An Overview of Recent End Milling Operation on MMCs

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ABSTRACT:

In the current global competition non conventional machining process is having specific interest. The different machining characteristics are developed over conventional milling operation is focused basically on quality of the product. The demand of high performance equipment parts in various field of industrial or academic application attracts the modification in milling process. The improvement in surface finish, material removal rate, stress free surface, burr free textures, tool life enhancement, multi operational system by optimizing the production time, tool replacement time CNC end milling has a significant role. As in the field of smart material revolution, MMCs (MMCs) are widely appreciated for its light weight and good functional property, mostly used in aerospace, automobile field. This article significantly focused on study of critical parameters on end milling operations of MMCs. The influence of milling process parameters i.e. Spindle speed/Cutting speed, Feed rate, Cutting thickness, surface roughness, tool wear, chatter stability, tool and work piece interface temperatures are well described. The optimization of burr formation in end milling of MMCs still requires more attention in the field of research. The micro structural studies of MMCs develop the surface quality including robust mechanical performance after the end milling operation. This review presents the overall study of governing parameters in end milling operation of MMCs.

Key Words: Milling machining, CNC machining, cutting parameter, chatter stability, Metal matrix composite material, Micro structural studies.

1. INTRODUCTION:

The significant objective of this paper is to represent the manufacturing of MMCs with its convenient composition and demand in the field of milling operation. It is focused about the performance development by controlling significant factorsi.e. (MRR , Surface Roughness , Machining Time) the output response are depend open the input factor (Spindle Speed , Feed Rate , Cutting Thickness) . The most predominant factorsconcentrate on desired superior quality of surface roughness, machining time & machining cost.

As in the current scenarioMMCs are having specific interest due to its good physical and chemical property with excellent development of mechanical property also. Composite is a versatile product amidst high strength to weight ratio,lightweight, fire resistance, electrical properties, chemical & weathering resistance, translucency, Design flexibility, low thermal conductivity, manufacturing economy. MMCs High strength, fracture toughness and stiffness are offered by metal matrices than those offered by their polymer counterparts. Most metals Titanium, Aluminium and Magnesium are the popular matrix metals currently in vogue, which are particularly useful for aircraft applications being its light weight.

2.End Milling:

In the end milling the cutter is used it is thin as compared to the work piece width. Most of cases this type of milling operation is used for slot operation. The slot operation is done on the work piece. The surface roughness is elaborately defined by M. Alauddin etal [1] with the mathematical model in end milling operation.The highly automated CNC end milling machine requires to reliable model for prediction of tool flank wear, here machining occurs on LM25 Al/Sic_p alloy is explained by Arkiadass et.al [2]. Sammy et al.[3] described the AA6351-B4C composite material has been manufactured by the stir casting method and subjected to end milling machining operation. Here it is analyzed the parameter of the milling operation as the chip thickness, surface roughness, temperature rises and critically studied tool flank wear. In the experiment the titanium nitride (TiN)-coated solid carbide tool with four flute end mill [3]. The surface integrity of particle metal matrix composite material is affected the parameter or surface formation by the MMCs. N.reddy et al. [4] used Al/Sic as work piece& TiN/Al coated carbide tool inserts. The performance characteristics ofS545C medium carbon steel is described by Chang et al. [5] used for evaluatingroughness in end milling process along feeding direction, axial direction & waviness. Palaniadaja et al.clearly explained the machining characteristics of LM 25 Al/Sic_p composite material along with TWR by RSM (response surface methodology) and CCD (Central Composite Design) method. Also tool flank wear was found out, which mostly buildupon the tool dimension or tool geometry, cutting fluid [6]. H. Öktem [7]experimented and certainly obtained the performance of various machining parameters of end milling operation on AISI 1040 steel using TiAlN solid carbide tool by ANOVA & Regression method.

