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Fabrication and Structural Analysis of a Plain Milling Cutter by Using Composite Material

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Abstract: Milling is one of the machining processes to expel material from a work piece utilizing revolving cutters by sustaining the shaper into the work piece at a specific course. The shaper may likewise be held at a point regarding the hub of the instrument. It is a standout amongst the most usually utilized procedures for machining certain parts to precise tolerances. There are different kinds of milling cutters. Some are prescribed for certain types of operations. In this paper, we deal with a plain processing shaper. Plain processing shaper is the most generally utilized apparatus in a flat processing machine. It is in the state of a plate or round and hollow, which has edges on the external boundary of the shaper for processing the plain which is parallel to the shaper hub. By and large, there are of 2 sharp edge shapes, straight and helical edge molded. The helical cutting edge shape is all the more ordinarily utilized.

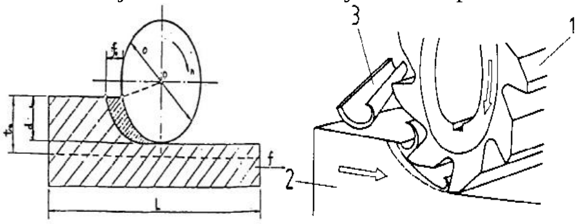
In this venture work, the outline of the plain processing shaper is adjusted and is analyzed. The objective is to increase the performance and strength of plain milling cutter by reducing the weight. The various designing strategies like different blade inclination angles 15°, 18°, 21°, 24°, diameter, thickness, and face width are considered to design the effective plain milling cutter. Design modifications are carried out using CATIA V5 software and analysis is done using ANSYS. In this study, the design and analysis are carried out for two different cutter materials, such as High-Speed Steel (existing material) and Aluminum Silicon Carbide (advanced composite material), and Boron Nitrite (advanced reinforced material). In this examination the heaps following up on the shaper and speed is differed and the outcomes got are looked at to which inclination angle gives a better working performance. The strength and stress values are analyzed and then the withstanding values are to be compared to find the suitable material. Then the material is finalized which is suitable for milling operations and then next we go for manufacturing the prototype of the milling cutter.

Keywords: Design modification of Plain milling cutter, Weight reduction, Increasing strength and performance, Fabrication.

1. INTRODUCTION

Machining is doubtlessly the most basic of the essential amassing shapes, since organizations around the world consume billions of dollars for consistently to perform metal departure. That is along these lines, in light of the way that by a wide margin the greater part of influenced things to require machining at some stage in their age, running from by and large unforgiving tasks to high-correct ones, including versatilities of 0.001 mm, or less, related with stunning surface wrap up. It is assessed that today, in industrialized nations, the cost of machining records to more than 15% of the total estimation of all things by their entire amassing industry, paying little heed to whether these things are mechanical.

Preparing machine is one of the basic machining activities. In this task the work piece is energized against a turning tube molded instrument. The turning device includes various bleeding edges (Multipoint cutting gadget). Regularly rotate of unrest of reinforce given to the work piece. Preparing activity is perceived from other machining tasks in view of presentation between the gadget rotate and the reinforce course; in any case, in various activities like entering, turning, et cetera the instrument is supported toward the way parallel to center point of insurgency. The cutting mechanical assembly used as a piece of handling task is called preparing shaper, which includes different edges called teeth. The machine gadget that plays out the preparing activities by conveying required relative development Handling activity is seen as a barged in on cutting task teeth of preparing shaper enter and leave the work in the midst of each change. This meddled with cutting action subjects the teeth to a cycle of impact control



and warm paralyze on each turn. The instrument material and shaper geometry must be planned to endure the above communicated conditions.

Figure.1. Working motions of plain milling operationCutting conditions in milling

In processing, every tooth on an instrument expels some portion of the stock as a chip. The essential interface amongst apparatus and work part is presented beneath. This demonstrates an exclusive a couple of teeth of a fringe processing shaper.

Cutting speed V is the fringe speed of the shaper is characterized by

$$V = \pi DN$$

Where D is the shaper external measurement and N is the rotational speed of the shaper.

As on account of turning, cutting rate V is first computed or chose from fitting reference sources and after that the rotational speed of the shaper N, which is utilized to modify processing machine controls, is ascertained. Cutting velocities are typically in the scope of 0.1~4 m/s, bring down for hard to-cut materials and for harsh cuts, and higher for non-ferrous simple to-cut materials like aluminum and for completing cuts.

