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"Ranking of non conventional machining process for selection of best method"

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Abstract: *In this novel research paper, USM, AJM,ECM,CHM,EDM,EBM,LBM,PAM eight alternates are considered to select the best method for cutting a given composite material. It becomes a decision making task. This problem becomes more difficult when five criteria capital investment, tooling, power required, efficiency and tool consumption is considered. To optimize this problem MOORA method was used. Solution for the given problem Rank 1 LBM Rank 2 AJM and last rank is ECM. With the help of this research paper, multi-criteria decision making task for metal cutting can be easily used for Artificial Intelligence based machining.*

Key Words: *ultrasonic, ultrasonic machining, Laser Beam, machining,*

1. INTRODUCTION:

In the last few years, verity of substances has been developed which are extremely hard, powerful and heat resistant. The main among these are stainless steel, titanium alloys, nemonics alloys, carbide and various composite materials. These substances are used in aerospace, nuclear engineering, jet engines and automobiles. Non-conventional machining processes are used for machining these materials. Non-conventional machining can be classified on the basis of energy, out of which the main types are thermo-electric heat energy, mechanical energy, chemical energy and electrochemical energy.

Through literature survey it has been revealed that most of the work till now has been done on selection of non-conventional machining and very little has been done on multi-criteria decision making. In this series, Kumar Sushil and Agarwal Nitin in their research paper, nine criteria for 7 alternatives were optimized by Moora method in which material removal rate tolerance, surface finish, surface damage and corner radius were taken as criteria in which electrochemical machining was found to be the best method [1].In this research paper, Kumar Sushil and Agarwal Nitin have explained about the impact of non-conventional machining on nature. In this paper, it has been told that pure water jet machining causes the least harm to the environment [2].Kumar Sushil and Agarwal Nitin research paper, to optimize non-conventional machining, four non-conventional alternatives have been optimized for nine criteria, in which 9 criteria include work piece material, temperature of cut, Workpiece thickness, machining accuracy, Kurf width kurf taper ,surface roughness cutting speed burr occurence . It was observed that Abrasive Water Jet Machining was found best non-conventional method for the above problem [3].In this research paper Kumar Sushil and Singh D P observed effect of nose radius on surface roughness. [4].In this research paper, Kumar Sushil and Singh D P explained the effect of cutting speed and feed on material removal rate for chromium high carbon material [5].In this research paper Singh D P and Kumar Sushil, the effect of ceramic tool on tool life while machining high chromium high carbon steel has been explained. It has highlighted the effect of cutting speed and feed on tool life and comparative Performance evaluation for High Carbon High Carbon Steel for ceramic Tools [6].In this research paper, ranking was found for non-traditional machining by critical method. In this method, it was explained how different types of non-conventional methods can be optimized for multi-criteria decision making and their rank can be found. By which we can use the most appropriate non-conventional method for cutting a given material [7].In this research paper, we have many alternate to cut a given

material .It becomes a decision making task. Problem became more difficult for nine criteria. This problem was optimized by moora metod. It was found that Abrasive Water Jet Machining is the best method among the given four alternatives. This was also validated by TOPSIS method [8].

Non Conventional Machining Process

1.1 Plasma Arc Machining.

In the process, the heat required for the machines is obtained from Hydrogen and Nitrogen gases heated by high temperature electric current. When a gas is heated to such a high temperature that it gets partially ionized, then such gas is called plasma. Electric spark is created between the electrode made of carbide and the work piece. The main difference between plasma spark welding and gas tungsten spark welding is that the plasma spark can be separated from the test gas envelope by placing the electrode inside the torch body. The plasma is then forced through a copper nozzle with a microscopic orifice which generates spark and through plasma reaches high velocity and temperature of 28000 degrees centigrade or higher.

1.2 Ultrasonic Machining.

In ultrasonic machining, mechanical energy is used for machining. In this, friction is generated between the work piece and the tool. High frequency vibrations are created between the workpiece and tool. A gap of point 0.05 mm is kept between the tool and the workpiece. A transducer is used to generate the vibrations. Various types of abrasive particles like aluminum oxide and silicon carbide are used. This method can be used for cutting both metal and non-metal. This method is suitable for machining glass. Both conductor and non-conductor metals can be easily cut by this method.

1.3 Chemical machining

In this method, a chemical is taken for metal removal which can react with it. Where machining is not to be done, a layer of paint is applied and where metal removal is to be done, a layer of paint is not applied. This method does not require much tooling and setup. No chips are formed. There is no distortion in the workpiece. Accuracy is very good. Hardness has no effect on machining. Even brittle metal can be cut easily. It is used in making company logo or making jewellry.