(Table-1 end milling process [1])

Work piece Material	I/P Parameter	O/P Parameter
190 BHN Steel	Speed, feed rate &Cutting Thickness	Surface Roughness
Hardened Steel AISI H13	Speed, Feed Rate &Cutting Thickness	Surface Roughness & Cutting Force
Aluminium,Brass,Mild Steel	Speed, Feed Rate & Cutting Thickness	Surface Roughness Chip Morphology
Aluminium, Aluminium Alloy	Speed, Feed Rate & Cutting Thickness	Surface Roughness , Tool Flank Wear
Inconel 718 Nickel Based alloy	Speed, Feed Rate& Cutting Thickness	Surface Roughness ,Power Consumption ,Tool Wear
AISI 304	Speed, Feed rate &Cutting Thickness	Specific Energy ,Tool Life & Surface Roughness
OHNS Steel	Speed, Feed rate &Cutting Thickness	MRR , Surface Roughness
EN 31 tool Steel	Speed, Feed Rate &Cutting Thickness	Surface Roughness & tool Vibration
EN 31 Steel	Spindle Speed, Feed Rate &Cutting Thickness	Surface Roughness

3.Tool Material:
The tool is most evidence for machiningand highlightedon its material, shape &design. Most of the cases in the end milling the High Speed Steel (HSS) (W: Cr: V = 18:4:1), Titanium Coated carbide tool, Cemented Carbide Toolsare used. According to Arkiadass etal. [2]. CNC Vertical milling machine is used in the machining the flat end coated solid carbide tool with diameter is 12 mm, helix angle is 45°, rake angle 10° &4 no of flutes and discussed the tool flank wear.A. Vishnu et al. [8] explained the significance of tool holder BT30-ER16for tool material used as CVD Brass Coated tool with its diameter 16 mm & 4 teethes on CNC Vertical milling machine while operated onwork piece EN-31 steel.Karakas et al.experimented for the Al-4Cu-B_4C MMCsby using both multiple coated & uncoated tool andinvestigated the variation in cutting speed with tool wear behaviour. Here un coated tool is used as cemented carbide tool, coated tool is used as (TiCN+Al_2O_3+TiN) cemented carbide tool, the rake angle is 0°, the relief angle is 11°,insert angle is 60°[14]. Chang et al.described for side milling operation done on B8 CNC machining centre up milling operation with cutting fluids. High Speed Steel tool coated Tin with specification of 12 mm tool diameter, 4 no of flutes, 35° helix angle is used [5].Huang et al. explained the use of high speed milling machining on (Sic_p/Al) MMCs.Poly crystalline diamond (PCD) & TiC based Cermetsare used as the tool considering the similar tool property. The tool cutting edge angle is 90°, tool minor cutting edge angle is 0° and tool noise radius is 0.4 mm[9]. G. S. Samy etal. explained that the Al-B_4C particulate MMCs used by end milling operation by monolayer Titanium nitride (TiN) coated carbide tool with tool diameter is 8mm, 4 no flutes and helix angle is 30°[3]. K Jayakumar et al. described the tool work piece interference temperature of (Al/SiC_p) MMCs using two uncoated cemented carbide insert (R 390-11T3 04E-NL-H13A) cutter. The diameter 16mm, nose radius 0.4mm, thickness 3.59mm, width of cutting edge 0.9mm & relief angle is 21°[10]. Fanghonget al. described Al-SiC particulate composite material is subjected to DMU70V high speed milling machine by TiN-Al coated Carbide tool having 2 edges. The tool is affected the surface integrity & cutting force [11].T. Findik et al.experimented the face milling operation on Al-SiC_p MMCs by uncoated cemented carbide tool & TiCN+TiN coated carbide tool having single tooth, the nose radius is 0.8. Mm, rake angle, relief angle and insert angles are 0°,11° and 60° and studied the change in different characteristics [12].

4.Cutting Parameter:
The most significant milling parameters are spindle speed, cutting force , cutting speed , machining thickness, axial depth of cut, radial depth of cut, feed rate, feed direction etc. Among all the parameter three main parameter that's mostly affects the milling operation & these parameter are cutting speed or spindle speed, feed rate &machining thickness.

4.1.Cutting Speed or Spindle Speed:A. Vishnuet al.experimented and optimized the value of spindle speed (796, 935, 1094) m/min using L_9 (3^4) Taguchi method on end milling operation of En-31 steel [8]. N. Reddy et al. described the machining response by controlling cutting speedon milling operation of Al/Sic particulate MMCs.[4]. J.A.Ghani et al. [13] explained the influence of cutting speeds (224 m/min, 280m/min, 355 m/min)on end milling operation ofhardened steel AISI H13. The influence of cutting speed (100, 125, 150, 175, and 200) m/min of end milling operation is critically studied byK Jayakumar et al.on Al-SiC_p MMCs.[10]. K. Palaniradjaet al. described milling operation on MMCs, with the carbide tool. The value of the spindle speeds 2000 rpm, 2500 rpm, 3000 rpm, 3500 rpm, 4000 rpm are optimized byRSM methods [10]. M. Karakas et al. proposed that end milling operation done on B_4C_p reinforced hybrid aluminium MMCs considering the tool geometry & cutting condition with varying cutting speeds(100, 130, 169, 220, 286) m/min[14].A. A.Premnath et al. concluded the impact of varying spindle speed(1500, 3000, and 4500) rpm on milling operation done on AA6061 aluminium hybrid MMCs [15]. G. S. Samy et al. also described the spindle speed influence onend milling performance on B_4C particulate aluminium reinforced composite material [3].

