Design and Fabrication of Mechanism to Drill Square Hole

Sanket Dangra, Saurabh Dangra
Research Scholar, Department of Mechanical Engineering, Shri Datta Meghe Polytechnic College, Nagpur, India.

Abstract - **Producing square holes in the field of manufacturing, is very common and useful technique. But at same time there is a problem of high cost and complexity in manufacturing. Creating square hole using drill, in addition to have an easier manufacturing is made possible using the special tool. In this paper, curves of constant width are discussed first of all and then, a mathematical model was achieved for the shape of the cam of constant width i.e. Reuleaux triangle. The system design considers modification to existing system for satisfying the requirement of making square hole. We have performed operation on wood and other soft metals. We have identified idea in the research papers for generating square hole by using drilling operation. To make square hole we have to convert circular motion into square motion. The idea is to use Reuleaux triangle which when rotated inside a square, each vertex traces a curve that is almost a square. So, by designing a bit on cam it would be creating square hole on the work piece. During the rotation of the cam, the center of rotation is not fixed and this is the main problem in this mechanism. So there is a need to a non-coaxial coupling to transmit the rotational motion.**

Keywords – **Reuleaux, Eccentricity, Drilling, EDM, Geometry**

I. INTRODUCTION

This paper discusses the mechanical design and simulation of a square hole producing tool based on Reuleaux Triangle. The most important point is that, during the rotation of the Reuleaux polygon, the center of rotation will not stay at a fixed point. So, in order to transmit the torque from drill to the cam, it is needed to use a non coaxial coupling which can transmit torque and thus in the proposed paper universal non coaxial coupling is used. Moreover, for this geometry to work from a rotating guide (such as a drill press) one must force the Reuleaux triangle to rotate inside a square, and that requires a square prototype to constrain the Reuleaux triangle as well as a special coupling to address the fact that the center of rotation also moves. The practical importance of this enhancement is that the driving end can be placed in a standard drill press; the other end, when restricted to stay inside the ambient square, will yield a perfectly square locus and this can be turned into a working square-hole drill. thus with the help of Reuleaux triangle, square guide, drill bit and universal coupling the task can be accomplished. The developed design had a success rate of 75.0% i.e. it removed approximately 75.0% area of the desired square. The fabrication of the tool of this has been done on HIGH CARBON HIGH CHROMIUM STEEL (HCHC) that is ideal for soft surfaces but if harder materials are used, hard surfaces application is also possible.

II. PROBLEM STATEMENT

The process of broaching involves a toothed tool which is known as broach. The broach is run linearly against a surface of the work-piece to effect the cut. As while broaching force is exerted on work-piece, so there are possibilities of failure of work-piece. This will have unfavorable ramifications on process strength, stability, geometry and integrity of the machined surface. Adequate gap flushing is therefore significant in terms of both machining productivity and the quality of the machining surface. Holes leaves their footprints on the machined surface, as the work shape produced in BROACHING is complementary to that of the tool. As compared to broaching, drilling is easy process. Also broaching machines are very expensive and is very large in size. If holes are drilled rather than Broached or press worked then stronger and better components can be made. Broaching is practical if huge quantities of components are required. So Drilling is advantageous as small quantities can be manufactured economically and efficiently. Also we can achieve particular depth of hole in drilling which is not possible in drilling. In this context, the present works relates and directs to design and implementation of novel tool kinematics motivated by the concept of a RT. The technique utilizes rotating curvilinear tools for sinking regular and non-regular polygonal cavities with sharp corners, Wire EDM is also used if broaching is not practical and it gives good quality result with excellent surface finish, but every operations has its limitation and advantages. If the thickness criteria is not allowed to control the process and still the blind one take square hole is required, then this gives the limit of these operations.

Thus there should be a tool which can directly provide the required cutting and is attachable to present manufacturing equipment's with ease and accuracy. If such a tool is readily available and is economical to use, it will definitely affect directly or indirectly in a positive way for machining industries and also to the customers.

Scope

The scope of this paper is to machine a square hole using a tool with three cutting edges and to select suitable material (HCHCr) to machine all surfaces, by connecting universal couplings at end of RT. With options to replace the tool of various sizes and can machine square hole of varying sizes. The Polygonal holes made by drilling instead of EDM are better in different ways.

