MULTIPLE RESPONSES PROCESS PARAMETERS OPTIMIZATION OF TURNING AL-TICp METAL MATRIX COMPOSITES

[1]V. NAGA PRASAD NAIDU, [2]R. RAMA CHANDRA, [3]P. HUSSAIN BABU

[1]Professor & Principle, Intell Engineering College, Anantapur.
[2]Professor & Principle, S.k.d Engineering College, Gooty.
[3]Assistant Professor, Intell Engineering College, Anantapur.

Abstract— This investigation is proposed to investigate the Machining response of Al-TiC_P metal matrix composites. Aluminum alloy is considered as a matrix metal composite. The reinforcing phase considered is TiC_P Metal matrix composites will be fabricated using stir casting techniques. The number of process parameters considered in this investigation is spindle speed, Feed rate, Depth of cut grain size of TiC_P and cutting tool material. Experiments will be planned and conducted according to DOE (Design of Experiments).The machining responses considered are surface roughness, cutting force, cutting power & tool wear. In order to predict the output responses within the range of process parameters modeling will be done using response surface methodology and artificial intelligence systems viz. Fuzzy logic / Neural Networks; Grey relational analysis is used for optimization of multiple response characteristics. Finally analysis of variance and confirmation test will be done in next step to validate the developed models.

Keywords – Stir Casting, Machining, Optimization.

I. INTRODUCTION

In presents days every organization or Industry should depends upon composite materials because of more consistent with high stability, low density and high specific strength to wear ratio. These materials are widely used in Aerospace, Automotive, Electrical & Electronics, and Metallic & Medical Industries.

Al based metal matrix composite materials are one of the important composites easily available with low cost. These Al base composites improved Strength, Stiffness, and Wear Resistance over unreinforced alloys. However the final conversion of these composites into engineering products is always associated with machining by turning operation is circular in machine industries where work-piece is rotated along its axis and cut in form of chips by cutting tools with considering cutting parameters, for instance speed, and feed, depth of cut. Despite of that it is difficult even to skilled operator to carry out the job with optimum parameters which avail better characteristics and excellent qualities. For the record optimization is the best suite technique to draw optimum values which reveals to accomplished optimum scenario of economy, performance hence overall profit.

The turning is controlled by cutting and the geometry parameters. The cutting parameters include cutting speed, feed and depth of cut. Hence there is a need to optimize the process parameters. The objective is study to find out optimization of the process for minimization of surface roughness, power consumption and machining time of turning. Design of experiments (DOE) will be adopted and optimize combination of process parameters chosen using response surface methodology. Optimization of the process parameters using Genetic Algorithm optimization. The Response Surface Methodology (RSM) and genetic algorithm are the tools to measure the performance and calculate most suitable optimistic values.

II. RELATED WORK

This emphasis basically on the number of materials and the fabrication methods of composites. Metal matrix composites (MMC) are advanced materials resulting from a mixture of two or more materials in which superior properties are realized. They are acknowledged significant attention in recent years because of their high strength, stiffness, low density.

III. MATERIALS

A wide variety of matrix cast aluminum & titanium alloy are used to fabricate composites based on different reinforcement materials depend upon on their application in industries. Aluminum and Titanium metal matrix composites are mainly used in defense, military, automobile and general engineering purpose because of their superior properties.

Composites are manufactured with great achievement by the use of fiber reinforcement materials in metal matrix metallic materials. The aim concerned in designing MMC materials is to unite the attractive attribute of metals and reinforcement. In reinforced MMC, reinforcement particle is mixed to the matrix of the mass material to boost its stiffness and strength. Applications which are subjected to serious loads, or tremendous thermal variations, such composite is superior to any machining process.

IV. CUTTING PARAMETERS

Speed

Speed always refers to the spindle and the work piece. When it is stated in revolutions per minute (rpm) it tells their rotating speed.

$$v = \frac{\pi DN}{1000} \frac{m}{min}$$

Here, V is the cutting in turning,
D is the initial diameter of the work piece in mm
N is the spindle speed in RPM.

Feed

Feed always refers to the cutting tool, and it is the rate at which the tool advanced along its cutting path.