4.2. Feed Rate:

A. VISHNU et al.described the influence of feed rate (50, 100, and 150) mm/rev on surface roughnessof end milling operation on En-31 steel [8]. N. Reddy et al. describes the micro structural changes with varying feed rate (0.10, 0.15, 0.20, 0.25, and 0.30) mm/rev on milling operation of Al/Sic particulate MMCs[4]. A.Ghani et al. explained the chip morphology of hardened steel AISI H13 when used for milling operation by controlling feed 0.1mm/tooth, 0.16mm/tooth, 0.25mm/tooth[13].K Jayakumar et al.critically studied the tool-work piece interface temperature of end milling operation done on Al-SiC_p MMCs optimizing the feed rate (0.1, 0.15, 0.2, 0.25, and 0.3) mm/rev by Taguchi method [10]. K. Palaniradjaet al.investigated about the tool flank wearonMMCs used in milling process usingcarbide tool with different feed rate values are 0.02 mm/rev, 0.03mm/rev, 0.04mm/rev, 0.05mm/rev, 0.06mm/rev [6].M. Karakas et al. proposed the influence of the tool geometry & cutting condition on end milling operation done on B_4C_p reinforced aluminium hybridMMCs by varying cutting speed with fixed feed rate 0.20 mm/teeth[14].

4.3. Cutting Thickness:

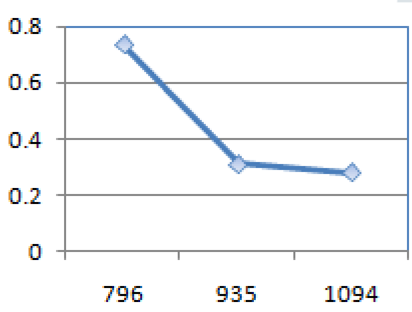
M. Karakaset al.suggested the both radial and axial depth of cut impact on the chip thickness & tool flank wear on end milling operation done on B_4C_p MMCsconsidering thecutting thickness value is 10 mm & the axial depth of cut value is 1.5 mm [14].G. S. Samy et al.studied the tool wear and chip rate of flow in end milling process on AA6351-B_4C metal MMCs using L_{27} Taguchi method for optimum value of depth of cut(0.5, 1, 1.5)mm respectively[3]. S.Fanghong et al. studied the distribution ofcutting temperature & surface integrity in milling operation done on aluminium based metal matrix composite material with the depth of cut value is 0.5mm [11]. Yakup et.al used two types of tool to verify the impact of cutting speed, feed and thickness on the cutting force & surface roughness during milling operation of Al/SiC MMCs [16]. A. Vishnu et al. describe that the milling machining on EN-31 steel material on varying cutting thickness (0.5, 1.0, 1.5)mm[8].N. Reddy et al. obtained various surface integrity with various depth of cut(0.2, 0.4, 0.6, 0.8, 1)mm on the Al/SiC metal matrix composite material [4].

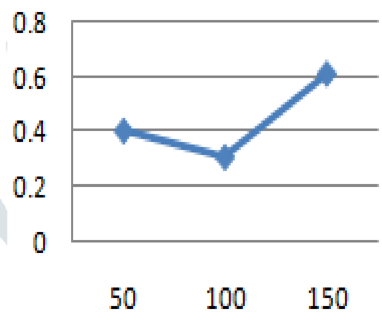
6. Significance of Response Parameters:

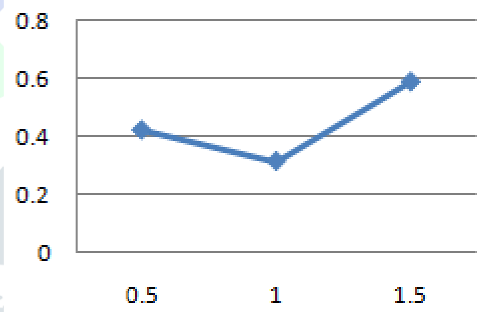
In CNC milling machining operation the different input parameter are used in different level (low, medium, high).The output result of the milling machine are the surface roughness, cutting force, tool wear, tool flank wear, tool work pieceinterface temperature etc. In manufacturing the composite material the output parameter are the tensile strength, hardness, stability, types of defect, porosity etc. These are the response which is depend open the input factors.