1. Electrically non-conductive materials can be machined only with specific set-up of the process.
2. Excessive tool wear occurs during machining.
3. The additional time and cost used for creating electrodes for ram/sinker EDM.
4. Power consumption is high.
5. Potential fire hazard associated with use of combustible oil based dielectrics.

Result expected

The development of square hole Drilling Machine, it simplify machining square hole at low cost and time. Machine is compact in size, which provides flexibility to produce square holes with low manufacturing cost. This prototype can prove that square hole can be generated by using Reuleaux triangle and universal joint arrangement. Other method, to generate square hole is quite time consumable and costly.

III. METHODS

The following equations will explain the phenomena correctly; Let us take an equilateral triangle of side „S" as shown in the figure. In the right angled triangle ACR [1],

AC= S AR= $0.5\times S$
CR= $0.866 \times S$
Considering ΔACR,
AP= $0.667 \times CR$ = $0.577 \times S$

Considering Reuleaux triangle,
BP= $S-AP = S - (0.577\times s) = 0.423\times S$

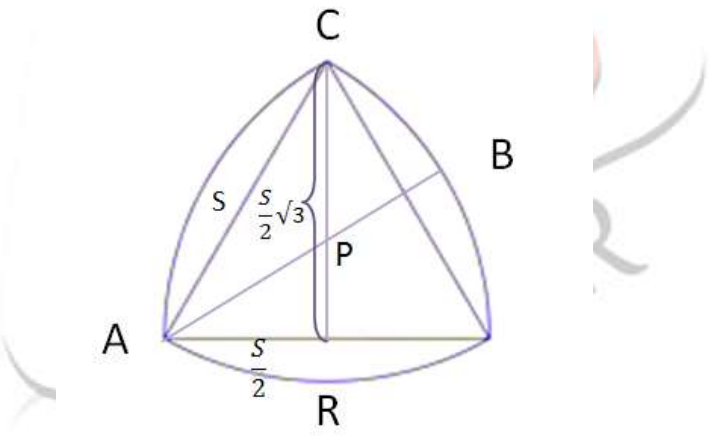


Figure 1. Reuleaux triangle

[2]The geometric centroid does not stay fixed, nor does it move along a circle. In fact, the path consists of a curve composed of four arcs of an ellipse. For a bounding square of side length, the ellipse in the lower-left quadrant has the parametric equations.

$x = \frac{S}{6}(-3 + \sqrt{3}\cos\alpha + 3\sin\alpha)$ ……..(1)

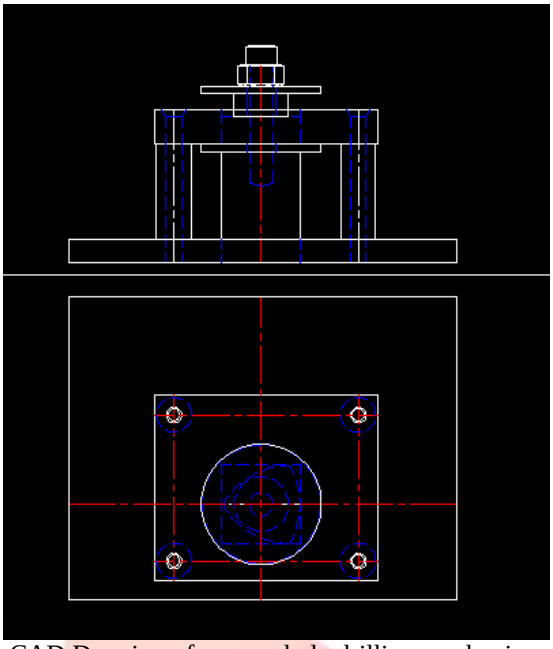
$y = \frac{S}{6}(3 - 3\cos\alpha - \sqrt{3}\sin\alpha)$ ……..(2)

IV. WORKING PRINCIPLE

The main idea for manufacturing a special tool for fulfilling the laid objectives is to make a mechanism which will transform the rotational motion of a shaft about its longitudinal axis to revolving motion around the same axis in a given profile which is confined by four governing ellipses at each corner, having their Center at the vertices of confining square which will guide the tool in confined profile keeping the rotation intact. This will lead to the cutting of the square geometry as required for the purpose. The rotation of tool with the same rpm as that of the chuck. This is necessary to overcome a large amount of force to cut a metallic component. Revolution becomes an integral part so the Reuleaux triangle center is not fixed and it has to move in a

profile which is made by those four ellipses. After following the basic principles a need arises to put the components together without compromising the working of each component.

