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A Review on Computer Aided Design and Analysis of Tapping Tool with Diametrical flexibility

Prof. Satish.G Bahaley, Amit.S Shende

Abstract— **Tapping operation which refers to production of internal threads forms an integral part of any machine shop and it is intended to provide semi permanent fastening to the components of product so as to lend themselves for repairs and replacements. Though various methods of internal threading are available such as internal threading by milling, grinding or forming but internal threading by metal cutting which employs a tapping tool is indeed the mostly used for products where accuracy forms the base of evaluation. Last few decades have seen the growth of automobile industries and has resulted in development of its allied operations of which tapping is one of the crucial operation performed. The conventional tapping operation which surely involves rotating the tool and feeding past the pre drilled hole to create the contours called as internal threads and this is followed by withdrawal of tapping tool by reversing it with aid of rotational energy. The present review paper attempts to focus the various tapping attachments for diametrical flexibility being designed and analysed . The tapping tool is subjected mainly to the torque which tends to be the design factor for tapping tool. The operation of tapping includes rotating the tool in clockwise direction and then withdrawing it by reversing which accounts for considerable amount of time and cost of operation. The tapping tool with diametrical flexibility is designed in CAD software and and analysed using FEA technique.**

Index Terms— **Tapping , Diametrical flexibility , FEA**

I. Introduction

Generation of internal threads by metal cutting is generally done by employing tapping tool of the form which is similar to form of thread to be generated. The tapping tool is provided the necessary torque for cutting by using lathe machine, drilling machine and CNC turning centres which provide the necessary cutting action by the edges of tapping during feeding of tapping tool across the pre drilled hole. The removal of tapping tool is assured by anticlockwise rotation of spindle which holds the tool and considerably accounts for energy and time for operation of tapping. In this project the conventional tapping tool is divided into two parts which retain cutting edges two on each side so as to shrink in size or collapse at the end of cutting of internal threads which would facilitate easy withdrawal of tapping tool without reversing the same. Computers employing microelectronics technology are called for aiding the geometric modeling of system which would provide the actuation in terms of diametrical flexibility to the two parts of tapping tool employed for cutting. This tool in two parts is subjected to torque due to cutting action and this analyzed under the view of structural analysis which has become an indispensible part of evaluation system used for validation of design .Geometrically modeled tapping tool in CATIA V5 is subjected to tapping torque acting on it and the shear stress results are calculated by FEA software named as ANSYS which are compared with the shear stress acting on the solid tap employed in conventional tapping to provide a platform for evaluation and validation of design.

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Prof. Satish.G Bahaley, Professor, Mechanical Department, PRMIT&R, Badnera Amravati
Amit.S Shende, M.E CAD/CAM ,Mechanical Department, PRMIT&R, Badnera Amravati

II. CONVENTIONAL TAPPING ON DRILLING MACHINES

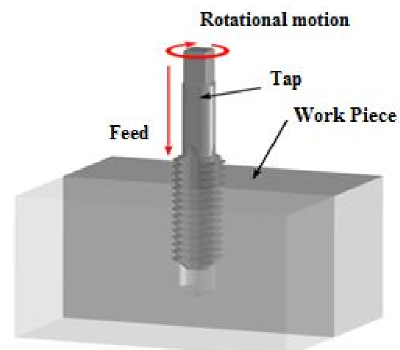

Fig.no.1. Conventional Tapping on Drilling machine.

Tapping operation is carried on drilling machine conventionally by holding the tap in the spindle which while rotating in horizontal plane moves vertically in downward direction past the work piece to generate internal threads. Depending upon the material of work piece the torque is acting on the tapping tool which is resisting in nature and has the effect of damaging out the cutting edges of tapping tool. Tapping tool is available in form of three geometries namely the plug tap , taper tap and bottom tap among which bottom tap is used to tap the blind holes by machine tapping. During each tapping operation the tap is to be reversed for its removal from machined surface and for various diameters of holes various tap are employed which requires considerable amount of time in form of installation new tap size. Moreover tapping operation is complex in nature due to the fact that the tool it employs is brittle in nature which leads to tap breakage in the pre drilled hole and thus it poses a serious problem as tapping is the last operation mainly carried out on product to be assembled and thus any error would render the previous work done as wastage and lead to failure of product. To overcome this problems the conventional design of tapping tool is subjected to a change of diametrical flexibility which owes its function to the feature of dividing the tool into two parts and actuating the same by aid of actuation member fastened by spring and actuation done through lead screw for efficient movement of tapping bits to set the diameter.