$F = fN$ mm/ min^{-1} --------------------- (2)

Here, F is the feed in mm per minute,
f is the feed rate in mm/rev and
N is the spindle speed in RPM

Depth of Cut

Depth of cut is practically self-explanatory. It is the thickness of the layer being removed (in a single phase) from work piece or distance from the uncut surface of the work to the cut surface.
Here, D and d represent initial and final diameter (in mm) of the job respectively.
Depth of cut = (D-d) /2 mm ------------ (3)

Surface Roughness

Roughness is a measure of the texture of a surface.

Material Removal Rate

The material rate (MRR) in turning is the volume of material/material that is removed per unit time in mm^3/min. For each revolution of the work piece, a ring shaped layer of material is removed.

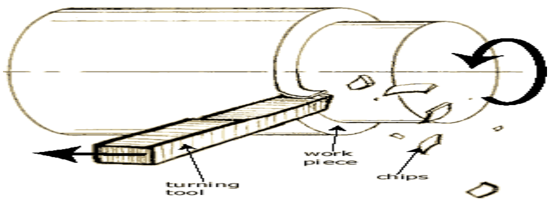

Fig- Material Removal Rate in Turning

$$MRR = \left[\frac{\pi D^2}{4} - \frac{\pi d^2}{4}\right] X\, F\, X\, rpm \; --- (4)$$

Where,
D = diameter of work piece before cutting
d = diameter of work piece after cutting

Manufacturing Methods

A number of composite fabrication have been developed that can be placed under. The following categories. They are (1) Stir Casting (2) powder metallurgical techniques (3) liquid Metallurgy (4) squeezes casting.

Among the number of techniques existing for metal matrix composites, stir casting techniques usually accepted as a namely promising way, at present practiced commercially. Its advantages are simplicity, flexibility and applicability to large quantity production. It allows a conventional composites fabrication is route to be used, and therefore minimize the final cost of the product. Metal matrix composites are usually fabricated by liquid metallurgy route or stir casting technique. A comparison of different fabrication methods are below table 1.

In stir casting the particulates phase are mechanically mixed in the liquid phase before solidification of the melt. Parameters such as unusual particle sizes, density, geometries, pour or the progress of an electrical charge throughout mixing may direct to agglomeration. In this method incorporation of matrix and reinforcement is a vital step to get a homogenous distribution of reinforcing particles in matrix. The reinforcement particles were mixed in a calculated mixer by stirring for few minutes and cast in a steel mold or sand mould. Magnesium (1%) addition during the stirring
Improves the wettability of reinforcement with the melt aluminum. The molten degasses in completely liquid condition with (Na-CL and KF) blend then skimmed, followed with degassing by pure argon for 30 to 40 seconds. Stirring, the molten metal composites are poured into the permanent mould, which was preheated to 200^{o}c.

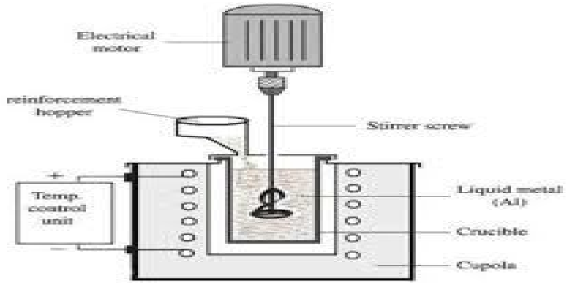

Fig.1 A schematic diagram of Stir Casting Technique

V. THE POWDER METALLURGY PROCESS

The concept of making parts from metal powder is simple and straight forward; however, the techniques employed can be very sophisticated, requiring a high level of technical competence and a substantial investment in capital equipment. The process consists of three steps: blending, compacting, and sintering.

Blending

Blending is the process of powder agitation for the purpose of homogenizing the particle sizes. Mixing also takes place and serves to intersperse powders of different chemical compositions. Alloyed powders are produced by combining a homogeneous mixture of carefully weighed and blended powders.
Lubricants are added to the powder to reduce friction between the particles as
They are being compacted, as well as to reduce die wear. Stearic acid, lithium stearate, or powdered graphite is the principal lubricants used. Blending is almost universally done dry; however, in some finely divided aluminum powders, to reduce dust and the danger of explosion or fire, the process is done wet.

Compacting

After the metal powders have been blended to achieve various desired properties, they are pressed or compacted to the required shape, size, and density.

