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Design and Fabrication of Precession Square Hole Drilling

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Abstract: **-- Hole serves various purposes in all machine elements. These holes may be round, square, rectangular or any other shape depending on the requirement or design. This paper discusses the mechanical design and simulation of a square hole producing tool based on Reuleaux Triangle. The main aim of this paper is to investigate how a circular motion can be converted into a square motion by purely a mechanical linkage; an application of which is to construct a special tool that drills exact square holes. A geometrical construction that fulfils the laid objective is Reuleaux Triangle. Additionally, for this geometry to work from a rotating drive (such as a drill press) one must force the Reuleaux triangle to rotate inside a square, and that requires a square template to constrain the Reuleaux triangle as well as a special coupling to address the fact that the centre 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 is restricted to stay inside the fixed square, will yield a perfectly square locus and this can be turned into a working square-to drill hole.**

Keywords—Reuleaux,Eccentricity, Drilling, EDM, Geometry

I. INTRODUCTION

The Reuleaux Triangle is one example of a wide class of geometrical discoveries like the Mobius strip that did not find many practical applications until relatively late in humankind's intellectual development. For circular holes,themachines are available in the market. But forsquareor any other type of holes, the Methodscurrentlyused are broaching, electrode-dischargemachine(E.D.M.), And electro-chemical machine. Thesearevery much expensive and require special toolsormachines. The reuleaux triangle is one example ofa wide class of geometrical discovery byGermanmechanical engineer Franz Reuleaux , discussedthefamous curvy triangle that is started being used innumerous mechanisms Watts BrotherToolWorks. Although Franz Reuleaux was notthefirst to draw and to consider the shape formedfromthe intersection of three circles at the corners ofanequilateral triangle. The width of a closed convex curve in a given direction is the distance between two parallel supporting lines perpendicular to that direction. A set of constant width b has the same width in all directions. Besides the circle, the best known closed convex curve of constant width b is the Reuleaux triangle of width b, i.e., a set in R2 whose boundary consist of three congruent circular arcs of radius b. See Fig 1. Below. The Blaschke Lévesque Theorem states that the Reuleaux triangle has the least area of all plane convex sets of the same constant width b. The minimum area is $((\pi-\sqrt{3})/2)b2$.The Reuleaux Triangle is example of a wide classes of geometrical discoveries like Mobius strip that did not find many practical applications until relatively late in humankind's intellective development. Used in numerous mechanisms by Watts Brothers Tool Works.

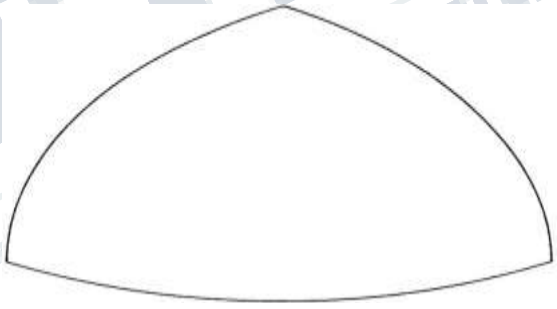

Fig 1. Reuleaux triangle.

II. SCOPE

The scope of this paper is to machine the tool with three cutting edge and to select suitable material (EN9) to machine all surfaces, by connecting tool holder 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 broaching are better in different ways.

1.) If holes are drilled rather than Broached or pressworked then stronger and better components can be made.
2.) Broaching is practical if huge quantities ofcomponents are required. So Drilling is advantageous as small quantities can be manufactured economically and efficiently.
3.) There is no need of broaching undercuts and alsothe hole have a flat unimpeded ends.
Conventional machining process like Wire EDM, Laser cutting, etc. Material removal in uniformly distributed gap

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contamination of a certain threshold is desirable in the interest of discharge initiation; however, excessive debris concentration confined to isolated domains in the gap due to insufficient flushing leads to repeated localization of the discharge location. This has unfavourable ramifications on process stability, and the geometry and integrity of the machined surface. Adequate gap flushing is therefore decisive in terms of both machining productivity and the quality of the machined surface.

III. PROBLEM STATEMENT

There are very limited options available in manufacturing if the geometry of an operation which is to be cut on a part is non-circular. In the present manufacturing processes, square hole are produced by Press working, Broaching, Non-conventional machining process like Wire EDM, Laser cutting, etc.

Material removal in electrical discharge machining (EDM) entails the generation of debris in the working gap that comprises eroded electrode particles and by-products of dielectric decomposition [Kunieda, M., Lauwers, B., Rajurkar, K.P., Schumacher, B.M 2005]. Uniformly distributed gap contamination of a certain threshold is desirable in the interest of discharge initiation; however, excessive debris concentration confined to isolated domains in the gap due to insufficient flushing leads to repeated localization of the discharge location. This has unfavourable ramifications on process stability, and the geometry and integrity of the machined surface. Adequate gap flushing is therefore decisive in terms of both machining productivity and the quality of the machined surface.

Flushing could be accomplished by forced flow of the dielectric fluid through holes in the tool, but flushing holes leave their footprints on the machined surface, as the work shape generated in EDM is complementary to that of the tool. Flushing could alternatively be through micro holes specially fabricated in the tool [Shibayama, T., Kunieda, T 2006]. In the instance that it is infeasible to provide flushing holes in either of the electrodes, the dielectric could be directed at the gap in the form of a jet from outside the machining zone. This technique is not effective when the machined depth or the frontal machining area is large: conditions that pertain to an acute need for good flushing. Another approach to flushing is to introduce a secondary motion between the tool and the work piece. In the jump-EDM process, the tool is periodically retracted off the gap to allow for the removal of the contaminated dielectric. Tool motion can further be extended to more than one axis [Masuzawa, T., Heuvelman, C.J 1983], in which case the tool and the work piece essentially constitute a pump that constantly regenerates the gap. These techniques are limited by the additional tool movement representing lost machining time.