1.1. Cutting speed

Cutting pace of a processing shaper is its fringe straight speed coming about because of activity. It is communicated in meters every moment. The cutting pace can be gotten from the above recipe. Shaft speed of a processing machine is chosen to give the coveted fringe speed of shaper.

$$V = \pi\ d\ n / 1000$$

Where,
d = Diameter of milling cutter in mm,
V = Cutting speed (linear) in meter per minute, and
n = Cutter speed in revolution per minute.

1.2. Feed rate

It is the rate with which the work piece under process moves under the pivoting handling shaper. It is understood that turning shaper remains stationary and urge is given to the work piece through worktable. All things considered support is imparted in three different ways.

1.3. Feed per Tooth

It is the separation went by the work piece (its progress) between commitments by the two progressive teeth. It is communicated as mm/tooth (ft.).

1.4. Feed per Revolution

Travel of work piece amid one upset of processing shaper. It is communicated as mm/rev. furthermore, indicated by f (rev).

1.5. Feed per Unit of Time

Feed can likewise be communicated as feed/moment or feed/sec. It is the separation progresses by the work piece in unit time (fm).

Above depicted three feed rates are normally convertible.

$$f\ m \times n \times frev$$

Where,
n = rpm of cutter.

It can be extended further as

F m □ n □ f rev □ z □ n □ ft.

Where,
z = Number of teeth in milling cutter

Feed rate (F) is characterized as the rate of movement of the work piece in mm/min. In any case, most device providers suggest it as the development per tooth of the shaper (f). Along these lines,

Where,
F =table feed in mm/min
f = movement per tooth of cutter in mm
u = number of teeth of cutter
N = R.P.M. of the cutter

$$F = f.\ u.\ N$$

1.6. Spindle speed

Axle speed in insurgency every moment (R.P.M.) for the shaper can be figured from the condition:-
N = R.P.M. of the cutter
CS = Linear Cutting Speed of the material in m/min.
d = Diameter of cutter in mm

2. LITERATURE REVIEW

Vikas Patidar1, Prof. Kamlesh Gangrade2, Dr. Suman Sharma3, (IJETT) – Volume 47 Number 6 May (2017).[1]. Wear analysis of multi point cutter using fem. The material expulsion process utilizes slicing apparatuses keeping in mind the end goal to deliver the coveted state of the work piece. Instrument wear has been an issue for cutting devices, since cutting devices wear and break. Research has been accomplished in the instrument wear field for apparatus life and all the more as of late device wear. The PC age has made a technique to reproduce the material expulsion process. Weights on confront processing device tooth found is low in M4 HSS steel when contrasted with AISI 4340 steel, M7 UNS and T15 UNS steel, four work piece materials (basic steel, cast press, gentle steel and aluminum combination 6061) were chosen to perform limited component examination and all the four materials of work piece M4 HSS is more accurate than other three steel. Wear on face milling cutting tool tooth found is low in M4 HSS steel when contrasted with AISI 4340 steel, M7 UNS and T15 UNS steel, four work piece material were chosen to perform limited component.

Chittibomma.Tirumalaneelam1,TippaBhima sankara Rao Vol, 03, Issue 4 (2013).[2]. Structural analysis of a milling cutter using fea.The machine instrument that generally plays out this activity is a processing machine. Processing is an intruded on cutting activity: the teeth of the processing shaper enter and leave the work amid every unrest. This intruded on slicing activity subjects the teeth to a cycle of effect power and warm stun on each revolution. The device material and shaper geometry must be intended to withstand these conditions. Cutting liquids are fundamental for most processing tasks. In this Paper the outline parts of processing shaper is examined. The goal considered is the outline and displaying of processing shaper and to investigations different pressure parts following up on it. In this investigation the plan and examination is completed for two diverse shaper materials and they are High Speed Steel and Tungsten Carbide. In this examination the heaps following up on the shaper and speed is differed and the outcomes got are thought about.

*Gummadi.RatnaKumar1,TippaBhimasankar a Rao2 Volume 6, Issue 7 (April 2013).[3].*Modeling and analysis of a plain milling cutter using finite element analysis. In this task work the outline parts of plain processing shaper is broke down. The target considered is the plan and cross section of plain processing shaper and to break down different pressure segments following up on it. Different planning methodologies are considered to outline the viable plain processing shaper like breadth, thickness, confront width and so forth. The plan and investigation is done utilizing programming resembles CATIA V5 and ANSYS. In this examination the outline and investigation is done for two diverse shaper materials and they are High Speed Steel and Tungsten Carbide. In this examination the heaps following up on the shaper and speed is fluctuated and the outcomes acquired are analyzed.