Metal powders present problems of internal friction when pressed in the die. Both density and strength decrease in the powder mass as the distance from the punch increases. To minimize this condition, punches are used at both ends of the die as shown in fig. the use of lubricants improves the density, minimizes the load required, and increases life, particularly by easing part ejection. However, lubricants can create problems in reduced green strength, in feeding the powder into the die, and in lubricant reaction. Lubricants must be driven off by a low temperature stage heating before sintering,

For high volume production, tungsten carbide is used as the die material.

Although the cost is higher, it will outwear the normally used tool steels by a ratio of

About 10:1. Some carbide dies can be used to produce a million parts before tolerances are exceeded. High pressures, sometimes in excess of 50 tons/in2. (689.5Mpa) are used to cause mechanical interlocking between the irregularities of the particles.

The compaction operation consolidates and dandifies the powders into what is commonly termed a green compact. The compact will be very close to the size, shape, density of the finished part. After ejection from the die the part can be handled, but is relatively fragile in the green state and if dropped will probably crack.

There are two main methods of compacting metal powders: (1) with a punch and Die (2) is statically. Part geometry is the major factor in determining which method is to be used. If the part shape is simple, mechanical pressing is likely to be used. Parts with intricate configurations can be made by isostatic compaction discussed later.

Die Compaction: Die compaction is limited to vertical motions only, so parts with back angles are undercuts cannot be made. For a mechanical press operating on powder fill/ compaction/ejection cycle of 3 to 4 seconds, approximately 1000 components can be produced per hour. For simpler parts, these outputs can be increased with multi station rotary presses, where multiple sets of tools are mounted on a rotary table. Punch motions are actuated by fixed, horizontal cam tracks or rollers, and the presses are capable of very high output rates in the order of 35,000 parts per hour.

Mechanical and Hydraulic Presses. Both mechanical and hydraulic types of Presses are used for compacting. The advantages and limitation of each are briefly as follows.

Mechanical presses are of lower tonnage (usually 200 tons or less) and have faster cycles. Normally no dwell time is possible, although newer presses have clutches. Compacting is done to given height, not to a given pressure or density.

Hydraulic presses are of higher tonnage (usually 500 tons or more), have slower Cycle time, even with accumulators, and have infinitely variable dwell time. Parts may be pressed to a given load to provide good density control. Limit switches may be used for height control.

VI. SINTERING

Sintering is the third step in producing powdered metal parts. The green compacts are heated in muffle type or wire mesh conveyer belt furnace. Special atmosphere, such hydrogen or dissociated ammonia, are required for sintering of ferrous metal to control both carburization and de carburization of iron and iron rich compacts.

Furnace temperature vary with the sintering requirements; for brass, a temperature of 1600^o to 1615^0F (870^o to 880^oC) is satisfactory, and for stainless steel, 2000^o to 2350^oF (1100^o to 1300^oC) is used. The temperature must remain between 60% to 80% of the melting point of the principle constituent. The sintering time may range from 20 minutes to an hour or more. The lubricants that were originally blended with the powders are permitted to burn off in a special chamber before the parts reach the high heat zone of the furnace.

VII. LIQUID METALLURGY ROUTE

Liquid state processes include stir casting or compo casting, infiltration, spray casting and in situ (reactive) processing. The selection of the processing route depends on many factors including type and level of reinforcement loading and the degree of micro structural integrity desired.

VIII. SQUEEZE CASTING

The squeeze casting process is actually a combination of casting and forging. A precise amount of molten metal is poured into the bottom half of a preheated die set and allowed to partially solidify. An upper die then descends applying pressure throughout the duration of solidification. Intricate shapes can be produced at that are far less than would normally can required for hot or cold forging. Both retractable and disposable cores can used to create holes and internal passages. Gas and shrinkage porosity are substance reduced and mechanical properties are enhanced. The process can be applied to both ferrous and nonferrous alloys and both wrought and cast alloy be processed.

An adaptation of the process can be used to produce metal matrix composites by forcing the pressurized liquid around formed or fiber reinforced that have been positioned in the mold. Another modification involves the use of thixotropic semi solid material. Here the need to introduce a precise amount of molten metal into the die is eliminated by starting with chucks of metal that have been heated into the semisolid range. Thixotropic material can be handled mechanically, like a solid, but shaped at low pressure because it flowed like a liquid when agitated or squeezed. The absence of the turbulent flow minimizes the gas pickup and entrapment. Since the material is already partially solid, solidification shrinkage and related porosity is reduced. Cooling while under pressure completes the solidification, while simultaneously producing high quality intricate parts with good finish and precision

Table.1.Comparative evaluations of the different techniques used for MMCs fabrication.

