Review on Computer Aided Design and Analysis of Modular Fixture for Milling Operation

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***Abstract*— Milling operation which refers to production of various profiles forms an integral part of any machine shop and it is intended to provide faster material removal rate due to application of multi point cutting tool. Fixture which comprises of the locators, clamps and support structure provides efficient machining of large volume of production by saving considerable amount of setting time involved by using conventional work holding devices. Last few decades have seen the tremendous growth of industries and has resulted in development of its allied operations of which milling is one of the crucial operation performed. The conventional milling operation which surely involves a dedicated fixture which has to be subjected to change with the change in design of the component results in wastage of time and material required to build a new fixture for new component. The present paper attempts to design and analyze a modular fixture which will can adapt to change in the design of the component. The component selected are swing lever and cylindrical component which are used in Ginning machine and this are milled using same fixture in the proposed design of milling fixture. The locators used for two components are according to the geometry of component of which swing lever requires cylindrical pin locator and diamond pin locator and cylindrical component requires V Block locator. The locators can be replaced on the same base structure and can be subsequently clamped using the strap clamp which can be employed for milling of both the coomponents. This milling fixture with modularity is designed in CAD tool named as CATIA V5 and efficiently analyzed by using FEA technique which is the working phenomenon for ANSYS.**

***Index Terms*— Modular Fixture, Analysis, FEA**

I. Introduction

The milling operation which involves feeding of constrained work piece across a fixed rotating tool employ a device called as fixture for supporting and clamping the workpiece that will be subjected to subsequent machining forces. The accuracy of machining depends on various factors such as positioning of tool and stability of work piece. Generally a single fixture with dedicated locators are employed to produce the mass manufacturing aspect of production. In this work design for modular milling fixture is proposed for two different components whose locators can be replaced when required and both the components can be clamped by same strap clamp.The modularity in fixture design provides the feature of incorporating the flexibility in terms of sizes for same shape component. Computers employingmicroelectronics technology are called for aiding the geometric modeling of system which would provide the modularityin terms of geometrical flexibility to the two components which are to be milled. This fixture which can be used for milling of two components is subjected to milling forces due to end milling operation performed on both the components due to cutting action and this analyzed under the view of structural analysis which has become an indispensable part of evaluation system used for validation of design .Geometrically modeled modular fixture with required locators in CATIA V5 is subjected to milling forces acting on it and the stress results are calculated by FEA software named as ANSYS which are compared with the compressive stress acting on the fixture materialemployed in conventional milling to provide a platform for evaluation and validation of design.

Manuscript received Aug 03, 2018

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II. MILLING FIXTURES

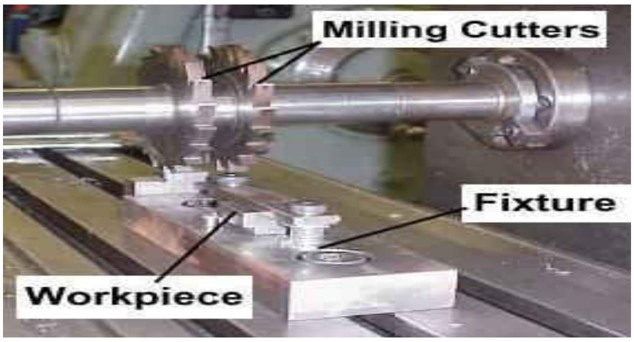

Fig.no.1.Milling Fixture

A Milling fixture is a work holding device which is firmly clamped to the table of the milling machine. It holds the work piece in correct position as the table movement carries it past the cutter or cutters.A heavy base is the most important element of a milling fixture. It is a plate with a flat and smooth under face. The complete fixture is built up from this plate. Keys are provided on the under face of the plate which are used for easy and accurate aligning of the fixture on the milling machine table. By inserting them into one the T slot in the table. These keys are usually set in keyways on the under face of the plate and are held in place by a socket head cap screw for end key. The fixture is fastened to the machine table with the help of two T bolts engaging in T slots of the work table

III. RESEARCH PROBLEM DEFINITION

The present work provides an insight of the design of milling fixture with flexibility which can be adapted to change in the component from swing lever to cylindrical component. The end milling operation results in the forces acting on fixture while milling of both the components on same fixture which are evaluated for three depth f cut which are 3mm, 2.5mm and

2mm resulting into stress acting on locator. The stress values are compared with ultimate stress of cast iron which is material for fixture so as the get the view of design in terms of failure.