V. DESIGN



CAD Drawing of square hole drilling mechanism

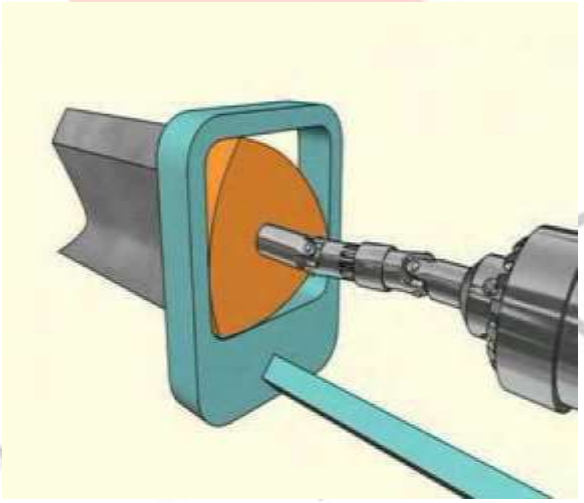


Figure 2. Model of square hole drilling machine

Reuleaux triangle

Side of equilateral triangle to construct reuleaux triangle is taken as S= 40mm.
From one edge to centre of RT =23.09mm
Length of arc from each edge (width of RT) = 40 mm
Thickness of RT , t =14mm

Area OF RT= $A = \frac{S \times S}{2} \times (\pi - \sqrt{3})$ = 1127.63 mm^2

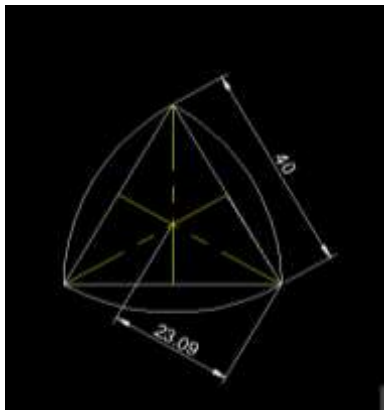


Figure 3. construction of RT in auto CAD

Tool Design

Objective of tool design [4].

- **a.** Reduce the overall cost of manufacturing a product by producing acceptable parts at lowest costs
- **b.** Increase the production rate by designing tools that will make the parts as quickly as possible and maintain quality by designing tools which will consistently make the parts with the required precision and accuracy.
- **c.** Reduce the cost of special tooling by making the designs cost effective and efficient as possible.
- **d.** Design tools that will be safe and easy to operate

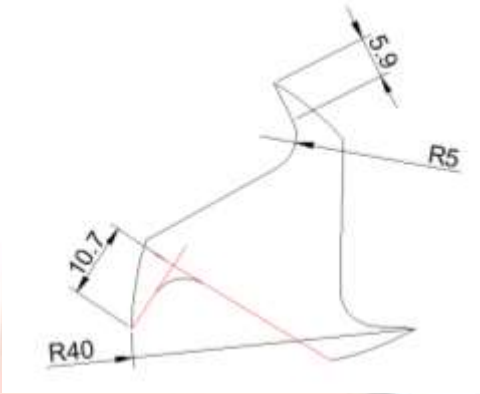


Figure 4. Cutting tool

VI. COMPONENTS

i) 3- Edge Cutting Tool

The Drill is a special cutter with one less flute than the number of sides of the hole. The tool is made up of HCHCr, which has high hardness strength. The flutes in this case are straight. Its action is to lodge one cutting edge in a corner and to 'sweep' round with another edge until this one lodges in a corner. The drill must only be sharpened on the end. The tool is mounted on a Reuleaux triangle of thickness 25 mm, the tool is made of HCHCr.

