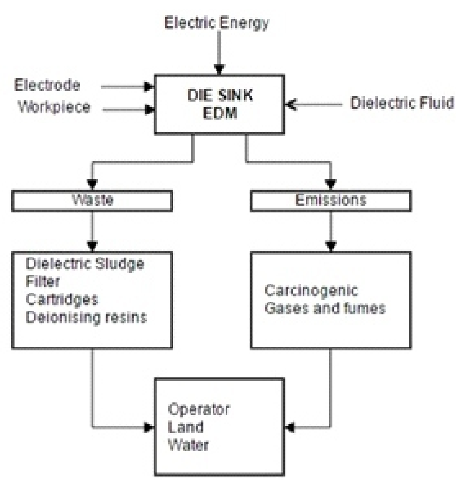
Keywords: Electric Discharge Machining, Waste vegetable oil, Castoff edible vegetable oil, Green Dielectric, Environmental Impact.

1. Introduction

The rapid development in the field of metal manufacturing sector results in development of alloys having inherent properties of hardness and strength. These properties increases the application area and makes the alloys hard to machine with conventional machining process as well. Electric-Discharge Machining (EDM) is most vital non-conventional machining process used to machine these hard to machine alloys, accounts for more than 7% market share in machining processes[1].Since 1943, when two Russian scientist B.R. Lazarenko and N.I. Lazarenko[2] reported the ability of EDM considerably improve its machinability when the machining area is immersed in dielectric medium rather than machining it dry most of EDM is done in a dielectric medium. This process have variant like Die sinking EDM, wire cut EDM, electric-discharge drilling, electro-discharge milling [3], electro-discharge grinding [4], electric-discharge texturing [5], electric-discharge coating [6], electro discharge deposition. Initially limited to electrically conductive materials, researcher also reported machining of insulating material ceramics [7] and composites [8].

Pulse current, Pulse on time, Pulse off Time, dielectric used are decisive element of EDM performance. Pulse current, Pulse on time, dielectric governs the machining capability and process stability whereas dielectric deals with the operator health and environmental concern of the process. The dielectric performs most of the vital function viz. concentrating and maintain ionization channel, carrying away the heat and debrises and maintaining insulation between workpiece and electrode. As the dielectric breakdowns it emits various gases which are reported to be of carcinogenic nature [9]. It has been reported that oil based dielectric emits aerosol, metallic particles, carbon dioxide, carbon mono-oxide, butyl acetates[10] and water based releases carbon mono-oxide, nitrogen oxides, metallic particles, chloride creating a hazardous zone near machine. Effects of EDM component on environment are shown in Fig.1

Many researches have been reported regarding better machining capabilities but for environmental concern are listed to few only. Some researchers suggest tap water [11], deionised water with additives [12], as an alternative of Conventional Hydrocarbon Oil (CHO) to minimise environmental impact without any significant effect on machining capabilities. However, some researcher also suggest use of gaseous dielectric viz. helium or argon [13] and air or Oxygen [14] to minimise environmental impact



.fig. 1: Environmental Effect of Edm Components

1.1sustainable Edm Process

Sustainability process could be defined as “a process which is employed to diminish the negative effects on environment, sustain energy and natural resources, to ensure safety to the society and economically intact”. It can be improved by minimising environment degradation, manufacturing cost, energy utilization, process waste and enhancing personnel health, operational safety. EDM process which is generic process to machine alloys which are hard and challenging to machine, uses dielectric fluid during machine. This dielectric fluid cause carcinogenic problems to the operator due to precarious emission near breathing zone [9], skin problems [15] generation of sludge and toxic waste degrades environment, land and water. In early stage of the process kerosene is used as dielectric but its capability degrade during long term machining. This drives researcher to look for some alternatives dielectric having longer life cycle.

Implementation of ISO 14001 standard forces manufacturing industry to care about environmental aspect rather than economical only. Manufacturing industry now tries to maintain a balance between economy and environmental side. The ISO standard which mainly consider environmental protection as prime importance guide the industries to use or create more eco-friendly process. Many researches have been reported using an alternative dielectric fluid which is as good as conventional dielectric fluid in machining as well as decreases environment impact. Usage of distilled water [11], water-oil emulsion [16] was reported giving satisfactory results and helps in reducing ill-effect on environment and operator as well. The EDM process produces sludge, dielectric waste, deionising resins need proper and effective discard into environment as these are non-recyclable and toxic[17]. On the contrary waste for these water based dielectric can be easily discarded into municipal sewer line after extracting debrises. Some research also reported usage of gaseous dielectric like oxygen [14] and helium or argon [18] during machining bringing pollutant to almost zero. Currently there is no dielectric that could completely replace EDM conventional dielectric to make this process total clean and sustainable.