IV. LITERATURE REVIEW

Various research work has been done on components of Modular milling fixture to enhance the productivity of the milling machine. The main feature of modularity can be conceived in form of adaptable locators. Various research work can be enumerated here as follows

Yu Zheng, Wen-Han Qianin their paper titled A 3-D modular fixture with enhanced localization accuracy and immobilization capabilityrevealed3-D modular fixtures in asystematic way. First, by repeated reviewing and improving,[1] Barišić et alin their paper titled as “ASSEMBLY SETUP FOR MODULAR FIXTURE MACHININGPROCESS“ explained a model of modular fixture setup relative to cutting forces is proposed, planned and assembled. Positioning is discussed and the best solution is offered.[2] Edurne et.al in his paper titled as “Adaptive fixturing system for the smart and flexible positioning of large volume workpieces in the wind-power sector” explained the design of a smart and adaptive fixture is presented for the accurate positioning of a planet carrier with very strict requirements of tolerances and for an intelligent adjustment during the machining process when required. [3]S. Arzanpour, J.K. Mills et al have proposed the reconfigurable fixture that permits different parts to be grasped for assembly by a fixture without the need to conduct costly redesign and fabrication of hardware fixtures, which is an industry standard in widespread use in industry. [4]W. J. ZHANG has proposed a fixture system is designed to be competent in fixturing as many work pieces as possible. In mass volume production, this can be achieved by fixturing a large quantity of the same kind of work pieces.[5]

V. VMETHODOLOGY

[5.1] To design milling fixture used for end milling operation by selecting the locator for two different components to be used on same fixture.
[5.2] To design strap clamp used for clamping of both the components on same fixture.
[5.3] To provide tolerance on swing lever component and locator to provide close running fit .
[5.4] To calculate the forces acting on fixture due to end milling operations.
[5.5] To analyze thestress generated on the locators due to end milling operation with subsequent comparison with ultimate tensile strength of locator to decide for design as safe.

VI. GEOMETRIC MODELING

[6.1] The first component to be modeled is swing lever having bigger end diameter as 170mm and smaller end diameter as 50mm. This component requires two locators which are cylindrical pin locator and diamond pin locator . The dimensions of locator are selected so as to provide a close running fit between the component and locator.