6.1.Surface Roughness/Surface Integrity:

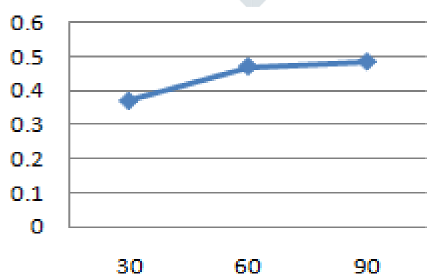
A.Vishnu et al. defined that here milling machining operation on EN-31steel. The input factor is taken as cutting speed, feed rate, depth of cut & coolant flow. It affects the surface roughness of the workpiece.Surface roughness measured by the surface roughness tester [8].N. Reddy et al. explained that the milling machining done on Al/SiC particulate metal matrix composite material. In this experiment the input factor taken as cutting speed, feed & depth of cut. This input factor affected the output response. In the experiment the surface integrity is taken as the output response. The surface integrity defined by that surface roughness, micro hardness & residual stresses. These are varied with the metal composition of the metal matrix composite material [4]. Yakup et al. defined that here milling machining operation done on Al/Sic metal matrix composite material. Here the cutting speed, feed rate, machining thickness is taken as the input parameter. These input factors are affected the surface roughness. In this experiment the input parameter is taken in two different type of tool one is coated tool & another is uncoated tool. The surface roughness is different in both the tool the roughness is decreased in uncoated tool. The roughness is increase in coating tool [16].







(fig.1 Graph between SR VS Cutting Speed[8]) (fig.2 Graph between SR VS Feed Rate[8]) (fig.3 Graph between SR VS DOC[8])



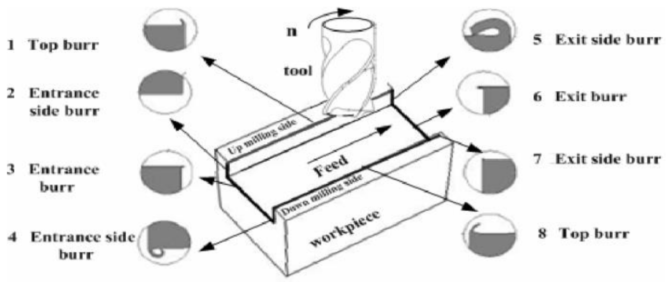
(fig. 4 Graph between SR VS Coolant flow rates[8])

6.2. Tool Wear – Tool Flank Wear Rate:

H.L. Wang et al. explained that here the milling machining done on cast iron & the carbide cutter is used as the tool for the machining process. The tool wear is taken as output response in result it defined that the tool wear is different in single tooth tool & multi tooth tool. The tool wear rate compared with the power[9]. M. Karakas et al. describe that here milling operation done on Al-4%Cu-B_4C metal matrix composite material. In the experiment it defined that the tool performance on composite material. The tool is used as 3 types. These are uncoated tool & coated tool. In output response it defined that the flank wear rate as compared with the chip formation & tool wear rate [14].

6.3. Burr Formation:

M.Luo et al. concluded that in the research paper burr formation occur on Al alloy in slot milling operation. Burr formation depend open the parameter. The burr formation is significant by the chip quantity. It defined by exit angle of the tool[20]. S. Niknam et al. explained that the calculation of burr thickness in milling operation of ductile material. It calculated by the parameter (cutting speed, feed per tooth, machiningthickness, tool material, work piece material). The burr formation calculated by the shear angle, friction angle & burr thickness [21].