III. RESEARCH METHODOLOGY

The following methodolgy is used for designing and validating the proposed mechanism for diametrical flexibility of tapping tool.

[4.1] To induce the feature of collapsibility in the working of tap by providing it the diametrical flexibility.

[4.2] To vary the diameter of tap in certain range to provide different tap diameter with same tap.

[4.3] To design an adapter enclosing the arrangement of diametrical flexibility to provide the same.

[4.4] To regain the original diameter after collapsing the tap at the end of cutting operation.

[4.5] To analyze the torque acting on tap at diameter of 24mm, 26mm and 28mm to compare them with the standard torque requirement of solid taps.

IV. LITERATURE SURVEY

With a an attempt to optimize various parameters of tapping operations many research are noticed and appreciated in form of patents during last few decades. One such optimization was to redesign the geometry of body tap to accommodate itself for a feature called as collapsibility . The term collapsibility in case of tapping refers to the feature that tap after cutting through hole would collapse at the end of operation so that it could be taken out without rotating in anticlockwise direction . It is worth noticing the patent secured by Edward Wolff, Donald Barnesand V. Shook under the name of replacable chasers bearing a number US20060024140 A1 which gives a way to use tapping tool in parts called as chasers. The present invention is directed to removable and replaceable tap chasers adapted for use with tap systems. One aspect of the present invention is more particularly directed to removable and replaceable tap chasers adapted for use in collapsible and non-collapsible tap systems designed for cutting internal threads in a single pass into the workpiece. The novel tap chasers described in the present disclosure may significantly improve machining productivity, reduce the cost of machined parts, increase tool life, and improve thread quality and finish.

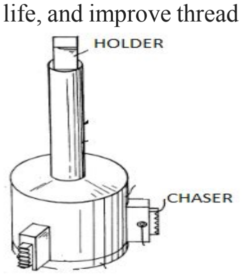

Fig.no.2. Replacable Chasers

The other successful attempt was made by JACOB E. GAIN AND FRANK A to develop a collapsible tap system under the name of Automatically-collapsible tap bearing a number as US 1466987 A. The present invention relates to automatically collapsible taps for cutting threads and consists in an improved structure resulting from a novel arrangement of parts which desirably brings about a more direct and effective cooperation of these parts in their assumption of the different positions of adjustment that necessarily occur in a device or" the type in question have provided an automatically collapsible tap wherein the bits which are ex- -tended in operation and automatically withdrawn at the end of each operation are mounted upon a plunger structure that is adjustably mounted in a stock.

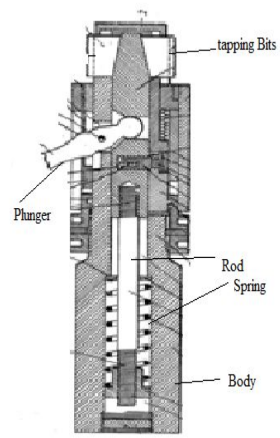

Fig.no3. Automatic Collapsible Tap

With advent of tapping technologies various research took place in the direction of analysis of the tapping torque and axial thrust which can be acknowledged here. In 1987, S. S. Patil, S . S. Pande and S Somasundaram have reported the results of an experimental program to study the influence of torsional vibrations on tapping process. An attachment has been designed and developed to produce controlled torsional vibration on the tap while tapping. Investigations have conditions, such as tap size, work material, vibration conditions, such as tap size, work material which enhance the tap life are reported. In 1973, E. D. Doyle and S. K. Dean have designed tapping attachment to reduce the axial forces generated during the tapping operation. When tapping threads on a machine tool, such as a drilling machine, axial forces on the tap can be generated by the cutting action of the tap, by the operator and by the machine, and they can threads and poor thread forms produced on a radial drill were found to be caused by axial forces generated by the machine. These defects were eliminated by using a tapping attachment specifically designed to reduce axial forces. A use enables the cutting of accurate thread forms. G.Lorenz, in 1980, has studied on tapping torque and tap geometry. Vibrations in tap geometry are reflected in the measurements of the tapping torque. The effects of cutting speed, thread relief, chamfer and rake angle on torque have been investigated in a statistically designed experiment when using 7/16 – 20 UNF bottoming taps and zp-oil on a pitch gear controlled tapping machine. J. D. Adams, L. Manning, B. Rogers, M. Jones and S. C. Minne, in 2005 have demonstrate self sensing tapping mode using commercially available, low- stress, piezoelectric cantilevers with sharp design integrated, silicon tips. Previous work has been limited by stress in the cantilever, thickness and size of the cantilevers, un-optimized electrical trace design and/or a lack of a probing tip. Tests indicate amplitude resolution with self-sensing to be as good or better than optical detection, and sensitivities up to twice as good, with the same type cantilever. A tapping mode image of an evaporated gold film and force curves that compare optical and self-sensing detection methods are presented .