ThambuSornakumar and arimuthuKathiresan, 23 December (2009)[4]..Machining studies of die cast aluminum alloy-silicon carbide composites. Metal framework composites (MMCs) with high particular solidness, high quality, enhanced wear obstruction, and warm properties are as a rule progressively utilized as a part of cutting edge auxiliary, aviation, car, gadgets, and wear applications. Aluminum amalgam silicon carbide composites were created utilizing another blend of the vortex strategy and the weight bite the dust throwing system in the present work. Machining thinks about were led on the aluminum compound silicon carbide (SiC) composite work pieces utilizing rapid steel (HSS) end-process apparatuses in a processing machine at various speeds and feeds.
Machining ponders were led on the aluminum compound silicon carbide (SiC) composite work piece using\high speed steel end-process devices. The surface complete is better at higher speeds and lower encourages. The surface complete of the plain aluminum combination is superior to anything that of the aluminum amalgam silicon carbide composites.

N and K. Jha and Kathryn Hornik, Manhattan College, Riverdale, NY, USA.[5]. Integrated computer-aided optimal design and fea of a plain milling cutter. The ideal outline parameters in this way got are tried for worries at the tip of the instrument and at the jillets. Intelligent use of enhancement, strong displaying, and limited component methods deliver the satisfactory ideal plan. The plan procedure exhibited in this paper is general and bland in nature. This has been represented through a case of outline of a plain processing shaper.
Limited component investigation. Any shaper, single point or various point, can be planned in view of the approach introduced here. It could even be wandered that this approach can be utilized to plan any complex mechanical part or framework. Particularly for the shaper plan, it created the cutting factors that yield the base cost of assembling.

3. DESIGN

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-stage CAD/CAM/CAE business programming suite created by the French organization Assault Systems. Written in the C++ programming dialect, CATIA is the foundation of the Assault Systems item lifecycle administration programming suite.

CATIA offers an answer for shape configuration, styling, surfacing work process and perception to make, change, and approve complex creative shapes from mechanical plan to Class-A surfacing with the ICEM surfacing innovations. CATIA underpins different phases of item outline whether began without any preparation or from 2D portrays. CATIA can read and create STEP format files for reverse engineering and surface reuse