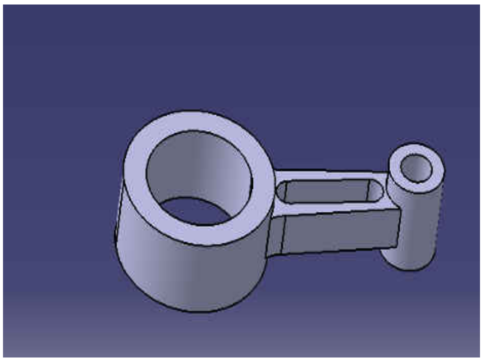

Fig.no.2. Geometric Modeling of Swing Lever

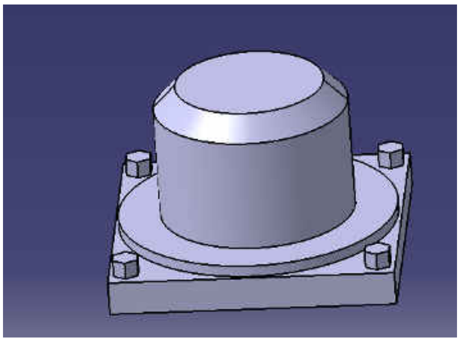

Fig.no.3. Geometric Modeling of Cylindrical Pin Locator

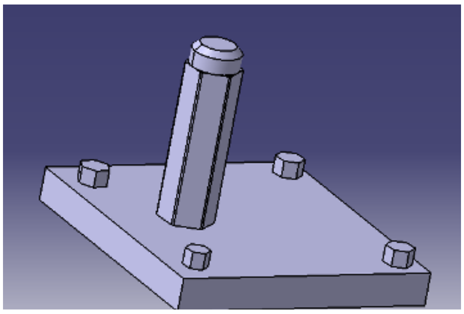

Fig.no.4. Geometric Modeling of Diamond locator

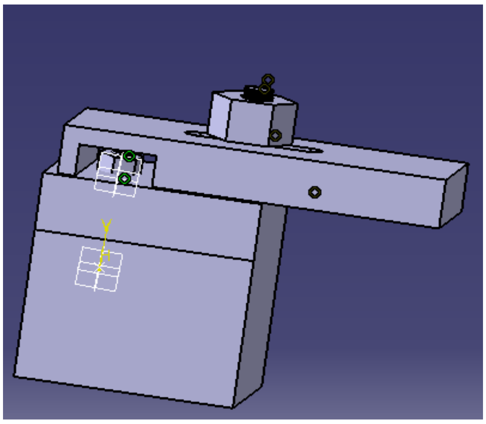

Fig.no.5. Assembly of Strap Clamp

[6.2] All the components and subassemblies modeled previously are assembled as single product to provide the design of modular milling fixture employed for two different components. The constraint provided are geometrical constraint which are used to define the relation of various components with each other as shown below.

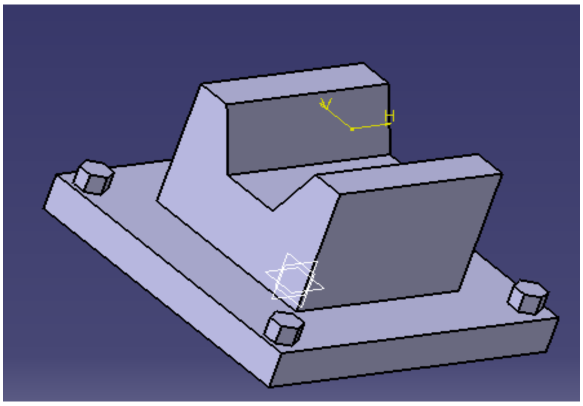

Fig.no.6. Geometric modeling of V Block lo

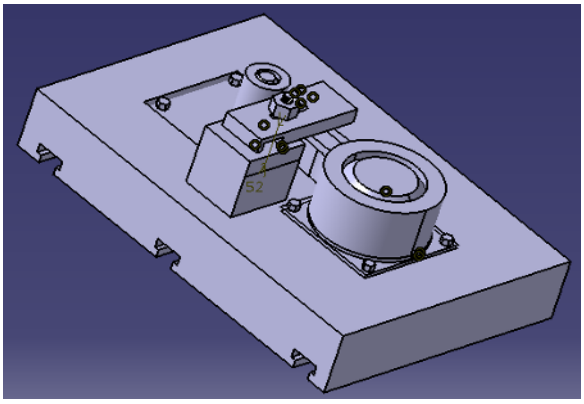

Fig.no.7. Assembly of milling fixture for swing lever fixture

[6.3] All the components and subassemblies modeled previously are assembled as milling fixture for second component which is cylindrical component as shown in figure below.

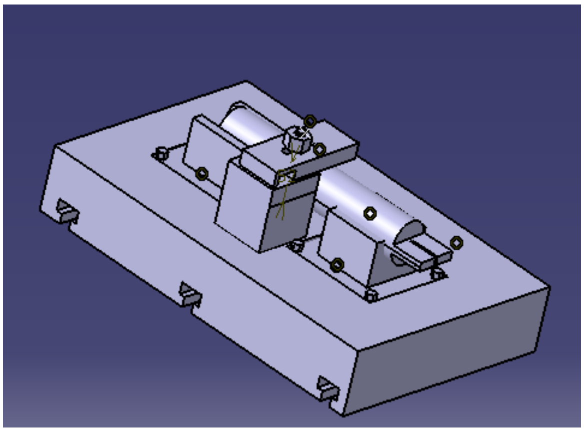

Fig.no.8. Assembly of Milling fixture for cylindrical component

VII. DESIGN ANALYSIS OF SYSTEM

[7.1] The milling operation is characterized by the employment of multi tooth cutter of which end mill cutter provides the face milling operation. The geometry of end mill cutter depends upon the application in this presented work a four teeth end mill cutter is considered. The end milling operation is performed on vertical machining centre.The three forces can be stated as axial force radial force and tangential force. During machining of the work piece end mill is cutting edge is subjected to three forces which in turn are to be sustained by the fixture.

