

Non-Traditional Machining Process: A Review

DEBASISH MOHAPATRA,Raajdhani Engineering College, Bhubaneswar[1]
AVAYA KUMAR BALIARSINGH,Aryan Institute of Engineering and Technology, Bhubaneswar[2]
DR. PUNITA KUMARI,NM Institute of Engineering and Technology, Bhubaneswar[3]
Mr. SARADENDU BHUJABAL,Capital Engineering College, Bhubaneswar[4]

***Abstract*: - The main issues with traditional machining process is its time consuming, less accurate manufacturing and difficult in machining the materials like stainless steel, titanium alloys, high strength temperature resistant (HSTR) alloys, fiber-reinforced composites, ceramics, refractories etc. Generation of complex shapes in such materials by the NTM processes has become much easier with higher accuracies and at a much faster rate. But NTM is not a cheaper process like traditional machining. It involves a bigger installation, maintenance and machining cost. Hence it is a tough job for the production/process engineers for selecting a suitable manufacturing process. In this literature, a clear analysis is done for the cost- benefit of non-traditional machining for different level of production.**

Keywords:- Non-conventional machining processes, Non traditional machining, Conventional machining, Titanium alloys.

INTRODUCTION:

In recent years there has been a massive growth in the usage of the non - traditional machining process. Especially in machining of hard materials likes titanium, stainless steels. These materials have wide use in modern industry due to their improved mechanical properties.

These materials have various applications in the manufacturing of product. These materials cannot be machined economically using conventional manufacturing process. In the competitive business environment customer expects high accurate product with low cost, cost and process optimization using conventional manufacturing methods is not suitable, this forces to use non tradition manufacturing methods. The unique characteristics of this processes is that there is no direct contact between tool and the workpiece and also in this process a huge amount of energy can be concentrated per unit area. Also the selection process becomes more important as all the machining processes cannot be done by using a single method we need to choose an efficient method for different machining processes. Also as we understand the importance and efficiency on non-traditional machining over traditional machining it gives us advantages over it and also this NTM processes leads to lot of advancement which has to be done day by day. This NTM process also gives us a path for various innovations as well as it makes us comfortable for designing of complex geometrical shapes. These situations made easier using a 16-digit classification process can be done as all the methods are stored in the database of the system. To conduct theses

There are various aspects to be considered before selecting

selection processes we require an expertise human resources and a structured approach is always made.

leads to a great competition in the market. As there is difficulty in the selection of NTM process this selection is code(cogun,1993,1994). Here the optimization selection of So in the given literature review we discuss various selection processes and methods through which the selection of the processes is done.

LITERATURE REVIEW:

Non-traditional machining (NTM) processes are typically classified based on the nature of energy employed in machining which includes:

- **Mechanical machining process:** The process in which mechanical energy is employed to erode the unwanted material by using high velocity jet of water, abrasives etc .The various machining process that utilizes mechanical energy include: Ultra sonic machining (USM), Abrasive flow machining (AFM),Magnetic abrasive finishing(MAF),Abrasive jet machining (AJM),Water jet machining (WJM), Abrasive water jet machining(AWJM).
- **Chemical or Electrochemical Energy:** In this process, the material is eroded by the mechanism of ion displacement or by chemical dissolution with the chemical reagent or etchants (acid, alkaline solutions) .This process requires high current as the source of energy and electrolyte as the medium for the process to take place. In order to enhance the machine capabilities and increase the efficiency of the process, different forms of energy are combined together to develop hybrid NTM process. Machining process which include chemical energy include: Electrochemical process (ECM), electrochemical grinding(ECG) ,electrochemical honing (ECH),Electro chemical deburring (ECD),chemical machining (CM).
- **Thermal or electrothermal energy :** Thermal energy is utilized to melt and vaporize small areas of the work surface by concentrating the heat energy such as heat developed due to high voltage, amplified light or ionized material. Machining processes that utilizes thermal energy include: Electrical discharge machining (EDM), laser beam machining (LBM), electron beam machining (EBM), plasma arc machining (PAM),

any NTM process, such as properties of the work material, Shape to be machined, physical parameters, process capabilities ,economic considerations

Process Parameters in selection of Non-Traditional

Machining:

The processes used for optimizing any NTM process includes the use of highly collimated, monochromatic and coherent light beam for melting and evaporation of the work material. The selection of NTM process involves the identification of the work material and the type of machining process to be carried out .More importance is given for the properties of the work material such as hardness, thermal resistance, chemical inertness, electrical conductivity, strength to weight ratio and life expectancy, All these properties are to be high for better machinability. Among the various process, USM has good capability and is versatile as both conductive and non-conductive, brittle, complicated in shape can be machined with great precision. There are two different categories in laser beam machining: laser micromachining and laser milling .In plasma arc machining high temperature plasma arc is generated to remove material in PAM process. ECDM involves material removal through electrochemical erosion and electro chemical dissolution. It utilizes electrical discharge in electrolytes for removal of material, which

assists in achieving higher material removal rate.

The selection of non-traditional machining process is based on three parameters, which include: workpiece material, machining operation, process characteristics.

DIFFERENT MACHINING OPERATIONS IN NTM:

Many complex designed products can be generated on the work piece material by the application of appropriate NTM processes.

- Deep cutting: The machining operations are carried out to generate the desired design on the work piece material with more depth of cut.
- Shallow cutting: In this operation the depth of cut is comparatively low.
- Drilling operation: This operation is used to cut or to machine a hole of circular cross section in a solid.
- Precision cavity: A cavity with close dimensional tolerances is produced for its internal application.
- Standard cavity: a cavity with clear set of dimensions is produced, but it cannot be employed for intrinsic applications.
- Double contouring: The shape feature obtained is demarcated into two separate and different, top and bottom contours of the work piece material.
- Surface of revolution: This operation is done to obtain good surface finish on the work-piece by rotating the work piece in two dimensional curve about its axis.
- Finishing: This machining operation is done to attain mirror finish on the surface of the work piece with high accuracy and superior surface finish.

PROCESS CHARACTERISTICS:

Some process characteristics have a direct influence on the productivity and effectiveness of the NTM process, which include:

- Voltage characteristics- A potential difference is applied to operate the non-traditional machining setup.
- Corner radius (in mm)- The radius of a circle that is generated if the corner arc of a rectangle is extended to form a complete circle.
- Total cost – Total cost of NTM setup includes the cost of tooling, fixture, power consumption, and tool wear cost.
- Current characteristic (in A) - To initiate the material removal process in NTM processes there should be flow of electrons or ions inside the electronic circuits.
- Volumetric material removal rate(in mm3/min) – The volume of material removed from the work piece per unit machine time.
- Power rating (in W) – The power rating of a NTM setup.
- Safety (in R scale) – The safety refers to the safety of the operators while performing a machining operation in an NTM equipment.
- Surface damage(in micro meter)- The damage caused on the work-piece surface due to the imperfect machining and the impact forces acting on the work-piece during machining or due to ion beam bombardment.
- Surface finish (in micro meter) – It is the allowable deviation from an absolutely flat surface which can be accomplished through the machining action and is measured in terms of center line average or roughness average value.
- Taper (in mm/mm)- A gradual narrowing of the work-piece from the reference towards one end of the work piece.
- Tolerance (in micro meter)- The dimensional closeness of the end product when compared with the given specifications .
- Toxicity – Toxicity is the environmental hazards caused due to the machining medium contamination.

The NTM process selection arises with the identification of the type of work piece material and the type of machining operation that has to be carried out. Many scholars are involved in research in the field of nontraditional machining processes, some of them have produced theories or systematic procedures for selection of nontraditional machining process:

Yurdakul and Cogun (2003) proposed a selection procedure for NTM processes based on a combination of analytic hierarch (AHP) and technique for order inclination which links the similarities to ideal solution (TOPSIS) methods. AHP method is used to determine the criteria for weights ,i.e. relative importance of the criteria, whereas TOPSIS method is used to rank each of the viable NTM process. Chajraborty and Dey (2006) presented a schematic methodology for selection of the best NTM process which are constrained of material and machining conditions.