3.1 15°degree

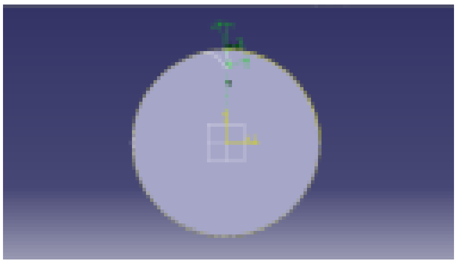


Figure.1. Sketch drawing of model for 15°

3.2 18°degree

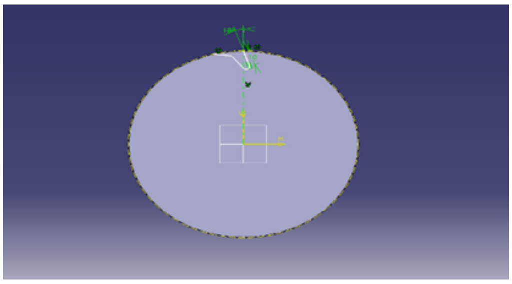


Figure.2. Sketch drawing of model for 18°

3.3 21°degree

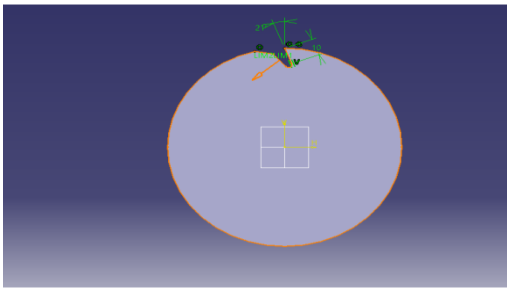


Figure.3. Sketch drawing of model for 21°

3.4 24°degree

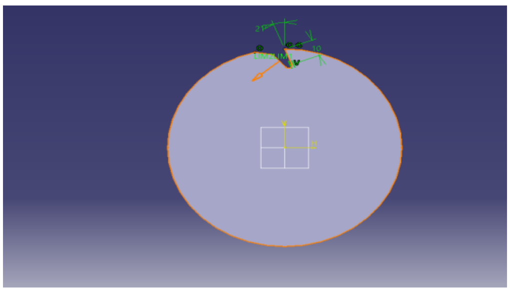


Figure.4. Sketch drawing of model for 24°

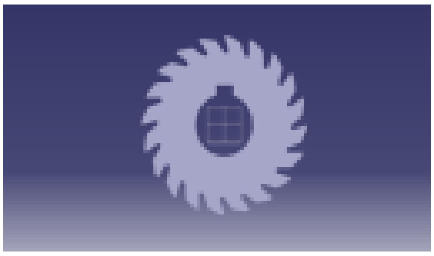


Figure.5. Final design model of plain milling cutter

4. MATERIAL DATA

4.1. High speed steel

Density	8.16e-006 kg mm^-3
Young's Modulus	2.1e+005MPa
Poisson's Ratio	0.3
Bulk Modulus	1.75e+005 MPa
Shear Modulus	80769 MPa
Compressive Yield Strength	3250 MPa

4.2. Aluminum silicon carbide

Density	4360 kg m^-3
Young's Modulus	1.37e+011MPa
Poisson's Ratio	0.35
Bulk Modulus	1.5222e+011 MPa
Shear Modulus	5.0741e+010 MPa
Tensile Yield Strength	1.6e+009 MPa

4.3. Boron nitride

Density	3460 kg m^-3
Young's Modulus	1.69e+010 MPa
Poisson's Ratio	0.3
Bulk Modulus	1.4083e+010 MPa
Shear Modulus	6.5e+009 MPa
Tensile Ultimate Strength	4.7e+007 MPa

5. ANSYS

ANSYS is broadly useful limited component investigation programming, which empowers designers to play out the accompanying undertakings: Build PC models or exchange CAD model of structures, items, segments or frameworks Apply working burdens or other outline execution conditions.

- Study the physical reactions, for example, feelings of anxiety, temperatures dispersions or the effect of electromagnetic fields.
- Optimize an outline from the get-go in the improvement process to reduce production costs.
- A commonplace ANSYS investigation has three unmistakable advances.
- Pre Processor (Build the Model).

5.1. Mesh

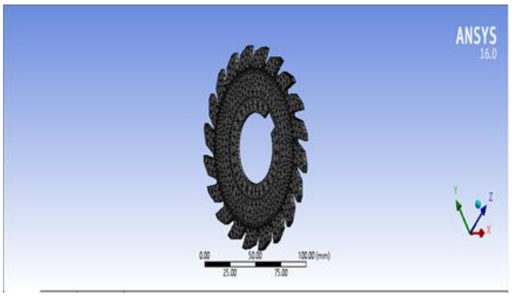


Figure.6. Mesh model of plain milling cutter

5.2. Total deformatio

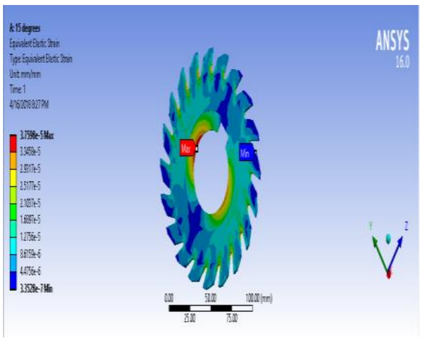


Figure.7. Total deformation

5.3. Equivalent Elastic Strain

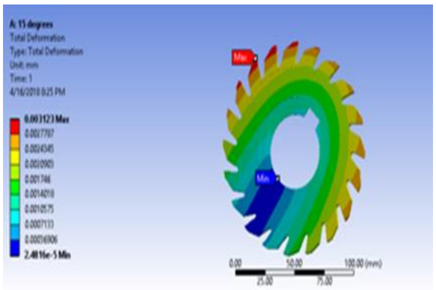


Figure.8. Equivalent Elastic Strain

5.4. Equivalent Stress

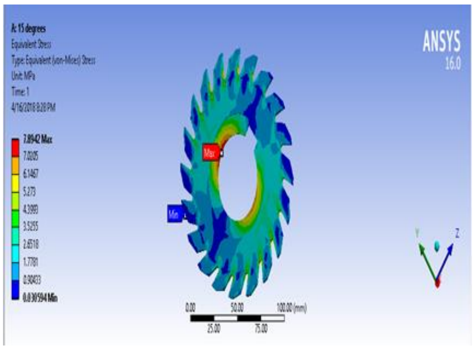


Figure.9. Equivalent Stress

5.5. Comparison Between 15°, 18°, 21°, 24° Angles For High Speed Steel

The analysis of plain milling cutter in ansys is not possible due to the error obtained while applying load, its exhibits the failure criteria due the critical loading condition. So the ansys 21°degree is not possible.