1.2.1properties Required in A alternative to Conventional dielectric For EDM Process

It has been reported by shah et.al. [19] that vegetable oil have comparable dielectric properties as that of hydrocarbon oils. These fluids may replace water, gas dielectric and hydrocarbon oils from EDM process. A fluid could be identified as a potential dielectric for EDM if it has higher flash point [19], higher oxygen content [20], higher Breakdown voltage [21], higher viscosity [21], nontoxic [22], lower volatility and toxic emissions and better biodegradability [23].However a lot of research work has been reported to improve the machinability of EDM process but application of Waste Vegetable Oil (WVO) as possible dielectric in EDM has been reported by few researchers [24]. Result of previous research work suggest that there is scope of usage of WVO as a possible dielectric for EDM process. Low price, easy and abundant availability and higher sustainability impact index among all bio oils [25]also help researchers to select WVO as an alternative dielectric. Authors have tried WVO to investigate feasibility through performance analysis and examine the response behaviour of Material Removal Rate (MRR), Electrode wear rate (EWR) and Surface roughness (SR) with comparison to CHO to minimise the environmental impact and ensure healthy working condition for the operator without a significant change in output parameters of the process. In this research work a WVO Pongamia Pinnata and Blended Used Vegetable Oil (BUVO) was used to study feasibility of oils as dielectric for EDM process. Effect of pulse current, pulse on time and duty factor on Output parameter viz. MRR, EWR and SR have been studied to analyse the feasibility.

2.Experimental Setup and Details

The experimental work has been performed on an ENC 35 Die sink EDM (Electronica® machine tools LTD), R-C based circuit is employed for pulse generation in this EDM machine with current rating 35A. Negative polarity on electrode was used during the experimentation.
The workpiece material that was used for this study purpose is a hard to machine super alloy, Inconel 718. The dimension of workpieces used for machining is 70mm x 15mm x 15mm, and hardness is 41 HRC. The workpiece material composition is give in Table 1. Sample images of machined work pieces are shown in Fig 2 (a-c).
Cylindrical copper electrode of 10mm diameter was selected for this experiment. Electrode material composition was shown in Table 2.Refined WVO, BUVO and CHO used as dielectric for this research work and properties of all the dielectric fluid used are shown in Table 3. Sample of CHO, WVO, and BUVO was shown in Fig 3(a-c)

2.2 Experimental Work

Influence of three control parameter viz. pulse current, pulse on time, duty factor (four levels of each), as shown in Table 4, on EDM response parameter, viz. (MRR),(EWR), and(SR), was examined. Depth of cut was kept constant for all set of experiments.
Loss of weight is considered to evaluate MRR and EWR using 1mg accuracy digital weighing scale manufactured by Wensar Electronic.
SR was measured using surface roughness tester (Surtronic-128) with accuracy of 0.001µm.Design of Experiment (DOE) was done using Taguchi OA and bust Design to

optimise the number of runs, time and resource consumption .A total of 48 runs were performed, 16 experiment each with CHO, WVO, BUVO as dielectric medium. Results have been recorded and comparative analysis has been done for all the three dielectric.

2.1 Workpiece, electrode and dielectric

Table 1: Workpiece material Composition

Element	Ni	Si	Mn	Cr	Fe	Mo	Nb	Ti
Compos.(%)	52.05	0.061	0.107	21.15	14.85	2.16	4.32	1.30

Table 2: Electrode material Composition

Element	Cu	Al	Si	S	P	Zn	Mn	Ni	Pb	C
Compos.(%)	99.58	0.006	0.002	0.035	0.052	0.25	0.002	0.023	0.02	0.028