V. GEOMETRIC MODELLING IN CATIA V5

[5.1] The actuation system for two bits of tapping tool are geometrically modeled by invoking CATIA V5 software. The number of components are each modeled using part modeling module of CATIA V5 and then assembled by subjecting the various components to bottom- up assembling method employed in assembly module of software. The first component to be modeled is in shape of disc of thickness 8mm and diameter of 70mm with a diametrical slot of 54mm x 10 mm to support the member to hold the bits of tap. The next part modeling deals with geometrically designing the subassembly employed for actuation by tapping bits assembly. All the components and subassemblies modeled previously are assembled as single product to provide the design of tapping tool with diametrical flexibility.

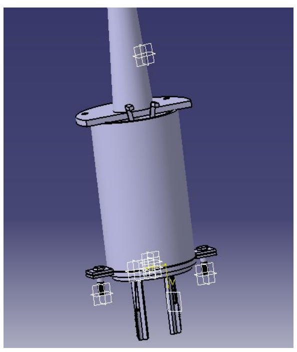

Fig.no.4. Assembly of the system

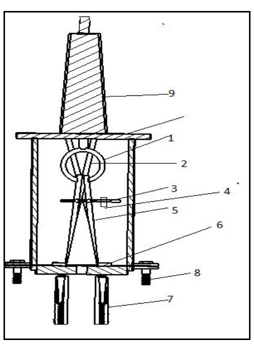

Fig.no.5. Section View of System

1 – Spring	2- Handle
3- Lead screw	4- Spindle for lead screw
5- Actuating member	6- Block for holding the tap
7- Collapsible Tap	8- Bolt
9- Sleeve	10- Disc

VI. DESIGN ANALYSIS OF SYSTEM

[6.1] The adaptive design for diametrical flexibility of tapping tool proposed here can be analyzed with a view of torque acting on the tapping tool. The torque acting on tapping tool is dependent on the material of work piece, geometrical complexity of tap and alignment with the pre drilled hole. This torque is the result of resistance force acting tangentially to the teeth of tapping tool as shown in figure below and it results into breakage or chipping of the teeth of tapping tool which in turn disposes the tapping tool as waste material.

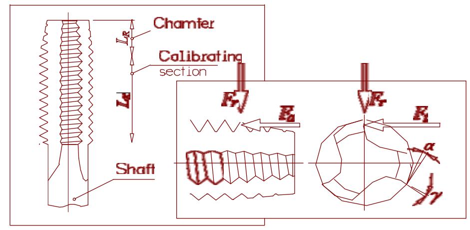

Fig.no.6. Forces acting on Tapping Tool

[6.2] The solid tapping tool which is lacking the diametrical flexibility is subjected to torque which is calculated by an empirical relation which takes into account the diameter of hole to be tapped and the material of the work piece which is aluminium in this case. This machining conditions remains same for tapping tool with diametrical flexibility and thus the solid tap and tap with diametrical flexibility are subjected to same torque conditions but the results which is in terms of shear stress is used to demarcate the design of two tools for validating the same. The experimental values of torque acting on solid tapping tool are given by the empirical relation provided by Taflet tool Co. which are used to calculate the shear stress acting on tapping tool of diameter 24mm, 26mm and 28 mm.

Torque= 0.0491x K x E x P

Where K= coefficient of material to be machined which is equal to 0.4 for aluminium

E = Basic pitch diameter of tap hole

P = thread pitch of tap

$$\frac{T}{J} = \frac{C\theta}{L} = \frac{\tau}{x}$$

Where , T= torque acting on member

J = Polar moment of inertia = $\frac{\pi}{32}$ x d^4

C= Modulus of rigidity, Θ= angle of twist

L= length of member subjected to torsion

τ = shear stress x = distance of neutral axis from the point of application of load.

