

LIFE CYCLE ANALYSIS OF KEROSENE AND EDM OIL FOR SUSTAINABLE EDM

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Abstract— The usage of nonconventional machining performs is growing for product manufacturing mostly when machining challenging to scratch material plus when extraordinary accuracy essential. There is plenty of examination piloted on refining sustainability of conventional machining. Though sustainability readings on nonconventional machining (EDM) observes are rare. Here research is carried out the Life Cycle Analysis (LCA) of dielectric fluid used in EDM for sustainable manufacturing. LCA is a versatile tool for quantifying the overall environmental impacts from a product, process, or service. The primary goal is to choose the best product, process, or service with the least effect on human health and the environment. In this research the focus is toward assess the total ecological effect of dielectric used in EDM. For the research work two dielectric used Kerosene and Synthetic oil and whole LCA studies carried out in GABI software. GABI is use for Life Cycle Analysis to assess life cycle environmental effect, rate, and social health ware, procedures and technologies. It also compromises records with world-wide coverage as well as Eco invent data. This LCA studies carried out on standard ISO 14040 and the overall environmental impact of different dielectric is measure with experiment and validate through software.

Keywords— Unconventional Machining; EDM; Life Cycle Analysis; Sustainable Manufacturing; CO2PE! Methodology; Kerosene; EDM Oil

1. INTRODUCTION

Electrical discharge machining (EDM) process is a non-conventional and non-contact machining operation which is utilized as a part of industry for high accuracy items particularly in assembling ventures, aviation and car enterprises, communication and biotechnology businesses [1]. In addition, non-conventional machining is described by the nonappearance of plastic distortion and chip arrangement, regularly detailed as the major weaknesses in traditional machining. In this procedure the metal is expelled from the work piece because of disintegration cause by quickly repeating flash discharge between the instrument and work piece. The figure show the mechanical set up and electrical set up and electrical circuit for electro discharge machining. A thin gape around 0.025mm is kept up between the device and work piece by a servo mechanism. Both instrument and work piece are submerged in a dielectric [2]. The different dielectric used in EDM process like Kerosene, mineral oil, paraffin oil, hydrocarbon oil etc. This dielectric generates number of gases during operational phase and affects the environment [5, 27, 28]. Life cycle Analysis of EDM fluid is important part for sustainable manufacturing [12]. The major constitute in Environmental impact are electricity and dielectric fluid. This study examined by kellens using CO2PE! Methodology. The main constitute in emission is aerosol and effect of human is dangerous [14, 15]. Sustainability term defined as “meets the needs of the present without compromising the ability of future generations to meet their own needs”. In other word it defines as the creation of goods and services using processes and systems that are Non-polluting, conserving of energy and natural resources, economically viable, safe and healthful for workers, communities, and consumers,

socially and creatively rewarding for all working people [8].

2. CO2PE! METHODOLOGY

The CO2PE! technique assumes a noteworthy part to ensure precise and institutionalized stock examination of manufacturing process. It concerns a LCA-situated procedure suited for the aggregation of unit process life cycle inventories (UPLCI). The procedure will be briefly presented in this section.

2.1 Goal and Scope Definition

To begin with the objective and extent of the examination ought to be plainly characterized and should reliable with the expected unit process. The most essential angles to be considered are the framework limits and the useful unit of the planned procedure. Besides, both the most compelling procedure parameters and the machine apparatus design are researched and all sub-procedures and production modes are identified and located.

The parameters or states of the information that represent LCI attributes and the created qualities in the yield item are recorded in light of accessible process understanding and literature. A few parameters are unequivocally connected to the made ecological effect while others are of minor significance, yet might be essential in an item quality sense. Along these lines, the rundown of parameters is positioned, in a rough path, from biggest to minimum impact.

2.2 Inventory

The procedure inventory contains two approaches with various levels of detail: the screening approach and the top to bottom approach. The screening approach depends on agent general information and hypothetical equations for energy utilize material loss, and identification of factors for development. In this approach, the total energy is determined based on a functional unit output and comprises

of two sections: the direct, incremental energy and the fixed energy from assistant frameworks. The mass misfortune figuring incorporate commitments from essential material misfortune (expelled material), helper chemicals, unit process breaking down, and so on. The top to bottom approach depends on modern process estimations and is subdivided into four modules, including a time study, power consumption study, consumables study and emission study, in which all applicable procedure data sources and yields are estimated and analyzed in detail.