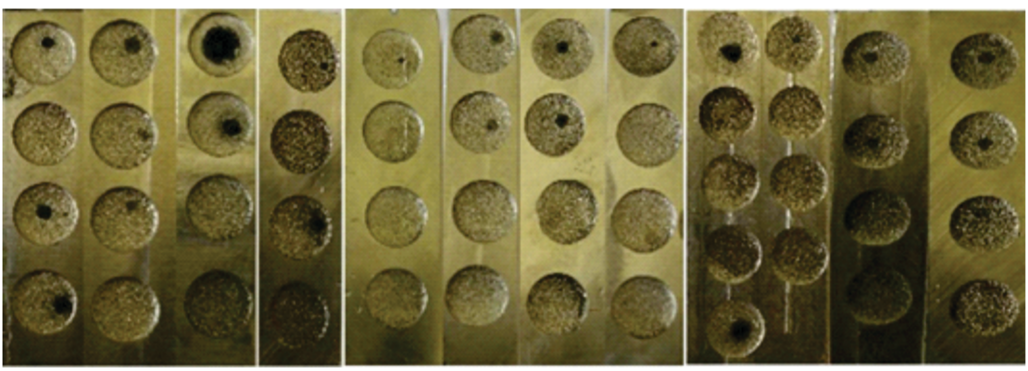


Fig 2(a) Workpiece machined using Fig 2(b) Workpiece machined using Fig 2(c) Workpiece machined using

CHO as dielectric fluid WVO as dielectric fluid BUVO as dielectric fluid

Fig 3(a) CHO sample

Fig 3(b) WVO sample

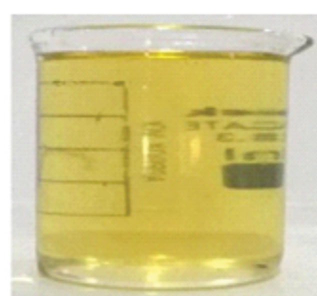


Fig 3(c) BUVO sample

Table 3: Physica Propertie of dielectric

Dielectric	Density (gm/ml)	Viscosity at (35°C) (mm^2/sec)	BD Voltage (kV/4mm)	Flash Point (°C)	Fire Point (°C)	Thermal conductivity (W/m.K)
CHO	0.810	25.0	35	101	103	0.14
WVO	0.924	40.2	49	225	230	0.22
BUVO	0.790	31.7	32	234	260	0.11

Table 4: Input Parameter and Levels

Parameter	Level
Pulse Current (A)	3, 6, 9, 12
Pulse on Time (s)	70, 90, 110, 130
Duty Factor	0.6, 0.65, 0.7, 0.75
Electrode Polarity	Negative

3.Experiment Results and Discussion

3.1 Influence of control parameter on MRR

The response behaviour of MRR has been recorded under the influence of control parameters selected and shown in Fig. 2(a-c). MRR is defined as weight of material removed per unit time, which is most significant for this process economy. To achieve better production economy a higher MRR is desirable.

In Fig 2-a. comparative response behaviour shows influence of pulse current on MRR. It was observed that the MRR increases with increase in pulse current, for all the three dielectric used, which is as result of increase spark energy. It was also observed that that MRR for WVO is higher than the other two dielectric fluids for current range used. Higher breakdown voltage and higher oxygen content causes intense oxidation [26] and delayed sparking, results into an efficient sparking cycle and concentrated discharge energy.

The Comparative response behaviour shown in Fig.2-b shows the effect of pulse on time on MRR. Result obtained here shows a similar trends and the WVO results in highest MRR while the BUVO results in lowest. With increase in Pulse on time the spark channel sustain for much longer time resulting in more

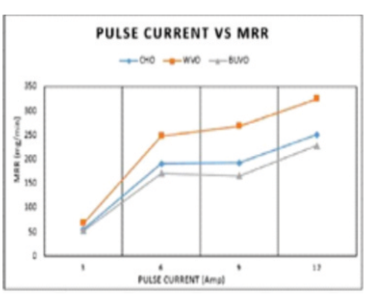


Fig 2-a: Effect of current on MRR

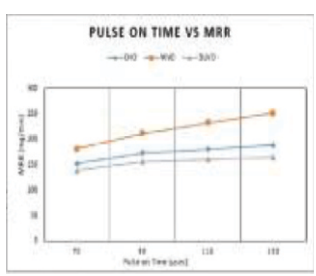


FIG. 2-b: Effect of Pulse on Time on MRR

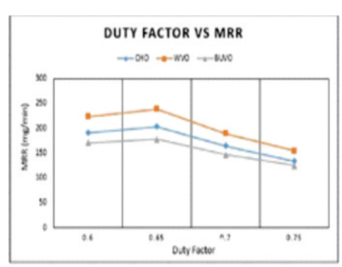


Fig. 2-c: Effect of Duty Factor on MRR

time and energy available for melting and vaporizing phenomenon. Hence increasing trend was observed. Also higher breakdown voltage and viscosity of WVO strengthen the dielectric ionisation in discharge gap results into longer sustain and thus higher MRR. Lower MRR with BUVO may be due to lower dielectric strength resulting in early spark and weaker discharge channel.

