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Design and Fabrication of Square Hole Drilling Machine

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ABSTRACT
The mechanical design and of a square hole producing tool based on Reuleaux Triangle. The main aim of our papaer is to investigate how the circular motion can be converted into a square motion by purely a mechanical linkages; an application of which is to construct a special tool that drills exact square holes. The geometrical construction that fulfils the laid objective is Reuleaux Triangle . Additionally, for this geometry to work like a rotating drive (such as a drill press) must force the Reuleaux triangle to rotate inside a square, and that requires a square guide to constrain the Reuleaux triangle as well as a special coupling to describe the fact that the center of rotation also in moves within in the constrain. 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

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. For circular holes, the machines are available in the market. But for square or any other type of holes, the Methods currently used are broaching, electrode-discharge machine (E.D.M.), and electro-chemical machine. These are very much expensive and require special tools or machines. The reuleaux triangle is one example of a wide class of geometrical discovery by germam mechanical engineer Franz Reuleaux , discussed the famous curvy triangle that is started being used in numerous mechanisms Watts Brother Tool Works[1]. Although Franz Reuleaux was not the first to draw and to consider the shape formed from the intersection of three circles at the corners of an equilateral triangle .But the use of this curve and its special properties for producing polygonal holes was given by Sir James Watts in 1914 and the geometry has been constantly evolving from day to day exactly reproduce the square in which it revolves.

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. Not until around 1875, when the distinguished German mechanical engineer Franz Reuleaux discussed the famous curvy Reuleaux triangle, that it started being used in numerous mechanisms by Watts Brothers Tool Works[1].

I.I Problem statement

Material removal in electrical discharge machining which involves the generation of debris in the working gap that comprises eroded with electrode particles and by-products of dielectric decomposition. Uniformly distributed gap contamination of a certain thresholds is desirable in the interest of discharge .However excessive debris concentration confined to isolated domains in the gap because of insufficient flushing leads to repeated localization of the discharge in a particular location. This will have unfavourable 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. Flushing could be accomplished by forced flow of the dielectric fluids through holes in the tool, but flushing holes leaves their footprints on the machined surface, as the work shape produced in EDM is complementary to that of the tool. Flushing could alternatively be through micro holes,which is specially fabricated in the tool . In the instance that it is infeasible to provide flushing holes in either of the electrodes, the dielectric could be directed and controlled at the gap in the form of a jet from outside the machining area. This technique is not effective when the machined depth or the frontal machining area is large.

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.

I.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 press worked then stronger and better components can be made.
2.) Broaching is practical if huge quantities of components are required. So Drilling is advantageous as small quantities can be manufactured economically and efficiently.
3.) There is no need of Broaching undercuts and also the hole have a flat unimpeded ends.

I.III Result 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.

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×s) = $0.423\times S$

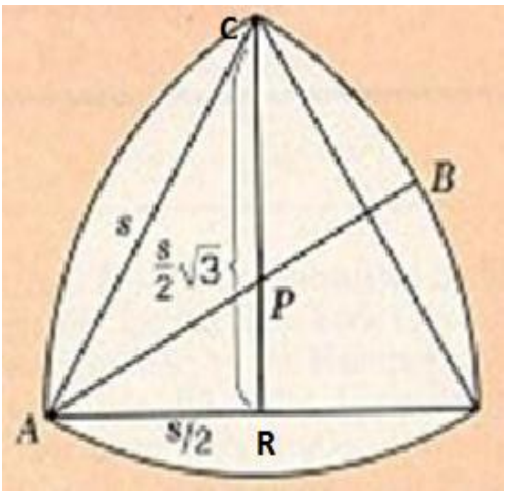

Figure 1. Reuleaux triangle

[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.
$x = \frac{5}{6}(-3 + \sqrt{3}\cos\alpha + 3\sin\alpha)$……..(1)