2.3 Impact analysis

In this section discussion carry out on the effect of data gather during process are calculated based on different available database. In impact analysis gather data impact analysis on land, water, global warming effect etc., is carry out for selecting proper database. In this step it is advisable to track data which identified by goal and scoping section discuss earlier. The all input/output data effect divided into different part of emission sector. After that analysis carry out of assess the effect of this data on a particular sector (ie, LCA of electricity production, the main area of analysis are land occupation, water usage, ozone delectation etc.) In next step the method is decided on which assessment is performing. In LCA different methods like ReCiPe mid – pint H, ReCiPe end–pint H, CML 2002, Eco indicator 99 etc. are used for analysis. In last step the analysis result effect on resource, human health, environment are present using different charts. This analysis divided on basis of which goal settled. Result mainly depend on input/output data and database used for performing LCA.

3. EXPERIMENTATION

Experiments have been conducted on a Die sinking Electro discharge Machine as shown in Fig 3.1 using cooper electrode and aluminium 3003 as work piece. The chemical composition of Al 3003 is presented in Table 3.1.

TABLE 3.1 CHEMICAL COMPOSITION OF AL 3003

Element	Composition (%)
Si	1.0
Fe	0.130
Cu	0.081
Mn	0.560
Pb	0.001
Zn	0.006
Cr	0.035
Ti	0.024
Al	97.483



Fig 3.1 Experimental Setup

In experimental setup Energy meter is connected between main supply and EDM for power consumption measurement and Gas analyser is used for Emission measurement. Before performing the experiments, the initial weights of tool and work piece are measured with pocket size weightner. Then work piece is fitted on fixture of work table. Similarly, electrode was also fitted in tool holder and machining carries out for one hour. The dielectric used for this study is kerosene and EDM oil and its specification shown in Table 3.2

TABLE 3.2 DETAILS OF DIELECTRIC

Dielectric	Specific Gravity	Flash Point	Dielectric Strength	Viscosity
Kerosene	0.82	100° C	22 MV	64 CS
EDM oil	0.78	105° C	45 KV	2.16 CS

The details of machining configuration for case 1 and 2, are listed in Table 3.3

TABLE 3.3 POCES PARAMETER

Description	Case 1	Case 2
Workpiece Specification	Aluminum Alloy 3003 (100×82×12 in mm)	Aluminum Alloy 3003 (100×82×12 in mm)
Tool Specification	Copper (φ15 mm)	Copper (φ15 mm)
Peak Current	6A	6A
Open Voltage	120V	120V
Pulse ON time	175µs	175µs
Pulse OFF time	40µs	40µs
Dielectric	Kerosene	EDM oil

4. LIFE CYCLE INVENTORY DATA COLLECTION

As discussed in section 2 the methodology divided in four modules, time study, power consumption study, Consumables study, Emission study. In this section data collection for these four modules was performed.

4.1 Time Study

The time required during machining work piece can be broadly divided into productive time and non-productive time. Productive time is the time taken for material removal process. For EDM sparking time (operational time) is productive time and machine set up and set down time are non-productive time. The time study divided into three phase for machining. Detailed time study for kerosene and EDM oil shown in Fig 4.1.

1. Machine set-up time (tool alignment, work piece setup, tank filling etc.)
2. Operational time (Sparking time)
3. Machine Set-down time (Tool and work piece unclamping, cleaning etc.)

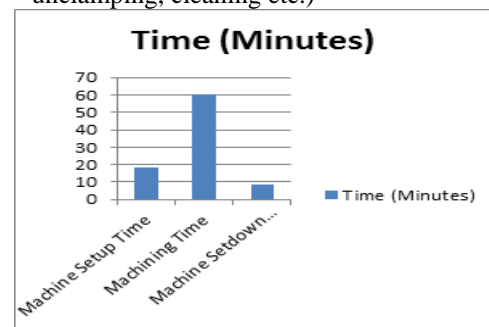


Fig 4.1 Detail Time Study For Kerosene & EDM oil

4.2 Energy Study

The Energy Study is carried out for both cases. For that Energy meter is connected between EDM and main power supply. Then data collected for Energy consumption in various time study section shown in Fig 4.2 for kerosene. For all modes, the Machining phase consume more electricity than after Machine setup phase and Machine setdown phase consume electricity less compare to Machining phase. Fig 4.3 shows energy consumption of machine during use of EDM oil. During machining using EDM oil have high energy consumption in machining phase.