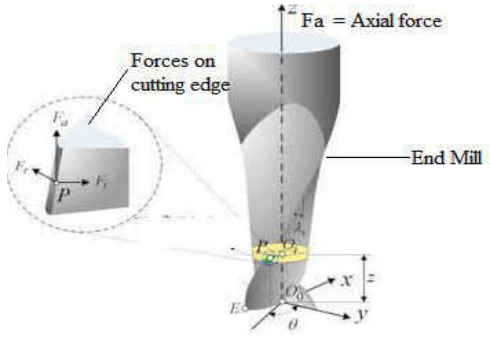

Fig.no.9. Forces acting on End Mill

[7.2] The force acting on end milling are in tangential and radial which can be converted into forces acting in X and Y direction on fixture by resolving the forces as follows.The empirical relation for radial and tangential components of forces are given as

Tangential force Ft = Kt x a x h
Radial force Fr = Kr x a x h
WhereKt = Tangential cutting coefficient = 2300 x 10^6 N/m2
Kr = Radial cutting coefficient = 760 x 10^6 N/m2
a = axial depth of cut for milling
And h = chip thickness while milling which can be calculated as follows
.h = C sinΦ
Where C = chip load / tooth which is = 1mm/ tooth
And Φ = angle of first cutting edge with normal
Substituting the values we get
. h = 1 x sin45
as Φ = 45 degrees
Hence h = 0.707 mm

Depth of cut	Force in X direction	Force in Y direction
3mm	4572.8	2329.8
2.5mm	3823.84	1924.4
2mm	3049.07	1549.53

Table.no.1. Force in X and Y direction at different depth of cut

[7.3] The modular milling fixture for both the components when subjected to milling forces is analyzed in FEA tool which is ANSYS and the results of stress are calculated by consecutively meshing the assembly of milling fixture and subjecting it to calculated force values. The stress results for both the components are shown in following figures below.

