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Sustainable Manufacturing and Environmental Impact Minimization on EDM Electrode

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Abstract—*Electric Discharge Machining (EDM) is one of the most commonly used unconventional machining processes. The selection of electrode is one of the most affecting factors of EDM process; this makes the EDM process as unsustainable process. By using brass electrode in EDM the process is highly conductive and strong. But as compared to copper the emission is higher. The emission in copper is minimum among other electrodes and deep slots can be made under poor flushing condition. By optimizing process parameters of EDM electrode such as pulse on time, pulse off time, discharge current and voltage. Selection of optimum electrode by using Sustainability express in solid works result in reduction of hazardous emission and toxic gases, therefore impact of environmental aspects and personal health aspects can be reduced so that the EDM process becomes sustainable manufacturing process.*

Keywords: *Unconventional, Machining, Hazardous Emission, Flushing Condition*

1. INTRODUCTION

Electric discharge machining (EDM) is the most widely practiced non-conventional material removal process and enjoys more than 7% market of worldwide sales of total machine tools.

1.1. EDM Process

EDM spark erosion is the same as having an electrical short that burns a small hole in a piece of metal it contacts. With the EDM process both the work piece material and the electrode material must be conductors of electricity.

The EDM process can be used in two different ways:

- A pre-shaped or formed electrode (tool), usually made from graphite or copper, is shaped to the form of the cavity it is to reproduce. The formed electrode is fed vertically down and the reverse shape of the electrode is eroded (burned) into the solid work piece.
- A continuous-travelling vertical-wire electrode, the diameter of a small needle or less, is controlled by the computer to follow a programmed path to erode or cut a narrow slot through the work piece to produce the required shape.

1.2. Environmental impact factors

1. Carbon footprint
2. Air acidification
3. Water eutrophication
4. Total energy consumed.

1.3. Life cycle assessment

To design a product for the environment, an assessment of environmental impact must be completed. This is done by Life Cycle Assessment (LCA). This process allows us to understand the environmental impact of a product, from manufacture through use through disposal. This process includes the following steps.

Fig. 1: Phases in life cycle assessment

1.4. Sustainable manufacturing

The creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound.

Sustainable manufacturing is a systems approach for the creation and distribution (supply chain) of innovative products and services that: minimizes resources (inputs such as materials, energy, water, and land); eliminates toxic substances; and produces zero waste that in effect reduces greenhouse gases, e.g., carbon intensity, across the entire life cycle of products and services.

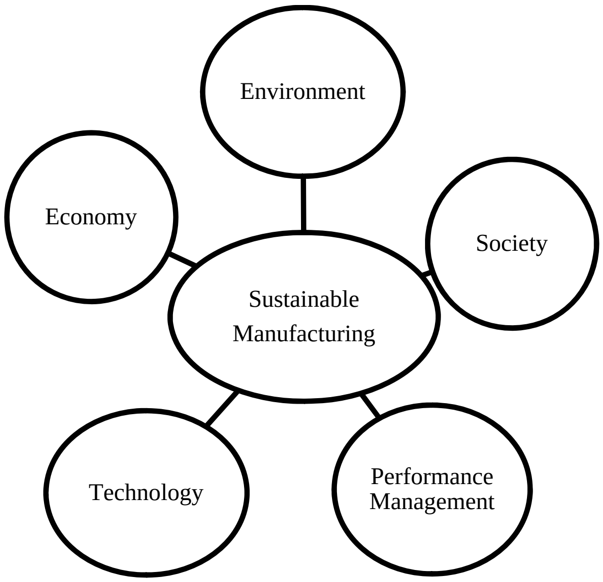

Fig. 2: Sustainable manufacturing

To achieve sustainability, products, processes, and services should meet the challenges not only related to their functions and performance but also to environment, economy, and social issues. Currently, researchers from different perspectives using various approaches are addressing these challenges. Companies interested in developing sustainable products should be sensitive to sustainability-related standards, design, and manufacturing techniques and tools.

Ensuring a sustainable future requires an integrated system of systems approach. Interlinked pathways of interaction at various levels characterize such systems. These levels span technical, economic, ecological, and societal issues. The interactions within and across these levels are critical to the fundamental understanding of sustainable design and manufacturing, because addressing any one of the issues in isolation could result in unintended consequences.

EDM is used to remove metal through electric spark. During this process hazardous emission occurs which makes harm to the operator. Based on this processes environmental impact will also be created which destroys the surroundings.

The increasing sensitivity to environment and health issues is reflected in the increasing stringent legislations and national and international standards. Scientists and engineers developed new and alternative manufacturing technologies. Machining processes generate solid, liquid or gaseous by-products that present hazards for workers, machine, and the environment. It is appropriate to understand the environmental hazards created by the NTM processes and analyse their impacts on the environment. These hazards can be considered within acceptable limits through the following steps:

- Reduction of emissions to air, water, land.
- Compliance with relevant legislations.
- Pollution prevention.
- Efficient use of energy.

Due to erosion of the work piece and tool electrodes, inorganic substances such as tungsten carbide, titanium carbide, chromium, nickel, molybdenum, and barium are released and condensate in the air.

Emissions of organic materials are generated by the vaporization of the dielectrics. Additionally, the rising smoke carries organic components from substances in the dielectric liquid. The erosion slurry contains eroded work piece and tool material and solid decomposition products of the dielectric.

By change in the electrode reduces these emissions and makes worker to work in the machine easily. The electrodes used for machining in EDM are:

- Brass
- Graphite
- Copper
- Tungsten copper
- Molybdenum
- Silver tungsten
- Tellurium copper

Among these electrodes the most used is copper which has more wear resistance than brass. It also provides fine finish. But the emission produced in it is more. Compared to copper the emission in the tungsten copper is less.