1.4 Electro Chemical Machining.

Electrochemical machining is used for machining hard metals and alloys. Electro chemical machine is based on Faraday's law of electrolysis. The principle of electrochemical machining is opposite to the principle of coating. In electro chemical machining, the workpiece is made anode and the tool is made cathode and an electrolyte like NaCl solution is placed between these two. In electrochemical machining, first of all the work piece is fixed on a Fixture and an electrolyte is placed between the tool and the work piece, then a potential is provided between them by connecting the work piece to the positive terminal and the tool to the negative terminal. A feed system is used to maintain proper distance between the tool and the workpiece. The metal removal takes place in the form of positive ions. Excellent surface finish is achieved through this process. Electro chemical machining is used for drilling, making mould polishing and grinding. This method is very useful for jewelry machining.

1.5 Water Jet Machining.

Water jet machining is done on the principle of mechanical energy to cut hard and brittle materials. High speed abrasive particles are sprayed on the workpiece with the help of a nozzle. In abrasive jet machining, nitrogen, carbon dioxide and inert gas is used. Abrasive particles are mixed with this gas in a hopper. Now in machining, the jet velocity hits the work piece at a speed of 300 meters per second. In this, a high quality nozzle with 13 mm size is used. Nozzle is made of tungsten carbide. Metal removal rate 15 mm^3/ min. It provides smooth cutting and can easily cut heat sensitive parts without damaging them. The method is very useful for hard and brittle metals. It is necessary to control environment hazardous. In this method nose life also remains a problem.

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1.6 Electron Beam Machining.

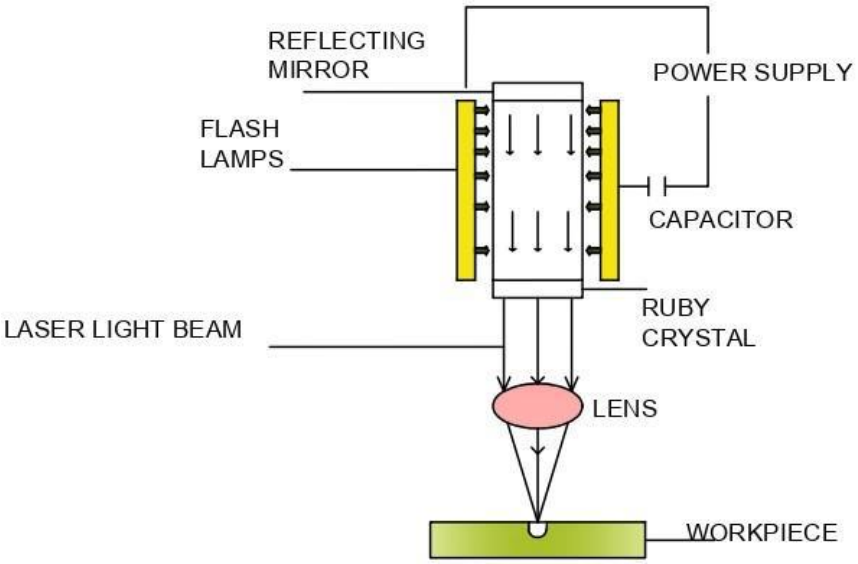
Electron beam machining uses the kinetic energy of electrons for machining. This method requires a vacuum chamber. First of all, 3 volt AC supply is given to an electron emitter which acts as cathode and the anode is kept in a vacuum chamber. High potential difference is given between cathode and anode. High energy electrons strike the workpiece resulting in metal removal. In this metal gets melted and vaporized. This method is suitable for refractory metals and chemical reactive metals. This method can be used in manufacturing PCB etc.

1.7 Electric Discharge Machining.

In the Electric discharge machining process, metal is removed by generating an electric spark between the work piece and the cutting tool. The tool is connected to the negative terminal and the work piece is connected to the positive terminal. A gap of 0.005 point is maintained between cathode and anode. The tool and the work piece are immersed in a dielectric fluid. When a DC power supply is applied to both the electrodes, the dielectric fluid is ionized and a spark is generated. Due to this spark, a temperature of 1000 degree centigrade is generated due to which the work piece melts and the metal are removed. To maintain the gap between the two electrodes, a servo mechanism is used through which the tool is fed continuously. This method is used for cutting hard metal. Since there is no contact between the work piece and the tool, no unwanted stress is generated in the work piece. This product can be used in making stamping tools, forging, mold, carbide, nozzle etc.