Fig.2-c shows response trends of duty factor influence on the behaviour of MRR. Results shows similar trend for all the three dielectrics. However the WVO results in higher MRR than the other two for all levels. This may be attributed to the fact that higher breakdown voltage and viscosity of WVO cause a strenuous ionised state for longer time resulting in higher MRR than other two while the saturated single bond restrict the formation of stable ionised channel resulting lower MRR.

It can be summarised that the WVO results in higher MRR than CHO while used vegetable oil results in lower MRR. Response trends similar to kerosene [27] can be observed with WVO and used vegetable oil for same set of experiment. It implies that the WVO undergoes similar melting, evaporation and dielectric breakdown phenomenon as kerosene. Moreover WVO used significantly increases MRR for the control parameter used in this experiment.

3.2 Influenc of Control Parameter on Ewr

In EDM process the spark generated causes high speed electron strike onto the surface of softer electrode resulting into erosion of electrode surface. This erosion alter the geometry and dimension of the electrode and the cavity produced as well. Hence, minimum EWR is desirable to achieve better dimension and size. Also due to this erosion electrode need frequent dressing increasing the loss of electrode material and hence the electrode cost

Fig. 3(a-c) shows a comparison of

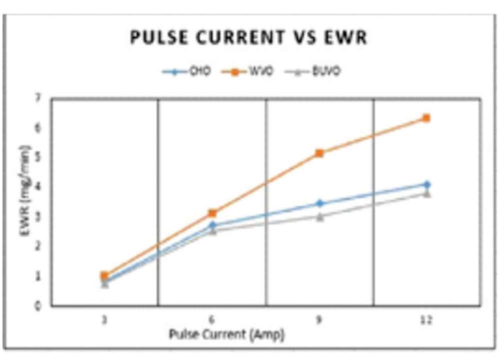


Fig.3-a: Effect of Current on EWR

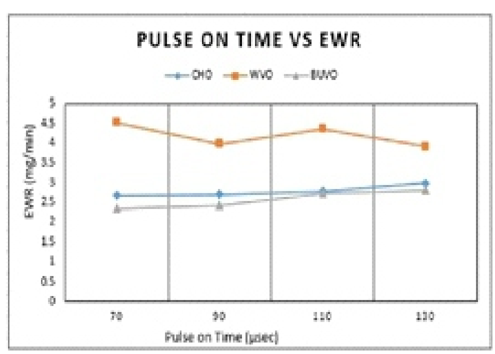


Fig.3-b: Effect of Pulse on time on EWR

response behaviour of influence of control parameters condition. Fig. 3-a shows that EWR increases for all the three dielectric fluid used here with an increase in pulse current. Similar trend was reported by Gopalakannan and Senthivelan[28] using kerosene. This may be due to the fact that with increase in pulse current spark energy increases resulting in increment in number for electron impinging on the surface of electrode. Higher Oxygen content and better conductive discharge channel results in highest EWR for WVO while lowest for BUVO

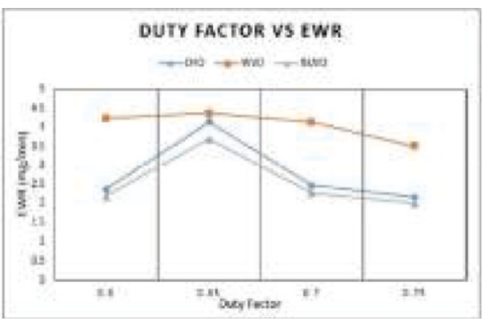


Fig.3-c: Effect of Duty Factor on EWR.

Fig. 3-b shows impact of Pulse on time on EWR. Results indicate that EWR increases for all the three dielectric used. However electrode surface worn out highest in case of WVO while lowest for BUVO for same pulse on time value. With increase in pulse on time more time is available for the electron to strike on the electrode surface. High viscosity of WVO results in high discharge energy density while for used vegetable oil the discharge channel density is less minimising the frequency of electron striking the electrode surface and hence increasing the EWR.

Fig. 3-c shows influence of duty factor on EWR. Results obtained shows similar response trend for all the three dielectric. Moreover, for same value of duty factor WVO results in higher value of EWR while BUVO results in lowest EWR. Higher duty factor cause heating of electrode due to lesser time available for heat transfer which soften electrode material results in higher value of EWR. Higher viscosity also confines the plasma channel[12, 16]results in more electron movement toward electrode which increases EWR.