Chakladar and Chakraborty (2008) proposed the use of the combined approach using the TOPSIS and AHP methods to choose the most appropriate NTM process for a particular work material and the shape feature combination. Chakraborty (2011) identified the application of a recent MCDM method , i. e the multi-objective optimization of the NTM process, based one the ratio analysis (MOORA) method to solve different MCDM problems in manufacturing environment including NTM selection problem. Das and Chakraborty(2011) proposed he use of analytic network (ANP) method to select the most precise NTM process for a given machining application considering the interdependency and feedback relationship among various criteria affecting the NCMP selection decision .

Sadhu and Chakraborty(2011) initiated the use of the data envelopment analysis(DEA) method fo solving NTM selection problems .The authors considered solving of two case studies and the results obtained proved the applicability, versatility and adaptability of this NTM selection approach. Karande and Chakraborty (2012) developed solution of selecting four NTM processes using an integrated preference ranking organization method for enrichment evaluation (PROMETHEE) and geometrical analysis for interactive aid (GAIA) method .

Chatterjee and Chakraborty (2013) found out the applicability, suitability, and potentiality of evaluation of mixed data (EVAMIX) method for solving the NTM process selection problems.

OCRA METHOD OF SELECTION OF MACHINING PROCESS:

Operational competitiveness ratings analysis(OCRA).The OCRA method was developed by Parkan (1991) and later was advocated Parak and Wu (1997, 2000). The OCRA method helps to select the more appropriate NTM process for a particular machining application considering the different qualitative and quantitative criteria,such as tolerance and surface finish, material removal rate, cost, power requirement, efficiency, tooling and fixtures, tool consumption, work material, safety, shape features, etc.

The OCRA method is a multi-criteria decision making (MCDM) method which is helpful in calculating the relative performance of a set of competitive alternatives.

The main improvement of the OCRA method is that it deals with the MCDM situations when the relative weights of the criteria are dependent on the alternatives and these different weight distributions are assigned to the criteria for different alternatives, and also some the criteria are not appropriate to all the alternatives which is given by Chatterjee and Chakraborty,2012).This method has the advantage for maximization and minimization criteria separately, this condition helps the decision makers not to lose information during the decision-making process. The other improvements in OCRA methods includes the non-parametric approach (i.e. calculation of procedure is not affected by the introduction of any additional parameters).The main benefit of OCRA method is to perform independent evaluation of alternatives with respect to beneficial and also the non-beneficial criteria, and lastly to combine these two sets of ratings to obtain the operational competitiveness ratings.

QUALITY FUNCTIONAL DEVELOPMENT PROCESS

Quality functional development (QFD) is a method developed by the japenese in the beginning of 1996 to help transform the voice of the customer into engineering characteristics for a product. This procees of selection of NTM process was developed by Akao (1990) and the inference brought out, were first implemented by Mitsubishi Industries in 1972. QFD is an efficient approach for product planning and development based on the customer requirement and technical requirement (TR). The process of quality function development (QFD) is described in ISO 16355-1:2015. Concept selection can be used in coordination with QFD to select a promising product or the service configuration from among the alternatives .modular function development uses QFD to establish customer requirements and to identify important design requirements with the special emphasis on modularity. The main goal of QFD is to translate the subjective quality criteria as quoted by the customer into objective ones so that it can be standardized and can be suitably used for the design and manufacture of the product. QFD is a systematic structural approach for product planning and development. By adopting this information, the research team can be able to specify the customer's requirement and then by evaluating each proposed product systematically so as to identify the degree to which it meets the expectation of customer (Hauser & Clausing, 1988; Wasserman, 1993). The implementation of QFD involves formation of house of quality (HOQ) matrix as named by Hauser and Clausing (Kahraman et al., 2003).

The Product characteristics as outlined by Chakraborty and Dey (2007), The basic characteristics of QFD is to provide better judgment amongst different criteria which will be easy and also help to examine those criteria influencing the selection of the suitable NTM process. The product characteristics which have been considered for NTM process are:Workpiece material (WPM), Shape feature (ShFe), Surface finish (SF), Minimum surface damage depth (SDD), Tolerance (T), Corner radii (CR), Production time (PT), Product economy (PE),

In order to avoid repetitive analysis all of the above-mentioned product characteristics it has to be assumed to be independent of each and every characteristic. Since the product characteristics can have a range of priority values, so the application of FAHP becomes essential to calculate the weights of individual product characteristics. The optimal NTM process selection decision depends on the extent to which its process characteristics are able to meet desired product characteristics. Thus, the process characteristics that are responsible for achieving the required product characteristics are listed as follows:

- Material application: It defines the frequency at which a particular NTM process is to be used for a given material.
- Shape application: It shows the capability of a NTM process for the generation of a specific shape on a particular material.
- Capital investment: It is the total initial cost and related investment needed for the installation of a particular NTM process.
- Tooling and fixtures: If a NTM process needs replacement of any tooling and fixture then it is covered under this product characteristic.