1.8 Laser Beam Machining.

The term laser refers to light amplification by stimulated emission of radiation. When the electrons of an atom are provided with the same energy source, they absorb energy from the various sources. By absorbing energy, these electrons move from their initial energy level to the highest energy level. But this is not the stable state of the atoms. It emits the absorbed energy in the form of photons and comes back to its initial state. This emission of photons by the electron is called spontaneous emission. When a laser is applied to the material with any energy when placed under the level it absorbs energy to some extent and when it reaches its absorption limits it releases it. The highly converted light thus produced is called laser. Laser machines work on the basic principle of laser. In this process, a laser beam is used which is a selective light. A selective light is transmitted through a lens to provide extremely high energy density to melt and vaporize any substance.



As seen in the picture, the laser crystal is in the form of a cylinder whose flat actuator head is placed in a flash lamp coil of about 1000 watts. A flash with high intensity white light is emitted from the crystal. The crystal is excited and emits a laser light beam which is focused onto the surface of the workpiece using a lens. The laser light beam produced is

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extremely narrow and is focused on the P point area with 1000 kW per square centimeter resulting in high heat generation causing the metal surface to melt and vaporize it at the P point area thus this machining is achieved.

Advantages of laser beam machining.

1 Any material including composite metals can be machined.

2 There is no wear on the tool.

3 There is no contact between the tool and the work piece.

4 Soft materials like rubber and plastic can also be machined.

5 Even extremely small holes can be machined with ease.

6 In this process no mechanical force acts on the work block.

7 heat affected zone is extremely small.

8 Less defects of laser beam machine.

9 This method cannot be used to produce blind holes.

10 The EBM method is used only on thin sections where only a small amount of the system needs to be separated.

11 Both the initial cost and operating cost of this system are high.

12 It requires highly skilled drivers.

2. Research Methodology.

When we have many alternatives and many criteria to do a task, then the MOORA method is the most used method to solve the problem in the last decade.Moora Method was invented in 2004. This method is used to solve many desirable and undesirable criteria simultaneously in different types of alternatives and criteria. Main advantages of this method, it requires only a single equation to solve the problem. It gives results in both the conditions without giving weight or criteria weight. This method can be used for both numerical values and grades. It can be used in any decision making problem. Mathematics is not required. It solves problems in simple MS Excel. No separate software is required.

In the first step, we create a decision matrix for any given alternative and criteria.

The second step is to normalize the decision matrix.

In the third step we can multiply weight to various criteria.

In the fourth step, classification of benefit criteria and non-benefit criteria is done.

In the fifth step, non-benefit criteria are subtracted from the benefit criteria.

Using the above equation, we get the ranking from the given alternative by performance evaluation. To get the rank through moora method, we arrange the assessment values in descending order. We get the highest value as the best alternate or rank one and the lower value as the lowest alternate or lower rank.

Table 1: Source Rao P. N. “Metal cutting & Machine Tools” Economic comparison of Unconventional Processes.

NCMP	Capital Investment	TOOLING	Power required	Efficiency	Tool consumption
USM	Low	Low	Low	High	Med.

AJM	V.Low	Low	Low	High	Low
ECM	V.High	Med.	Med.	Low	V.Low
CHM	Med.	Low	Low	Med	V.Low
EDM	Med.	High	Low	High	High
EBM	High	Low	Low	V.High	V.Low
LBM	Med.	Low	V.Low	V.High	V.Low
PAM	V.Low	Low	V.Low	V.Low	Low
Milling	Low	Low	Low	V.Low	Low

Table 2: Initial Decision matrix of non conventional machining process selection problem.

NCMP	Capital Investment	TOOLING	Power required	Efficiency	Tool consumption
USM	2	2	2	4	3
AJM	1	2	2	4	2
ECM	5	3	3	2	1
CHM	3	2	2	3	1
EDM	3	4	2	4	4
EBM	4	2	2	5	1
LBM	3	2	1	5	1
PAM	1	2	1	1	2

3. Results and Discussion :

In this problem, Eight NCMP alternates have been solved to get the ranking. Five criteria have been considered for these eight alternates in which capital investment, various tooling fixture, power required, tool consumption and efficiency have been considered. This problem becomes a multi criteria decision making task. To solve it, moora methods have been used to optimize this problem. Moora method is an excel based 5 steps method which has been used for ranking the eight alternatives to find out the best method.

Moora method.