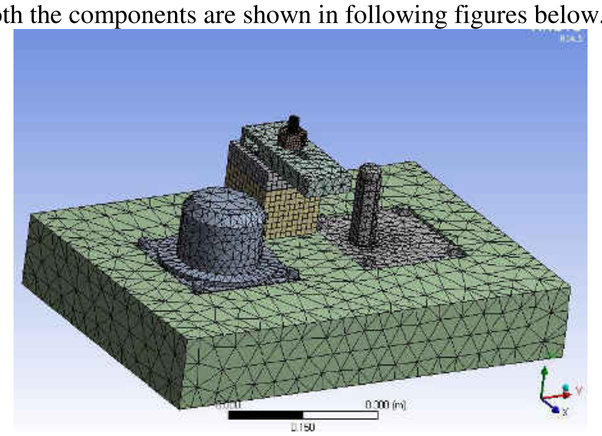

Fig.no.10Meshing of Swing Lever fixture

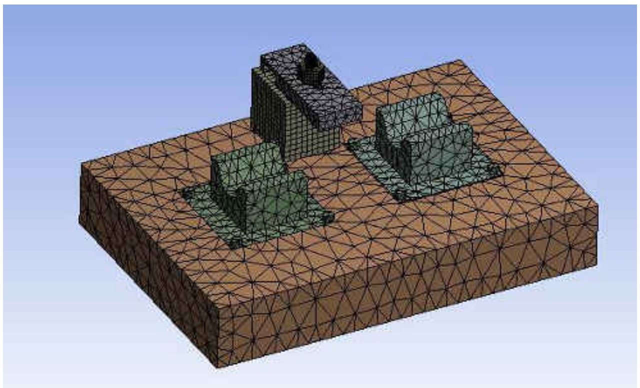

Fig.no.11Meshing of Cylindrical Component fixture

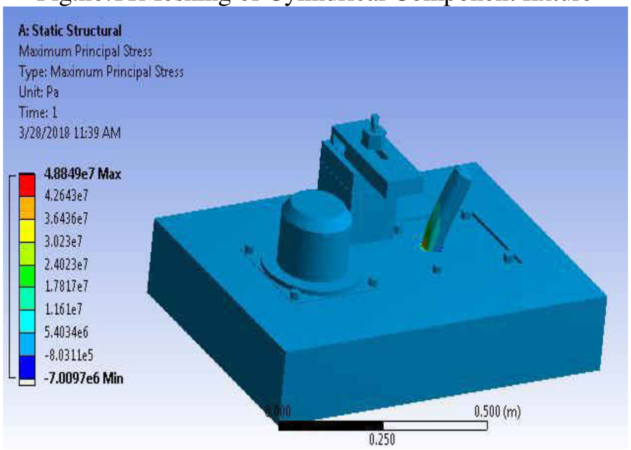

Fig.no.12 Stress at 3mm depth of cut on swing lever fixture

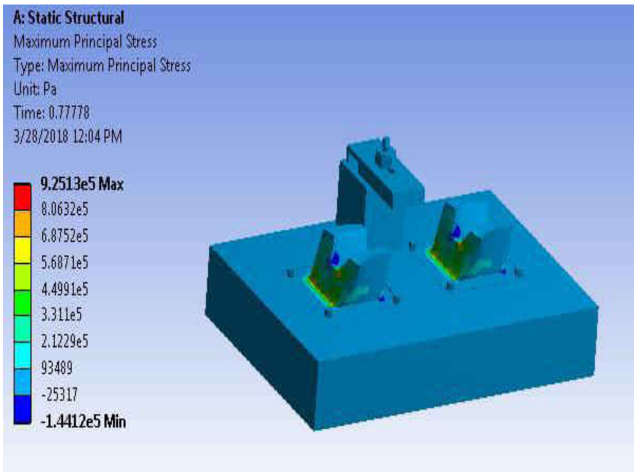

Fig.no.13 Stress at 3mm depth of cut on cylindrical component fixture

VIII. RESULTS AND COMPARISON

[8.1]] The process of designing and analyzing the modular milling fixturewith relevant parameters of study is followed by inferencesgenerated by evaluation process of the data obtained during the process of analysisThe results calculated can be drawn on the lines of effect of milling forces which is stress in this case. The various input values which are same for both conditions are presented and the variation in the effect due to component variation in the system canbe presented as follows. The ultimate tensile strength of Cast iron used for fixture has the value of 200N/mm^2 . The values of stress acting on modular milling fixture while machining of both the components are found to be lesser than this valueand thus validating that desigh is safe.

Property	Analysis of Swing Lever Fixture		
Depth of cut in mm	3	2.5	2
Material for fixture	Cast iron	Cast iron	Cast iron
Force in X direction	4572.8N	3823.84N	3049.07N
Force in Y direction	2329.8N	1924.4N	1549.53N
Principal stress (in N/m^2)- Analytical	0.16×10^7	0.13×10^7	0.13×10^7
Principal stress (in N/m^2) - FEA	4.8×10^7	4.07×10^7	3.2×10^7

Table.no.2. Analysis of Swing Lever Fixture

Property	Analysis of Cylindrical Component Fixture		
Depth of cut in mm	3	2.5	2
Material for fixture	Cast iron	Cast iron	Cast iron
Force in X direction	4572.8N	3823.84N	3049.07N
Force in Y direction	2329.8N	1924.4N	1549.53N
Principal stress (in N/m^2)- Analytical	4.13×10^5	3.4×10^5	2.7×10^5
Principal stress (in N/m^2) - FEA	9.25×10^5	7.64×10^5	6.15×10^5

Table.no.3. Analysis of Cylindrical Component Fixture

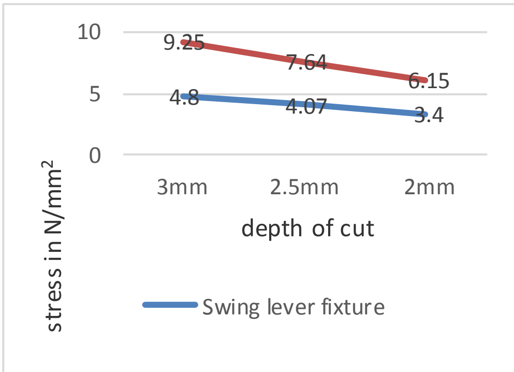

Fig.no.14. Comparison of maximum principal stress on swing lever fixture and cylindrical component fixture

CONCLUSION

Thus it can be inferred that this paper projects a work to show that modular milling fixture using two different locators can be employed for milling of two different components on same fixture. The evaluation of cutting force due to end milling operation and relevant stress by using FEA technique and comparing it with the standard stress which is ultimate tensile strength of fixture material shows that the fixture can be used for milling of both the components.The fixture for milling is designed in context of providing its application to milling of two components which are swing lever and cylindrical component. Thus the single fixture can be used for milling of two different components and thus provide a single machine station which can be used to mill two different components as per the availability of work piece. Thus idle time for machine is reduced which provides higher machine utilization which increases the productivity of the milling operation involved

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