(fig.5 Burr formation in different position in slot milling [24])

6.4. Chatter Stability:

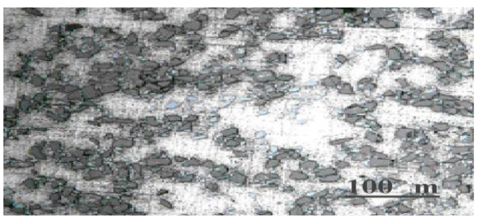
N Grossi et.al defined that Chatter prediction depends open the cutting force coefficients & frequency response, mostly it depends open the spindle speed the better cutting force coefficients is done by high speed milling machine. The material used for the machining tests is an Al-6082-T4 alloy. The chatter stability depends open the stability lobes diagrammed on milling machine is defined the chatter stability machine vibrations .Mainly the stability lobes diagrammed is two type radially & tangentially. The chatter production depend open the depth of cut [19]. A.Scippa et.al purposed that, cutting force depend open the cutting force model; it is mostly used to optimize parameters which are affected on the milling operations. The cutting force depends open the spindle speed and the cutting force model depend open the tangentially, radially, axially.Here the work piece used as Aluminium 6082 with TiN coated tool and calculated 17 runs of cutting coefficients evaluated by least mean square approach. The cutting coefficients is influenced by the chip thickness & feed per tooth. It is concluded that cutting force coefficients & chip production depend open the spindle speed, feed rate,machining thickness, radially , tangentially , axially coefficients of cutting force of feed rate[18].

6.5.Tool – Work piece interface temperature:

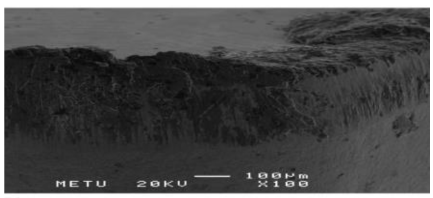
K Jayakumar et al. defined that milling experiment is done on Al/SiC$_p$ metal matrix composite material. In this experiment 4 process parameters are considered as input. These factor are cutting speed (V_c), feed (f), depth of cut (d), vol% of SiC$_p$. These parameters are affected by the tool – work piece interface temperature. The interface temperature is measured by non contact type radiation pyrometer. Here it is analysed the input parameter vs. the interface temperature [10].

6.6. Micro structure studies of composite material& tool after machining:

N. reddy et al. defined that the Al/SiC particulate metal matrix composite material is used in end milling process. Here the input parameter is cutting speed, feed rate, and depth of cut. It affected the output response these are surface roughness, micro structure, micro hardness, and micro hardness. Microstructure is studied by the Scanned electron microscopy (SEM) machine. It depend open the hardness, mixing composition of the metal matrix composite material. It is varied by the input parameter [4].



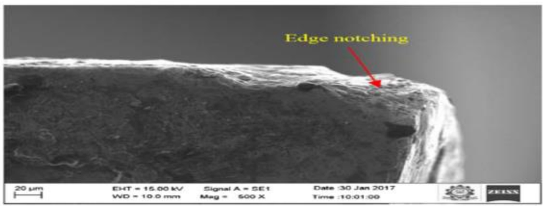
(Fig.6Microstructure study of MMCs)



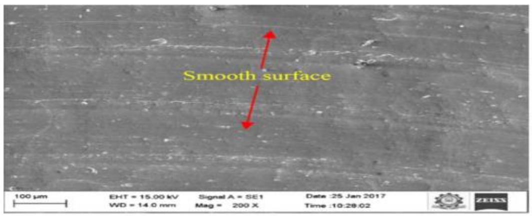
(b)

(Fig.7 SEM View of tool wears after machining [14])

G.S.Samy et al. describedabout the milling machining operation on B_4C particulate Al aluminium composite material. The design of experiment done was L_{27} Taguchi method. The cutting speed, feed rate & depth of cut are taken as input the microstructure of tool and work piece are varied. The micro structure is varied as compare with the spindle speed, feed rate & depth of cut [3].



(Fig.8Micro Structure of Tool wear rate at 3000rpm [3])



(Fig.9Micro structure of surface morphology at 3000 rpm [3])

7. Conclusion:

The critical study of review on end milling operation on different alloys and MMCs concludes the impact of various process parameters on improvement of surface integrity, chip morphology, heat distribution and micro structural study.Most of cases the coated tool & uncoated tool is used in the milling machining operation.Still a lot of research gap arises considering in different field of application i.e. based upon the revolution on material field due to its improved performance. The different types of milling operationscan beused in most of the industrial areacomposite like in face milling, up milling etc.It can be also suggested for milling operation of new functional graded materials, polymer composites , hybrid metal matrix composites application in different field, which are having most significant demand in aerospace, nuclear, ship building etc.

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