- Power requirement: It is power rating of a particular NTM process.
- Efficiency: It is ratio of the amount of energy applied for the material removal on NTM to the amount of input energy given to machine.
- Process capability: It is the capability of a particular NTM process to achieve high precision and surface finish, maximize material removal rate (MRR), mitigate surface damage depth.
- Tool consumption: This characteristic takes care of the tool-changing requirement for machining a particular product and also takes care of any cost involved with it.

Coğun (1993) used an interactively developed 16-digits classification code to eliminate inappropriate NTM processes from consideration and rank the remaining efficient processes. Yurdakul and Coğun (2003) presented a multi-attribute selection procedure integrating technique for order performance by similarity to ideal solution (TOPSIS) and analytic hierarchy process (AHP) to help the manufacturing personnel in determining suitable NTM processes for given application requirements. Chakraborty and Dey (2006) designed an AHP-based expert system with a graphical user interface for NTM process selection. It would depend on the logic table to discover the NTM processes lying in the acceptability zone, and then select the best process having the highest acceptability index. Chakraborty and Dey (2007) proposed the use of a QFD- based methodology to ease out the optimal NTM process selection procedure. Das Chakladar and Chakraborty (2008) developed an expert system while combining TOPSIS and AHP methods for selecting the most appropriate NTM process for a specific work material and shape feature combination. Prasad and Chakraborty (2014) Chandrasselan et al. (2008) developed a web-based knowledge base system for identifying the most appropriate NTM process to outfit specific circumstances based on the input parameter requirements, like material type, shape applications, process economy and some of the process capabilities, e.g. surface finish, corner radii, width of cut, length-to-diameter ratio, tolerance etc.

Das Chakladar et al. (2009) presented a digraph- based approach to solve the NTM process selection problems with the help of graphical user interface and visual aids. Das and Chakraborty (2011) initiated an Analytic network process (ANP)-based approach to select the most appropriate NTM process for a given machining application taking into account the interdependency and feedback relationships among various criteria affecting the NTM process selection decision. An ANP solver was also developed to systemize the entire NTM process selection decision procedure.

Sadhu and Chakraborty (2011) applied the input- minimized-based Charnes, Cooper and Rhodes (CCR) model of data envelopment analysis to shortlist the efficient NTM processes for a given application, and then engage a weighted-overall efficiency ranking method to rank those efficient processes. Chakraborty (2011) employed multi-objective optimization on the basis of ratio analysis (MOORA) method to select the most suitable NTM process for a given work material and shape feature combination.

Karande and Chakraborty (2012a) integrated PROMETHEE (preference ranking organization method for enrichment evaluation) and GAIA (geometrical analysis for interactive aid) methods for NTM process selection for a specific machining application. Karande and Chakraborty (2012b) applied reference point approach for choosing the most suitable NTM processes for generating cylindrical through holes on titanium and through cavities on ceramics. Chatterjee and Chakraborty (2013) explored the applicability of evaluation of mixed data (EVAMIX) method for solving the NTM process selection.

Temuçin et al. (2014) proposed a decision support model to assess potentials of seven distinct NTM processes in the cutting process of carbon structural steel with the width of plate of 10 mm. A decision-making model is thus developed to reduce the gap between the prediction of the best NTM processes and real time machining requirements.