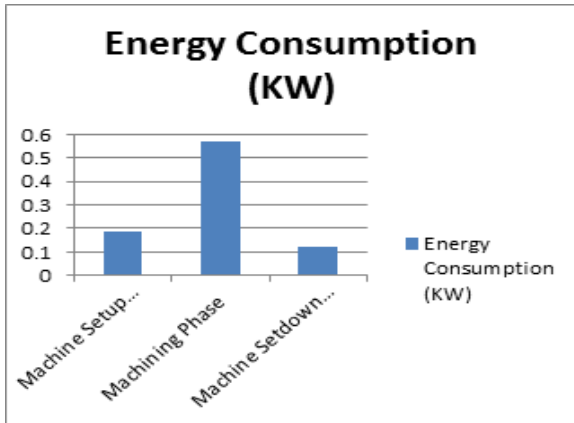


Fig 4.2 Energy Study for Kerosene

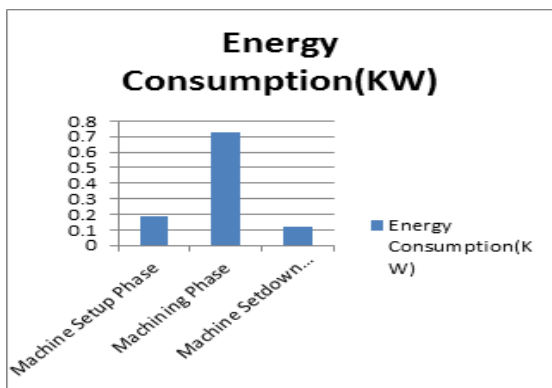


Fig 4.3 Energy Consumption for EDM oil

4.3 Consumable Study

Consumable study divides into work piece and tool material consumption, dielectric consumption and cotton consumption during cleaning of tank. For material consumption data of work piece and tool are measured with weight the material before and after machining and dielectric consumption measured with measuring before and after level of dielectric in tank. Cotton consumption is measured with weight of cotton material before and after washing cotton.

TABLE 4.1 DETAIL OF CONSUMABLE

Constitute	Tool	Workpiece	Dielectric	Cotton
Kerosene	0.07g/hr	0.94 g/hr	1.45 kg/hr	6 g
EDM oil	0.05 g/hr	1.22 g/hr	1.21 kg/hr	6 g

4.4 Emission Study

Emission Study is carried out during operational phase, because during other phase no machining done and no Emission generate. Testo 340 Gas analyzer is used for measuring harmful gases during machining phase for kerosene and EDM oil. Kerosene generates more harmful gases during machining.

TABLE 4.5 EMISSION GASES FOR BOTH CASE

	Kerosene	EDM oil
Emission gases	CO ₂ =1.70 ppm NO=1.02 ppm O ₂ =19.06%	CO ₂ =1.02 ppm NO ₂ =1.009 ppm O ₂ =20.02%

5. LCA RESULT

The information assembled from one hour of machining for each case are then utilized as a part of an ecological execution investigation. The analysis refers to the Ecoinvent variant 3.1 LCI database for analysis, and utilizations the GaBi Educational form programming apparatus. An assortment of strategies can be utilized for impact analysis, for example, Eco-marker 99, CML 2001, EDIP 97, and Impact2002+, and they are chosen in view of the approach, midpoint or endpoint of the natural system. The analysis technique utilized here is ReCiPe Mid-point H. Fig 5.1 demonstrates the environmental impact of one hour of EDM utilizing Kerosene as a dielectric for cooper tool and aluminum 3003 workpiece.

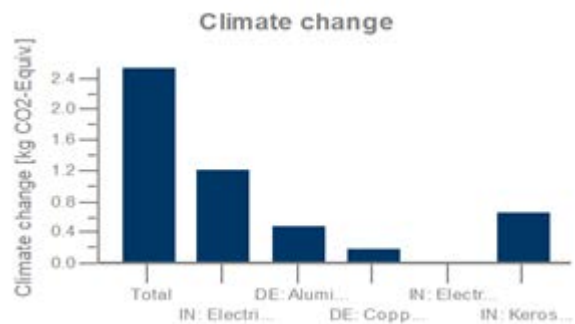


Fig 5.1 Environmental Impact of one hour EDM using kerosene based on ReCiPe Mid-point H method