IV.METHOD

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 0.5CR= $0.866 \times S$

Considering ΔACR,

AP= $0.667 \times CR$ = $0.577 \times S$

Considering Reuleaux triangle,

BP= $S-AP = S - (0.577^{\times}s) = 0.423 \times S$

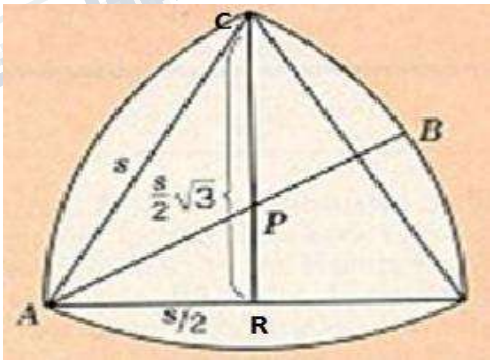

Fig 2.Dimension of triangle of both sides

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)

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y= $\frac{5}{6}(3 - 3\cos\alpha - \sqrt{3}\sin\alpha)$ .....(2)

The centroid of the triangle from which RT is made is not at the same distance from the three sides of reuleaux and this can be shown by simple geometrical analysis. 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,

AC= s
AR= s/2 CR= s/2*√3

Considering ▲ACD,

AP= 2/3 CR = 2/3*s/2*√3 = 0.577 s
Considering Reuleaux triangle,
BP= s-AP = s-0.577s = 0.423s

IV.I RESULTS EXPECTED

Other method, to generate square hole is quite time consumable and costly. With 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.

V.METHOD

Here the bevel gear arrangement is used for carrying out the operations. Bevel gear is used to perpendicular (90^0) power transmission. One of the bevel gear is connected with the handle and another one with the drill chuck hence when the handle is rotated the drill chuck also rotates. The handle shaft is connected to a cam arrangement on the other side. Cam arrangement converts rotary motion into reciprocating motion and the reciprocating motion is used for the slotting and cutting operation. The slotting tool and cutting tool are guided by a horizontal guide bush. The up down table is mounted on a hydraulic bottle jack piston rod hence when the bottle jack handle is pumped the table height can be adjusted according to the requirement when the after the process is completed the pressure should be released through pressure relief valve to make the table come down. A vice is mounted on the table to hold the work piece.

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 centre 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, which is necessary to overcome a large amount of force to cut a metallic component. Revolution becomes an integral part so the Reuleaux triangle centre 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 components

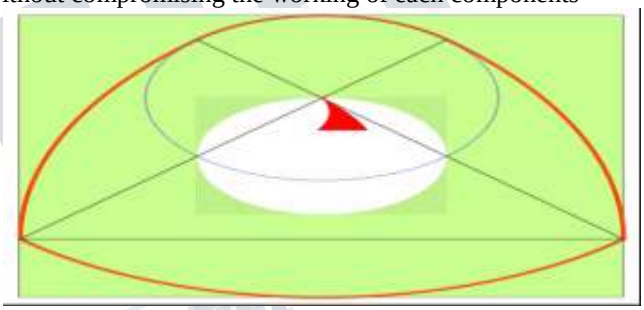

Fig 3.Cutting of Square Edge by Reuleaux triangle

VI. COMPONENTS

i) 3- Point Cutting Tool

The special tool mounted on RT which has 3 cutting edge in order to obtain the square hole. The tool is made up of EN36, which has high hardness strength. Predrilling is highly recommended, this reduces wear on tooling and the amount of swarf to be removed.it also relives some pressure on the tool and hence has greater tool life. The tool is mounted on a Reuleaux triangle of 25mm

Fig 4: 3point cutting tool

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TYPE	C%	Si%	Mn%	Cr%
EN36	0.12 TO 0.18	0.10 TO 0.35	0.30 TO 0.60	0.60 TO 1.10

Table 1. The chemical composition of EN36

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

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 drilling machine using two steel rods,and these rods are clamped to the drilling machine by using clampers. Clampers are provided to attach supporting member to portable drilling machine. 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 tool without jamming inside the square hole.

iii) Universal joint

Universal joint is used to connect two shafts at an angle for transmitting torque. The centre of RT must rotate itself and also revolves in a noncircular path, by using universal joint RT can revolve in noncircular path. coupling or joint whichcan 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.

Fig 5: universal joint

iv) AC motor

To provide rotating motion to RT and tool, the impact drill 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 centre 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.

Specifications

1. Chunk size: 13 mm
2. Power: 0.25 Hp
3. Frequency: 50 Hz
4. Current: 1.5 A
5. Speed: 0 - 1890 rpm
6. Voltage: 220 V

Fig 6: ac motor

VII. EXPERIMENTAL SETUP

The drilling tool developed is approximately 300 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

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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.

Fig 7: Front view of precession Square hole drilling

Fig 8: side view of precession Square hole drilling

VIII. 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 labour 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.The project carried out by us made an impressing task in the field of industrial and automated workshops. It is very usefully for the workers to work in the industrial workshop are in the service station. This project has also reduced the cost involved in the concern. Project has been designed to perform the entire requirement task which has also been provided.

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