DEVELOPMENT OF A QFD-BASED NTM PROCESS SELECTION FRAMEWORK:

The importance of weight of each technical requirement can be calculated through simple mathematical expression, while identifying the correlation among all these factors (Chan & Wu, 2005). These customers' requirements are placed along the rows of the HOQ matrix. On the other hand, work material, safety and cost are considered as the technical requirements (process characteristics). These product characteristics and process characteristics for the developed HOQ matrix for NTM process selection are shortlisted only after considering the valuable opinions of the process experts and after a detailed review of the past research works. In the HOQ matrix, the beneficial or non-beneficial characteristic of the customers' requirements is identified by the corresponding improvement driver value (+1 for beneficial criteria and –1 for nonbeneficial criteria). Thus, among the considered product characteristics, machining cost, power consumption and tool wear, being non-beneficial attributes, always require minimum values for the selection of the NTM process. On the other hand, in the HOQ matrix, power requirement and cost are identified as the non- beneficial process characteristics. In this HOQ matrix, the relative importance (priority) of the product characteristics can be evaluated using a fuzzy priority scale having triangular membership function with scale values set as 1 - not important, 2 - important, 3 - much more important, 4 - very important and 5 - most important. For filling up the HOQ matrix and developing the interrelationship matrix between product characteristics and process characteristics, again a fuzzy priority scale is proposed as 1 - very very weak relation, 2 - very weak relation, 3 - weaker relation, 4 - weak relation, 5 - moderate relation, 6 - strong relation, 7 - stronger relation, 8 - very strong relation and 9 - very very strong relation. These triangular fuzzy numbers for providing the relative importance of product characteristics and process characteristics are later defuzzified using the centroid method. Once the HOQ matrix is filled up with the necessary information, the weight for each process characteristic is computed using the following equation:

In this NTM process selection model, the following NTM processes, work materials and shape features are considered based on which the best NTM process is to be chosen for a given machining application. NTM process:

- Abrasive jet machining (AJM),
- Chemical machining (CHM)
- Electron beam machining (EBM)
- Electrochemical machining (ECM)
- Electro discharge machining (EDM)
- Laser beam machining (LBM)
- Plasma arc machining (PAM)
- Ultrasonic machining (USM)
- Water jet machining (WJM).

Work material: aluminium, steel, super alloys, titanium, refractories, plastics, ceramics, and glass.
Shape feature: deep through cutting, shallow through cutting, double contouring, surface of revolution, precision small holes (diameter ≤ 0.025 mm), precision small holes (diameter > 0.025 mm), standard holes with L/D ratio ≤ 20 (L/D = slenderness ratio), standard holes with L/D ratio > 20, precision through cavities, and standard through cavities.

A combined approach of AHP and TOPSIS methods

In this method the critical cretiria factor is decided by the decision makers which make it a challenging task during implementation stage. In TOPSIS method by doing the tasks we end up getting a ideal solution to a problem so coming close to these ideal solutions we can get a optimized solution. In the TOPSIS method in associate with the AHP method completes the entire MCDM process, dealing with subjective and objective aspects. The final step of TOPSIS gives us the alternatives on basis of descending order of preference.

For calculating the normalized matrix using TOPSIS method, it is important to have both objective and subjective estimates for each of the attributes as alternatives. Once we get all the values of the decision matrix, we can continue with our further processes steps. Similarly, once the computation of the normalized matrix, the weighted, normalized matrix is found out where the relatedness of the attributes are accounted by AHP.

MADM generally helps decision-makers to find the best alternative from a fixed set. MADM methods have been vastly used in the selection of work materials, rapid prototyping processes, thermal power plants, industrial robots, evaluation of projects, mobile phones, product design, flexible manufacturing systems, performance measurement models for manufacturing organizations, plant layout design, and in other fields as well.

Hwang & Yoon (1981) established TOPSIS according to which they would find out ideal values and a negative ideal value now on the basis of which value is nearer to the ideal value that value was considered for the process.. The AHP can efficiently calculate the tangible and non-tangible solutions by processes of subjective analysis of different individuals during process of decision- making . TOPSIS method is more efficient in dealing with the tangible attributes and the number of alternatives to be assessed. The TOPSIS method needs a powerful technique to check the relative importance of different attributes with respect to the objective or final product; this can be achieved by AHP provides such a procedure. Therefore, to make use of both the methods, a combined MADM (using TOPSIS and AHP) approach is used to select the most suitable NTM process .