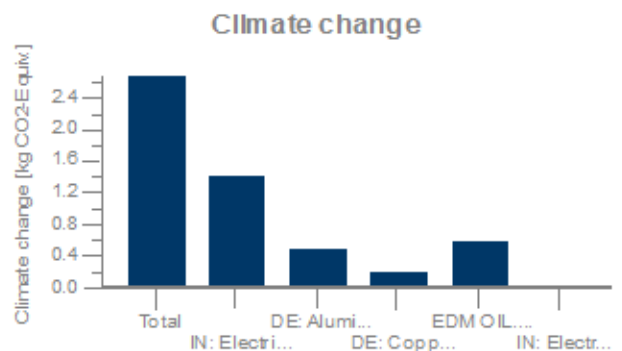


Fig 5.2 Environmental Impact of one hour EDM using EDM oil based on ReCiPe Mid-point H method

From above two graph clearly shows the Electricity and dielectric (Kerosene & EDM oil) have high environmental impact comparing to other, below table demonstrate

percentage contribution of each constitute for different cases.

TABLE 5.1 ENVIRONMENTAL IMPACT OF DIFFERENT CONSTITUTE

Kerosene			EDM oil		
Constitute	Value	%(Contribution)	Constitute	Value	%(Contribution)
Electricity	1.22 kg CO ₂	48.03	Electricity	1.42 kg CO ₂	53.18
Kerosene	0.655 kg CO ₂	25.78	EDM oil	0.583 kg CO ₂	21.83
Al	0.483 kg CO ₂	19	Al	0.483 kg CO ₂	18.08
Cu	0.186 kg CO ₂	7.32	Cu	0.186 kg CO ₂	6.96
EDM	1.7E-066 kg CO ₂	0.01	EDM	1.5E-006kg CO ₂	0.009

It is evident that electricity has high contribution in Environmental impact, due high consumption of electrical power during the operational phase. During operational phase chiller, pump, servo mechanism has consumed more electrical power which generates high contribution of electrical power in environmental impact. This result only shows the environmental impact during one hour of EDM roughing operation. So using EDM process during industry for part production generates high level of pollution in context of co2 equivalent. Environment impact caused by Electrical power is reduced by automation of EDM process, so the productive time of machining increases. Also the second most dominate constitute in environmental impact is dielectric. Kerosene generates high number of pollution during machining which make less appropriate for mass production on EDM, but EDDM oil generate less pollution compare to kerosene which make more appropriate for mass production.

6. CONCLUSION

Two case studies of die-sink EDM, with aluminum composite 3003 and copper instrument, have been explored in this investigation. The unit procedure LCI information of non-conventional machining have been found out through time, Energy, Consumables and Emission studies for each case. Regardless of a few restrictions identifying with obtaining airborne emission information, all other information and yield reference streams were traced and dissected. It is demonstrated that a lot of electricity utilization happens amid non-profitable phases of machining which is in charge of expanded environmental effects. The outcomes demonstrate that the fundamental wellspring of effect is electrical energy in all cases, which is in charge of roughly 48% in Kerosene case and 53% in EDM oil of the total environmental impact. However, the second most noteworthy effect caused by dielectric oil roughly 26% in Kerosene and 22% in EDM oil of the total environmental impact.

The results demonstrate that electrical energy is the major impact source, which can be minimizing through

appropriate machine tool design and also by using sensible operation process. A typical EDM machine is automated to a great extent, and is programmed to operate each sub unit based on manufacturer specific algorithms. All the energy consuming sub units, for example, pump and chillers, have space for enhancement for better energy execution separated from the concentration nature of cut. Operational level enhancements can likewise be proposed to keep energy and asset utilization to a base level. As can be seen from the present outcomes, keeping machines in standby mode utilizes a lot of energy. Enhanced generation arranging and mindfulness are required to better use the machines in profitable mode generally, an OFF mode could mean higher investment funds potential in energy utilization and consequently could diminish environmental effect.

7. FUTURE SCOPE

The literature show that some research works done on emission sides of EDM, but few works carried out in the field of LCA. Following regions have been represented future work to influence EDM process more feasible.

- Present work can be extended for the different dielectrics like paraffin oil, mineral oil, other hydrocarbon based dielectric etc.
- Present work can be extended for changing tool and workpiece material.
- Also changing parameter like Current, Voltage, Pulse ON Time, Pulse OFF Time etc. This present work can be extended for changing parameter.
- This Life Cycle Analysis study also be used for implementing in dry and near-dry EDM process

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