TAP SIZE IN MM	TORQUE in N-m	SHEAR STRESS in N/mm^2
24	4.7068 x10^{-3}	1.73
26	5.09912 x10^{-3}	1.477
28	5.2952 x10^{-3}	1.370

Table.no.1. Torque and Shear Stress on Solid Tapping Tool

[6.3] The tapping tool with diametrical flexibility when subjected to torque is analyzed in FEA tool which is ANSYS and the results of shear stress are calculated by consecutively meshing the assembly of tap bits and subjecting it to given torque values calculated by using empirical relation . The shear stress results are shown in following figures below.

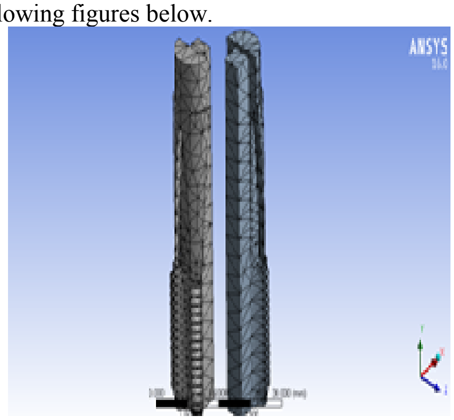

Fig.no.7 Meshing of Tapping tool with Daimetrical Flexibility

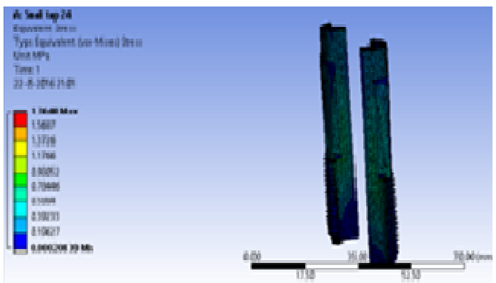

Fig.no8 Nodal Solution of M24 Tapping tool

VII. RESULTS AND COMPARISON

[7.1] The process of designing and analyzing the system with relevant parameters of study is followed by inferences generated by evaluation process of the data obtained during the process of analysis The results calculated can be drawn on the lines of effect of torque which is shear stress in this case. The various input values which are same for both conditions are presented and the variation in the effect due to design variation in the system can be presented as follows. This values when compared with actual values of tapping tool which is solid and is applied by the present technology of tapping provide us with inference that the tap with diametrical flexibility can work in safe zone without chipping off the teeth due to excessive shear stress. Thus it can be implied that proposed design of system can be employed efficiently to produce the threads on internal surface of work piec

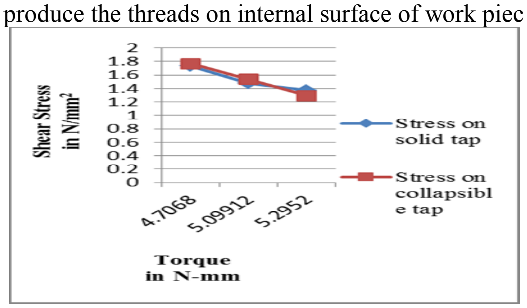

Fig.no.9. Comparison of shear stress on solid tap and tap with diametrical flexibility

Property	**Solid Tapping tool**		
	M24	M26	M28
Tool Material	HSS	HSS	HSS
Shear Strength of HSS	100Mpa	100Mpa	100Mpa
Work material	Aluminiu-m	Aluminium	Aluminium
Boundary condition	Fixed support on top	Fixed support on top	Fixed support on top
Torque on tool (in N-mm)	4.7068	5.09912	5.2952
Shear stress on tap in N/mm^2	1.73	1.477	1.370

Property	**Tapping tool with diametrical flexibility**		
	M24	**M26**	**M28**
Tool Material	HSS	HSS	HSS
Shear Strength of HSS	100Mpa	100Mpa	100Mpa
Work material	Aluminium	Aluminium	Aluminium
Boundary condition	Fixed support on top	Fixed support on top	Fixed support on top
Torque on tool (in N-m)	4.7068	5.09912	5.2952
Shear stress on tap N/mm^2	1.768	1.5351	1.2696

CONCLUSION

Thus it can be inferred that this paper projects a work to show that an adaptation in conventional design of tapping tool geometry can be employed to save the time of machining and energy involved in each operation of tapping by providing the diametrical flexibility to the tapping tool by mechanism of actuation modeled in CAD tool. The evaluation of tapping torque and relevant shear stress by using FEA technique and comparing it with the standard shear stress acting on conventional tapping shows that tapping tool with diametrical flexibility is achieving the saving in time of operation and energy and at the same time it is under the safe zone of shear stress acting on it. Thus the mechanism can be efficiently applied for tapping operation.

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