From the above results in can be summarised that WVO results in higher EWR than the other two while the used vegetable oil shows lowest EWR for the selected control parameters. Moreover similar trend has been observed for all three dielectric and also similar to the results of other researchers for the same control parameter. The similarity in response trend for WVO and used vegetable oil as compared with CHO indicates operational feasibility of WVO and Used vegetable oil for EDM process.

3.3 **Influence of Control Parameters On Sr**

SR could be termed as the average roughness of the surface machined by EDM process. For the good accuracy, low wear and high service life low SR is desired. Response trends under the influence of control parameter on SR has been shown in Fig. 4(a-c)

.Fig. 4-a shows the response trend between pulse current and SR for all the three dielectric. At higher value of current the spark impinge on the work surface with more intensity to remove the material. The higher impact force results in formation of wider crater and generates coarse surface. Higher SR has been reported with WVO may be due to high energy density of plasma channel. Also higher breakdown voltage of WVO results into higher spark energy which causes deeper penetration in work surface to remove the Material[27]. The higher impact

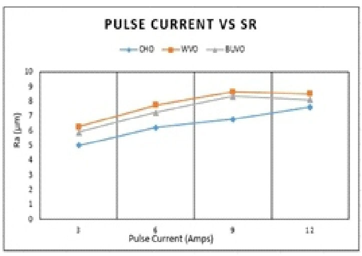


Fig 4-a. Effect of current on SR

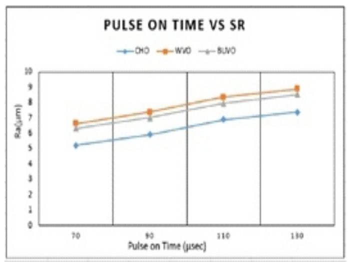
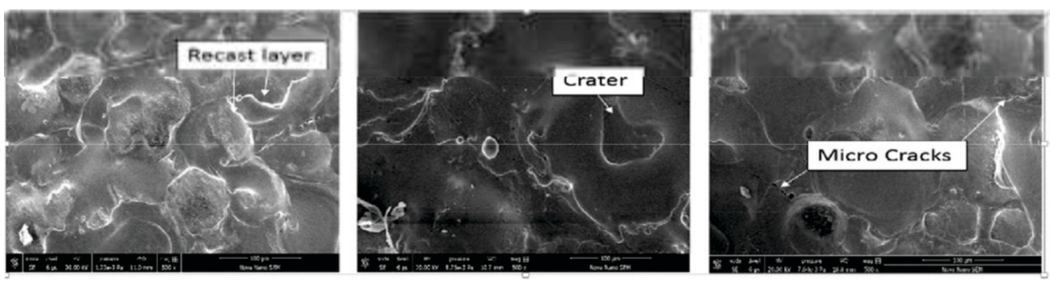


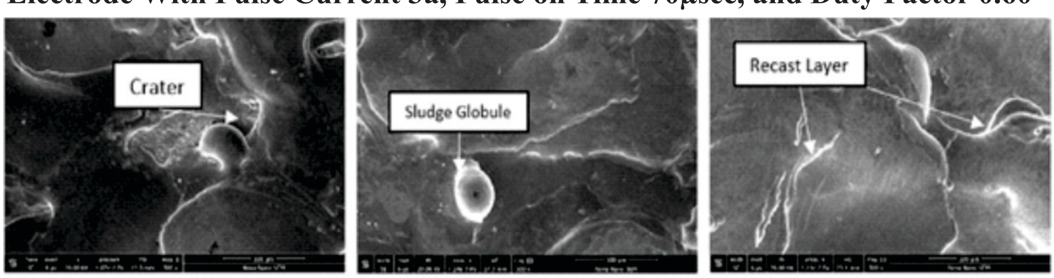
Fig 4-c. Effect of Pulse on time on SR

Fig 4-c. Effect of Duty Factor on SR



(a) Machined with CHO (b) Machined with WVO c) Machined with BUVO

Fig 5.1: Sem Images of Inconel 718 Machined By Edm Process Using a Copper Electrode With Pulse Current 3a, Pulse on Time 70µsec, and Duty Factor 0.60



(a) Machined with CHO (b) Machined with WVO c) Machined with BUVO

Fig 5.2: Sem Images of Inconel 718 Machined By Edm Process Using a Copper Electrode With Pulse Current 12a, Pulse on Time 70µsec, and Duty Factor 0.75.