TYPE	C%	Mo%	Si%	Mn%	V%	Cr%
HCHCr D2	0.12 TO 0.18	0.5 TO 0.8	0.10 TO 0.35	0.30 TO 0.60	0.9 TO 1.0	0.60 TO 1.10

Table 1. The chemical composition of HCHCr

Hardening Temperature (◦c)	780-860
Quenching Medium	OIL
Brinell Rock well hardness	61-63
Tempering Temperature(◦c)	170-210

Table 2. HCHCr steel properties

ii) Supporting Member

Square guide is a stationary part that guides the Reuleaux triangle to move in square shape and also helps the RT to rotate in fixed plane, square guide is connected to base plate using four M.S spacers, these spacer are bolted to the base plate by using M6 ALLEN bolts. In order to obtain the smooth running of RT inside the square guide, we made the square hole of size larger than the width of RT, hence we can ensure rotation of triangle without jamming inside the square hole. We have also constrained the vertical movement of the reuleaux triangle in order to obtain required depth of cut.

Size of square hole=45mm
Material: Mild Steel

iii) Universal joint

Universal joint is used to connect two shafts at an angle for transmitting torque. The center of RT must rotate itself and also revolves in a non-circular path, by using universal joint RT can revolve in non circular path. coupling or joint which can transmit rotary power by a shaft at any selected angle, coupling in a rigid rod that allows the rod to 'bend' in any direction, and is commonly used in shafts that transmit rotary motion. It consists of a pair of hinges located close together, oriented at 90° to each other, connected by a cross shaft. The universal joint is not a constant-velocity joint.

iv) Drilling Machine

To provide rotating motion to RT and tool ,the drilling machine is used .The end of universal joint is connected to tool holder of drilling machine. The spindle speed is constant for all operations, while the cutting speed varies all along the cutting edge. Cutting speed is normally computed for the outside diameter. The center of the chisel edge the cutting speed is zero; at any point on the lip and it is proportional to the radius of that point. This variation in cutting speed along the cutting edges is an important characteristic of drilling.

VII. EXPERIMENTAL SETUP

Figure 5. View of square hole drilling machine and special tool

VIII. RESULT & DISCUSSION

The tool developed is approximately 57 mm in length and it is slightly heavy with approximate weight of 3kg. The cutting tool after proper assembly and installation is found to be accurate up to 90 %. That is, it is able to cut a square profile with approximately 90% area of the original square with same dimensions as that of the cutting tool. The remaining 10% which is not cut is present on the four corner of the square in an arc form.

Working of the present tool is done on cardboard sheet. It is not employed on the workshop material as it is made with mild steel as the base material. So it does not have the required hardness to be able to check on market materials. The main aim is to observe the feasibility of the mechanism in fulfilling the required motion and to check its employment with a cutting tool for producing the square of its size. The first aim has been fulfilled as desired and success of about 80 % has been achieved in the secondary goal. In the future studies, the tool will be studied in detail and required modifications shall be provided thus there are certainly chances of 100% success rate.

IX. CONCLUSION

Fabricated square hole drilling machine and it is found that it is capable of drilling square holes on various wooden materials (pre-drilling is essential).The project is simple in construction and compact in size for use. With less installation cost and less labor skill square holes can be drilled using this arrangement, hence it can be used in small scale industries. The future scope of project is to clamp the machine on bench drill to obtain constant working feed and also the size of drill bit can be made compact using Oldham coupling instead of universal joint.

X. ACKNOWLEDGEMENTS

The authors would like to thank Department of mechanical Engineering, Shri Datta Meghe college, Nagpur, for their technical support and valuable suggestions.

XI. REFERENCES

[1]. Watts Brothers Tool Works (1996).review article on“How to Drill Square, Hexagon, Octagon, Pentagon Holes” Wilmerding, Penn
[2]. Scott G Smith (1998) review on “Drilling square hole-The mathematics teacher” vol 86,no 7 ,pp 579-584

[3]. Bangar Sunil Kisan and Prof. Mythili Sreeram (2014)review on "Modification of square hole drilling", IJFEAT journal-ISSN: 2321-8134 , pp 4 -7
[4]. S K Hajra Choudhury , A K Hajra Choudhury and Niranjana Roy(2010) review on "Drilling machines"-Elements of workshop Technology vol 2,pp 227-255
[5]. Weisstien,EW.,Reuleauxtriangle,Mathworld, mathworld.wolfram.com/reuleaux triangle.html
[6]. H. G. Eggleston.,1952. A proof of Blaschke"s theorem on the Reuleaux Triangle, Quart. J. Math. 3 296-2.