Data envelopment analysis (DEA) was began in 1978 when Charnes, Cooper and Rhodes (CCR) showed how to change a fractional linear measure of efficiency into a linear programming(LP) format (Charnes, Cooper, & Rhodes, 1978). Due to which, the decision-making units (DMUs) could be assessed on the basis of multiple inputs (non-beneficial attributes) and outputs (beneficial attributes), even if the production function is unknown. DEA is a technique used for measuring the relative efficiencies using multiple inputs and outputs without given any priori information about which inputs and outputs are the most important in determining an efficiency score. This non-parametric approach solves an LP formulation per DMU and the weights assigned to each linear aggregation are the results of the corresponding LP. The weights are taken so as to show the specific DMU in as positive a light as possible, under the restriction that no other DMU, given the same weights, is more than 100% efficient. Consequently, a Pareto frontier is attained, marked by specific DMUs on the boundary envelope of the input–output variable space. This frontier is considered as a sign of relative efficiency, which has been achieved by at least one DMU. An efficient alternative possesses a relative efficiency score of 1 that indicates none of its outputs can be increased without increasing the inputs or decreasing the outputs.

Charnes, Cooper, and Lewin (1994) stated DEA as ‘a mathematical programming model applied to observational data which provides a new way of obtaining empirical estimates of external relations, such as the production functions and/or efficient production possibility surfaces that are a cornerstone of modern economics’. DEA has become one of the most efficient and fastest growing areas of operations research and management science in the past decade (Adler, Fried-man, & Sinuany-Stern, 2002; Cook & Seiford, 2009)

Due to the advancement in engineering and technology, and with the continuous development of new and harder materials, an attention has been paid to the non-traditional machining (NTM) processes to machine those materials having low machinability properties. For generation of a specific shape feature on a given work material, the most suitable NTM process needs to be selected from a pool of alternative processes with diverse machining characteristics. In this paper, the CCR model of DEA is employed to identify the most efficient NTM processes for a given shape feature and work material combination, and then the MADM method is subsequently applied to rank those efficient NTM processes in descending order of priority.

To select the most suitable NTM process for generating a specific shape feature on a given work material, the following four machining aspects are considered, i.e.

- Physical parameters
- Properties of the work material and dimensions of the shape feature to be machined
- Process capability
- Economy

Keeping in mind the above-mentioned requirements, this paper considers the following ten attributes/criteria that usually influence the NTM process selection decision.

- Tolerance and Surface Finish (TSF): It reflects the machining capability of a NTM process, highlighting how closely the NTM process can maintain the tolerance and achieve the required surface finish on the work material. Surface finish is measured in terms of center line average (CLA) or Ra value (in microns).

- Power requirement (PR): It relates with the power rating of the machine/equipment for a particular NTM process in kW.
- Material removal rate (MRR): It measures the amount of material (in 3mm) removed from the workpiece by a particular NTM process per unit of time. The efficiency of a NTM process is directly proportional to MRR.
- Cost (C): It considers the initial acquisition cost and investment needed for installation of a NTM process- based machine/equipment for a given machining application.
- Efficiency (E): It is the ratio of output energy available to remove the required amount of material from the workpiece to the input energy for a given NTM process.
- Tooling and fixtures (TF): It takes into account the cost of tooling and fixtures that need to be replaced from time to time in a particular NTM process.
- Tool consumption (TC): It is associated with the cost of tool changes for a particular NTM process, although it does not consider the time required for such tool changes.
- Safety (S): It is related to the safety of the machine operators for a specific NTM process. It also considers the toxicity, machining medium contamination, and other adverse and
- Hazardous effects of the NTM processes.
- Work material (M): It mainly caters with the fact that how easily a particular NTM process can machine a given material and how often the NTM process can be used for that material.
- Shape feature (F): It considers the machining capability of a particular NTM process to generate a desired shape feature on a given work material.

LASER SINTERING:

Selective laser sintering (SLS) is a manufacturing process according to which powder coated metal additives are used, a process generally used for rapid prototyping and instrumentation.

A continuous Laser beams are used or sometimes pulsating as a heating source for scanning and aligning particles in predetermined shapes and sizes of the layers. The geometry of the scanned layers resembles to that of end product which is designed by computer-aided design (CAD) or from files produced by stereo-lithography (STL). After scanning the first layer, the scanning continues with the second layer which is placed over the first, this processes is repeated till the layer reaches top than the product is complete. SLS is also known as solid free and open shape manufacturing process, as a layer fabrication technology, rapid prototyping technology, a selective sintering of metal powders.