NCMP	Capital Investment	TOOLING	Power required	Efficiency	Tool consumption
USM	2	2	2	4	3
AJM	1	2	2	4	2
ECM	5	3	3	2	1
CHM	3	2	2	3	1
EDM	3	4	2	4	4
EBM	4	2	2	5	1
LBM	3	2	1	5	1
PAM	1	2	1	1	2

NCMP	Capital Investment	TOOLING	Power required	Efficiency	Tool consumption
USM	4	4	4	16	9
AJM	1	4	4	16	2
ECM	25	9	9	4	1
CHM	9	4	4	9	1
EDM	9	16	4	16	4

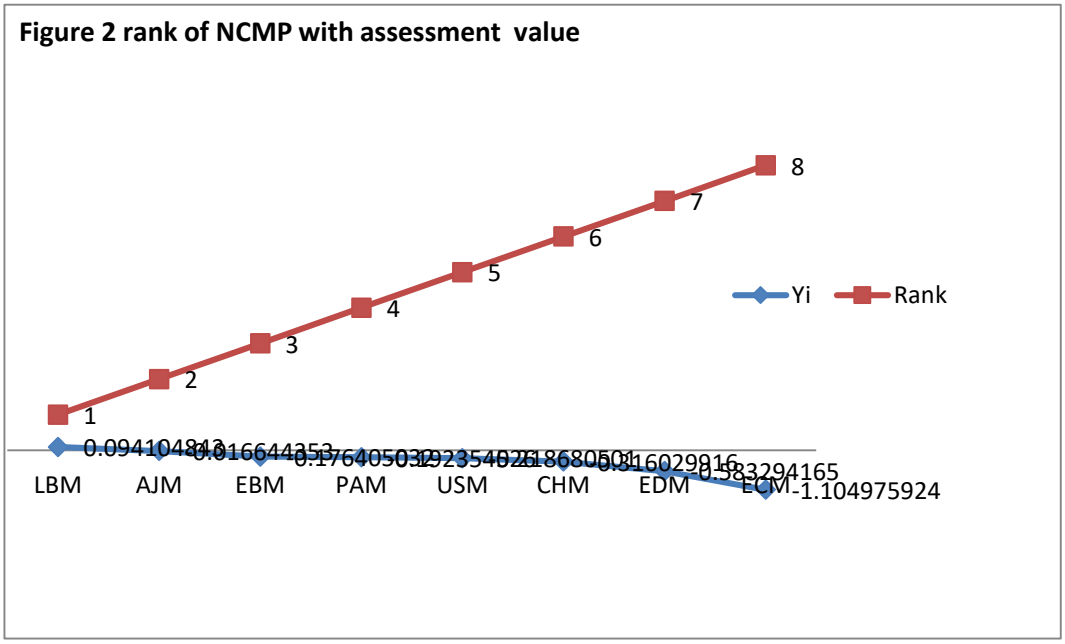
EBM	16	4	4	25	1
LBM	9	4	1	25	1
PAM	1	4	1	1	2
	8.60232527	7	5.56776436	10.5830052	10.58300524

NCMP	Capital Investment	TOOLING	Power required	Efficiency	Tool consumption	Yi
USM	0.09299811	0.11428571	0.14368424	0.30237158	0.170084013	-0.21868
AJM	0.02324953	0.11428571	0.14368424	0.30237158	0.037796447	-0.01664
ECM	0.58123819	0.25714286	0.32328954	0.07559289	0.018898224	-1.10498
CHM	0.20924575	0.11428571	0.14368424	0.17008401	0.018898224	-0.31603
EDM	0.20924575	0.45714286	0.14368424	0.30237158	0.075592895	-0.58329
EBM	0.37199244	0.11428571	0.14368424	0.47245559	0.018898224	-0.17641
LBM	0.20924575	0.11428571	0.03592106	0.47245559	0.018898224	0.094105
PAM	0.02324953	0.11428571	0.03592106	0.01889822	0.037796447	-0.19235

Rank of NCMP with Assessment Value

NCMP	Yi	Rank
LBM	0.09410484	1
AJM	-0.01664435	2
EBM	-0.17640503	3
PAM	-0.19235453	4
USM	-0.2186805	5
CHM	-0.31602992	6
EDM	-0.58329416	7
ECM	-1.10497592	8

Figure 2 rank of NCMP with assessment value



4. Conclusion:

In this novel paper there were eight alternatives for cutting a given metal. There were five criteria for these eight alternate. Capital investment, tooling fixture, power requirement, tool consumption and efficiency were considered as criteria to find out the best alternative for this problem and to find out its rank. This problem was optimized by moora method. Moora method is a simple MS Excel based optimization technique in which the rank of any task is determined by a single equation without much complicated mathematics. The result showed that the Laser beam machining is the best alternative for the problem and AJM got the second rank and other methods also got rank. We can use these results to do artificial intelligence based machining. In future, efficiency can be increased by further research by converting laser beam machining into CNC machine with an algorithm.

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