Method	Range of shape and size	Metal Yield	Range of volume fraction	Damage to reinforcement	Cost
Liquid metallurgy(Stir Casting)	Wide range of shapes; up to 500kg	Very high,>90%	Up to 0.3	No damage	Least expensive
Squeeze casting	Limited to perform shape	Low	Up to 0.45	Severe damage	Moderately expensive
Powder metallurgy	Wide range; restricted size	High	-	Reinforcement fracture	Expensive
Spray casting	Limited shape; large size	Medium	0.3-0.7		Expensive
Lanxide technique	Limited by pre-form shape; restricted size	-	-	-	expensive

IX. LITERATURE REVIEW

The following review given us an idea of the techniques used for fabricating, Wear Analysis, Machining of Turning & Optimization of aluminum and titanium carbide powder metal matrix composites.

Raidu et al, (2010) developed a fuzzy logic based model for selecting cutting parameters in turning tool and die steel with cemented carbide, ceramic and sintered PcBN cutting tool during hard turning operation.

M.Subramanian et al, (2013) In this metal matrix composites (AL 7075-T6) they developed a statistical model a predict cutting force on terms of machining parameters such as cutting speed, feed rate and axial depth of cut Responses surface methodology experimental design was use for conducting experiments. The tool was shoulder mill with two carbide insert the cutting force were measured using three axis milling tool dynamometer. The second order mathematical model in terms of machining parameters was developed for predicting cutting force; the optimization of shoulder mill machining parameters to acquire minimum cutting force was done by Genetic Algorithm (GA)

C.Dileep Kumar et al, (2014) the effect of cutting parameters on surface finishes and optimizes them for better surface finish and material removal rate (MMR) during turning of Ti-6Al-4V. A combined Taguchi method and grey relational analysis is used for the optimization. Analysis of variance (ANOVA) is employed to find out contribution of each at three level and is designed by using Taguchi's L9 Orthogonal array (OA) MINITAB statistical software is employed to create the plan carrying out the analysis.

K.Krishna et al. (2015) They study the prediction of material removal rate (MMR) of CNC turning using back propagation neural network (BPNN) machining operation have been performed in AL work piece by carbide insert over a range of cutting parameters of BPNN & MRR, spindle load has been use as output of the network, And they inclusion of cutting speed, fee rate, depth of cut as an input parameters lead to better training of the network. And they performance of the Artificial Neural Network (ANN) has been found.

Girish Kant et al,(2015) it develops a predictive an optimization model b coupling the two artificial intelligence approaches- artificial neural network (ANN) and genetic algorithm (GA)-as an alternative to conventional approaches in predicting the optimal value of machining parameters(cutting speed, feed rate, depth of cut and flank wear) leading to minimum surface roughness. A real machining experiment has been referred in this to study to check the capability of the proposed model for prediction and optimization of surface roughness.

Arezzo et al, developed an expert system to select cutting tools and cutting conditions of turning operations using Prolog. The system can select the tool holder, and the insert and cutting conditions, such as cutting speed, feed rate and depth of cut. Dynamic programming was used to optimize the cutting conditions.

R.Arularasan et al, (2015) they study titanium alloy composites the non conventional optimization technique, Genetic algorithm (GA) results were compare with taguchi optimization technique. Te process variable considered for optimization are speed, feed & depth of cu

CONCLUSION

Based on the above investigation, it is conclude that there are number of techniques which are used to prepare composite material, the Stir casting Technique is best way to fabricate the MMC's. In this research the optimization of machining condition with corresponding surface Roughness, Cutting Power & Tool wear rate, In this field the turning parameters optimization using Grey Relational Analysis, Neural Network method but there is a lack in studies in the field of vibration optimization in turning operation which is very important. The performance of quality of surface and optimization of cutting parameters with aid of DOE, Grey Relational Analysis Neural Network, optimization is one of the goals of manufacturing systems also it is simple to use and are increasingly used to solve inherently intractable problems quickly. However many studies are concentrated on optimization of surface roughness and cutting parameters.

ACKNOWLEGEMENT

Finally I Wish special thanks to all authors & my guides to give excellent path of my investigation in Al based composites.

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