force results in formation of wider and deeper craters generating coarse surface[29].
Fig 4-b shows the response trend with change in pulse on time. Higher pulse on time results in more sparks that extends the melting and evaporation of material resulting in wider crater. However higher temperature due to prolong sparking softens the material and resulted in formation of coarse surface.
Fig.4-c shows the effect of duty factor on SR. Higher duty factor result in lower time for heat dissipation and reionisation of discharge gap. Reduced spark time also results in shallower and smaller crater. However higher viscosity results in formation of concentrated plasma channel increasing the surface roughness. While with BUVO weaker plasma channel and smoother surface.
It could be summarised from the above results that higher viscosity and higher breakdown voltage results in highest SR in case of WVO while lowest with CHO.

3.4 Surface Micrographs

To analyse the machined surface SEM images have been recorded and analysed. Fig 5.1 shows the SEM images of surface machined at lowest value of current while fig5.2shows images at highest value of current used in this experimental work of all the three dielectrics fluid used.
Fig 5.1(a-c) shows machined surface at 3A pulse current. Fig.5.1-a shows SEM image of surface machined using CHO as dielectric. Very few micro-cracks has been observed which may be due to a rapid machining and cooling cycle. Smoother surface has been observed. Recast layer has been observed which may be due to melting and solidification of material on the workpiece surface. Using WVO as dielectric deeper and wider crater has been observed shown in fig 5.1-b which may be due to higher viscosity of WVO which resist the expansion of plasma channel. Larger micro cracks has been observed due to higher strength of spark associated with higher breakdown voltage. Surface machined with BUVO as dielectric shown in fig 5.1-c shows recast layer and smaller micro crack. Shallower craters was observed may be due lower spark energy to impinge into the surface deeply.
Fig 5.2 (a-c) shows surface machined at 12A pulse current. Fig 5.2-a shows surface machined using CHO as dielectric. Recast layer on the surface shows material solidified on the machined surface. A coarse surface with deeper craters was observed due to higher spark energy associated with higher pulse current. Surface machined with WVO shown in fig 5.2-b shows a smoother surface with very few micro cracks. Sludge globules was also observed which may be due to absence of flushing pressure. BUVO results in generation of a smoother surface as shown in fig 5.2-c.Lesser micro cracks was observed may be due to low spark energy. Surface with smaller crater than the other two dielectrics used has been observed.

4. Conclusion

Feasibility of WVO and used vegetable oil has been studied in this experimental work. Following conclusions can be made on the basis of experimental results obtained

I. WVO results in 32% higher MRR as compared to CHO means low production cost as higher volume of material will be removed per unit of time while BUVO results in 10% lower causing a higher cost of production.

II. EWR obtained while machining with WVO is 40% higher compared to CHO while BUVO results in 8% lower EWR. Higher EWR results in high cost of tooling and poor geometrical and dimensional accuracy. Also the electrode wears at faster rate increasing tool changing cost as well.

III. Average surface roughness obtained with WVO is 21% higher than that with CHO results in coarse surface while BUVO results in 16% higher average surface roughness results in a coarse surface after machining.

IV. The response trend observed with alternative dielectric is quite similar with that of CHO. This indicate that the material removal principle and erosion mechanism are similar to that of CHO. This indicates the feasibility of WVO and BUVO for EDM. WVO is found to be best out of three dielectrics used.

V. A coarse surface was observed by surface morphology after machining with WVO while a surface smoother than WVO was observed with BUVO. Also recast layer phenomenon was seen with all the three dielectric used.

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Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Professional articles:

1. Professional paper (contribution offering experience useful for improvement of professional practice but not necessarily based on scientific methods);
2. Informative contribution (editorial, commentary, etc.);
3. Review (of a book, software, case study, scientific event, etc.)

Language

The article should be in English. The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and Summary

An abstract is a concise informative presentation of the article content for fast and accurate Evaluation of its relevance. It is both in the Editorial Office's and the author's best interest for an abstract to contain terms often used for indexing and article search. The abstract describes the purpose of the study and the methods, outlines the findings and state the conclusions. A 100- to
250- Word abstract should be placed between the title and the keywords with the body text to follow. Besides an abstract are advised to have a summary in English, at the end of the article, after the Reference list. The summary should be structured and long up to 1/10 of the article length (it is more extensive than the abstract).

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Acknowledgements

The name and the number of the project or programmed within which the article was realized is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programmed.

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All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

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Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.

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