Modelling of Electrode

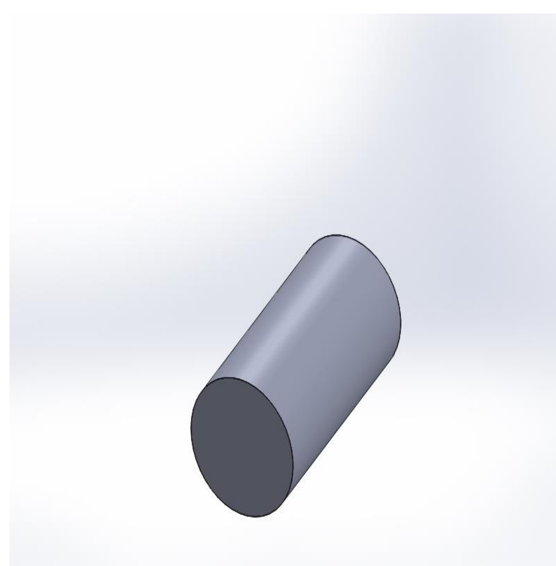

Fig. 3: Electrode made up of brass and copper

2. ENVIRONMENTAL IMPACT ANALYSIS

Here the environmental impact analysis is carried out by using SOLIDWORKS SUSTAINABILITY XPRESS TOOL in SOLIDWORKS.

2.1. Environmental impact (calculated using CML impact assessment methodology for brass electrode

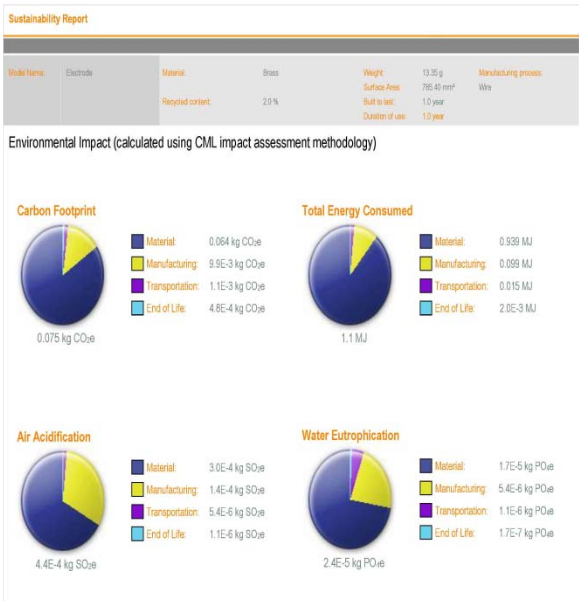

Fig. 4: Environmental impact of brass electrode

2.2. Environmental impact (calculated using CML impact assessment methodology for copper electrode

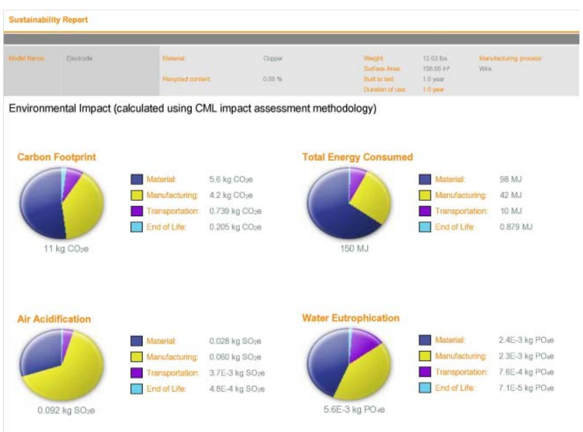

Fig. 4: Environmental impact of copper electrode

2.3. Air acidification

Sulphur dioxide, nitrous oxides other acidic emissions to air cause an increase in the acidity of rainwater, which in turn acidifies lakes and soil. These acids can make the land and water toxic for plants and aquatic life. Acid rain can also slowly dissolve manmade building materials such as concrete. This impact is typically measured in units of either kg sulphur dioxide equivalent (SO_2), or moles H+ equivalent.

2.4. Carbon footprint

Carbon-dioxide and other gasses which result from the burning of fossil fuels accumulate in the atmosphere which in turn increases the earth's average temperature. Carbon footprint acts as a proxy for the larger impact factor referred to as Global Warming Potential (GWP). Global warming is blamed for problems like loss of glaciers, extinction of species, and more extreme weather, among others.

2.5. Total energy consumed

A measure of the non-renewable energy sources associated with the part's lifecycle in units of mega joules (**MJ**). This impact includes not only the electricity or fuels used during the product's lifecycle, but also the upstream energy required to obtain and process these fuels, and the embodied energy of materials which would be released if burned. Total Energy Consumed is expressed as the net calorific value of energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.

2.6. Water eutrophication

When an over abundance of nutrients are added to a water ecosystem, eutrophication occurs. Nitrogen and phosphorous from waste water and agricultural fertilizers causes an overabundance of algae to bloom, which then depletes the water of oxygen and results in the death of both plant and animal life. This impact is typically measured in either kg phosphate equivalent (PO_4) or kg nitrogen (N) equivalent.

2.7. Material financial impact

This is the financial impact associated with the material only. The mass of the model is multiplied by the financial impact unit (units of currency/units of mass) to calculate the financial impact (in units of currency).

3. RESULTS AND DISCUSSIONS

Thus the Environmental Impact calculated using CML impact assessment methodology using Solid works and finally the copper produces less Environmental impact compared with the brass.

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