- Less deformation accrued in 18° degrees comparing to other materials
- Von misses stress more in 18° degrees so better stress acted withstand values more in 18 degrees.
- Observing results comparing with existing HSS material 18° degrees are gives better performance results so this 18° degrees are Suitable to milling cutter comparing to existing angels.
- By observing above results 18° degrees giving best performance so will chose the 18° degrees angle for farther analysis

Object Name	*Total Deformation (mm)*	*Equivalent Elastic Strain (mm/mm)*	*Equivalent Stress (Mpa)*
HSS	3.1624e^{-003}	4.1456e-005	8.448
AlSiC	1.1175e-005	6.2661e-005	8.3238e +006
Boron Nitride	3.112e-005	5.0558e-004	8.2888e +006

Table.1. Comparison Between 15°, 18°, 21°, 24° Angles For High Speed Steel

5.6. Comparing The Maximum Values Of 18° AngleBetween Composite Materials

From above tabulated Ansys values following conclusions are drawn:

- The total deformation of plain milling cutter for AlSiC is 1.1175e-005 which is less than the existing material (HSS) and Boron Nitride.
- On comparing the values of Equivalent Elastic Strain, AlSiC has maximum load bearing capacity other than the two materials.
- Equivalent Stress for HSS is less than the other two materials, i.e., AlSiChas high stress bearing capacity than HSS.
- AlSiC has high shear stress value than HSS (1.0964 MPa). But the value of AlSiC (1.0561e+006) is slightly less than the Boron Nitride (1.0722e+006 MPa).

Table.2. Comparing the Maximum Values Of 18° Angle Between Composite Materials

Finally, from the above analysis it is decided that AlSiC is the best material when compared with the other two materials. A Plain Milling cutter is manufactured using AlSiC material and Experimental tests are conducted on the test piece.

6. FABRICATION PROCESS

To produce a milling cutter, there are few main tools required:

1) Lathe machine – this machine is mainly used, when manufacturing milling cutter, it requires heavy machining.
2) Shaper – to shape, oil grease ways
3) Precision Drills - to make gap to ensure oil experiences the processing shaper to keep it greased up, so to cool.

Object Name	*Total Deformation (mm)*	*Equivalent Elastic Strain (mm/mm)*	*Equivalent Stress (MPa)*
Minimum	2.4816e-005	3.3528e-007	3.0594e-002
Maximum	3.123e-003	3.7598e-005	7.8942
Minimum	2.4085e-005	4.3033e-007	4.0132e-002
Maximum	3.1624e-003	4.1456e-005	8.448
Minimum	3.851e-003	3.9039e-007	-1.3028e-005
Maximum	1.3871e-002	1.0842e-004	1.5097e-005

Figure.10. Fabricated piece of plain milling cutter

7. EXPERIMENTAL RESULTS

7.1. Impact test

Observed Values (joules)	*Al-SiC*
Impact 1	4
Impact 2	4
Impact 3	4
Average	4

7.2. Shear test

Input data

Machine Model	200 series single column	
Specimen piece	milling cutter sample piece	
Output data		
Al-SiC	Applied force (KN)	Shear Stress (MPa)
	10	$1.1826*10^3$

- Under the impact test plain milling cutter withstand impact load 4 joules, which is comparatively as ansys value.
- Plain milling cutter made with AlSiC can bear shear stress of 1.1826*103 MPa under the loading condition of 10KN.

8. CONCLUSIONS

The model of the shaper is outlined in CATIA and examination is completed utilizing ANSYS. The outcomes got are classified in the outcome table. The sources of info taken for the investigation are distance across of shaper, speed, control and load in which diameter and power are kept constant and the speed and load are varied. The outputs obtained are mass, stress and deformation. From the results table, it is observed that the stress and deformation of the cutter. Less deformation accrued in aluminum silicon carbide 1.1175^{e-005} m comparing to other materials. Von misses stress more in aluminum silicon carbide $8.3238^{e+006\ Pa}$ so better stress acted withstand values more in silicon carbide.

Observing results comparing with existing HSS material aluminum silicon carbide are gives better performance results so this materials are suitable to milling cutter comparing to existing material.

9. FUTURE SCOPE

By keeping the angle constant other parameters such as load, speed, diameter, number of teeth can be varied along with the composite materials. Also the failure analysis can be done for the 21 degree angle.

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