SLS is reactive when we use a chemical reaction of mixing components in the presence of a laser and a selective laser melting (SLM), a direct metal laser sintering (DMLS) or direct metal laser re-melting, when the complete melting of powders is pervasive over the solid state dust sintering. This process is also used in manufacturing molds, rapid handling of electrodes manufactured, polymer moulds, die casting, die casting of titanium zirconium, bio-medical application etc. MATERIALS USED IN SELECTIVE LASER SINTERING

The SLS process can be performed to a variety of materials. Some of these materials use SLS process superiorly as compared to other rapid prototyping techniques, where the material properties depend on the process. Among these materials, the most commonly used are: wax, paraffin, polymer-metal powders, or various types of steel alloys, polymers, nylon and carbonates. Polycarbonate powders were initially used as starting materials for both experimentation and modelling in the SLS process.

For example, a number of systems and metal alloys (Fe-Cu, Fe-Sn, Cu-Sn), metals (Al, Cr, Ti, Fe, Cu), ceramics (Al_2O_3, FeO, NiO, ZrO_2, SiO_2, CuO) and other alloys (bronze, nickel, Inconel 625) were tested for laser sintering. The results showed that any material can be combined with another material with a low melting point due to which it acts as an adhesive. The use of special materials for rapid prototyping is growing and the quality of products is going higher. The sintering achieves higher performance if you use a powder mixture consisting of two groups of materials: Thermoplastic materials (nylon, polyesters, waxes, some nylon or polycarbonate mixtures especially);completion materials whose mechanical properties and thermal properties determined decisive use of new products (metal, non-metallic and composite).

Selective laser sintering processes are based on a variety of materials which will result in superior products at a stage performance, the physical and mechanical properties close to the loads of the usual parts of a machine. Rapid prototyping and manufacturing technologies using materials and various other processes have been developed in recent years in several directions, depending on the material used and the technology of solidification of the material.

METALLIC POWDERS FABRICATION PROCESSES

The most modern powders and granular mixtures used by major manufacturers of carbide or drying by atomization is atomization spray. The atomizer and its related annexes are, by scale and complexity of their facilities, an independent micro-fabrication in any technological process of making pieces of hard carbide alloys. It is the main facility which provides the development of the granule in any modern manufacturing in large scale production and requires high precision and dimensional parts, such as the production of interchangeable cutting plates. Granules obtained by atomization are perfectly spherical in shape and are with no risk of oxidation in a plant partly sealed. The atomization takes place continuously and applies to basic components (fuel-oil-binder sintering), achieving good flow properties. The powder (12%Co, 88%WC) spray, grit 105 micron (600 x magnifications) Atomized powder (12%Co, 88%WC), granulation 45 microns (zoom x 300), The first operation of the process of producing atomized granules - mixing the components in a continuous flow – uses a machine called Attritor to ensure homogenization of the components and a fine wet grinding in a vertical centrifugal ball mill. The objective of this milling – mixing operations is not only to produce a uniform dispersion of cobalt , used as a binder or sintering of the mass composition of various hydrocarbons, but also used to crush, pulverize and mechanically connect with the particles of cobalt carbide in order to obtain a good sintering process.

REASONING APPROACH TO NON-TRADITIONAL MACHINING PROCESS

Using the two multi-attribute decision making (MADM) tools, i.e. analytic hierarchy process (AHP) and technique for order preference by similarity to ideal solution (TOPSIS),

Yurdakul and Cçogun attempted to simplify the NTM process selection procedure for the manufacturing personnel. A list of feasible NTM processes satisfying the users' requirements was first generated and those processes were then ranked based on their suitability to meet the desired machining operation. Chakraborty and Dey developed an expert system for selecting the best NTM process under constrained material and machining conditions. It would rely only on the priority values of different criteria and sub-criteria for a specific NTM process selection problem, and the NTM process with the highest acceptability index was finally identified.

CONCLUSION

For effective utilization of the capabilities of different NTM processes, careful selection of the most suitable process for a given machining application is often required. Selection of the best suited NTM process for a work material and shape feature combination requires the consideration of several criteria. The results obtained using the OCRA method have good correlation with those derived by the past researchers which validate the usefulness of this method while solving complex NCMP selection problems.

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