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

V. DESIGN

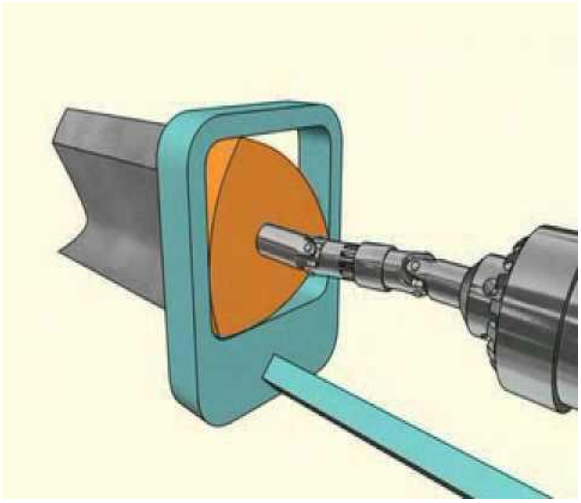

Figure 2. Model of square hole drilling machine

V.I Reuleaux triangle

Side of equilateral triangle to construct reuleaux triangle is taken as S= 25mm.
From one edge to centre of RT =14.44mm
Length of arc from each edge (width of RT) = 25 mm
Thickness of RT , t =20mm
Area OF RT= $A = \frac{5\times5}{2} \times (\pi - \sqrt{3})$ = $\frac{25\times25}{2}(\pi - \sqrt{3}) = 439.98\ mm^2$

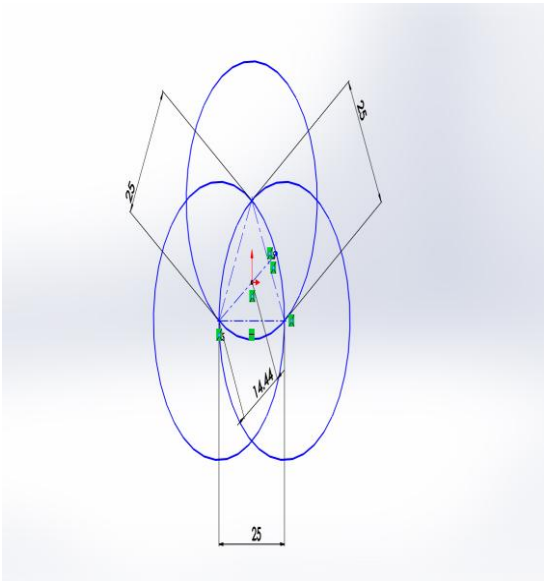

Figure 3. construction of RT in solidworks

V.II Tool Design

Objective of tool design[4].

a. Reduce the overall cost of manufacturing a product by producing acceptable parts at lowest costŠ
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

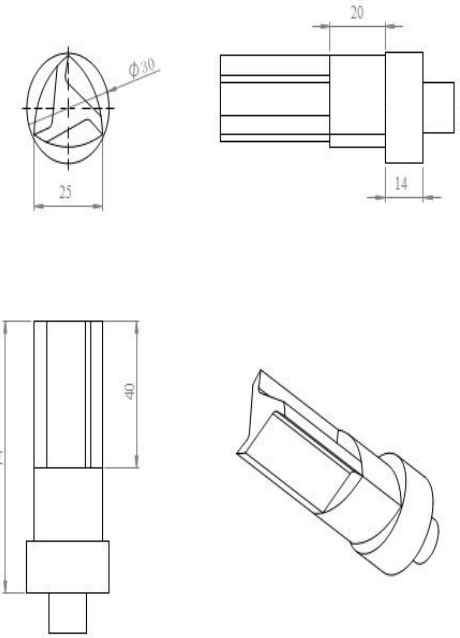

Figure 4. Cutting tool and RT

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 , the tool is made of EN36.

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

Table 2. EN36 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 drilling machine using two steel rods , 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.

Size of square hole =30cm

Material: Mild Steel

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 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 impact drill is used .The end of universal jont 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.

Specifications:

1. Chunk size: 13 mm
2. Power: 350 W
3. Frequency: 50 Hz
4. Current: 1.5 A
5. Speed: 0 - 2800 rpm
6. Voltage: 220 V

VII.EXPERIMENTAL SETUP

Figure 5. Top view of square hole drilling machine

VIII. RESULT & DISCUSSION

The tool developed is approximately 250 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 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.

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