Design and Development of Special Tool to Produce Square Hole

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Abstract— The main aim of this paper is to produce square hole by converting a circular motion into square by using a mechanical linkages such as flexible coupling, guiding mechanism and Reuleaux triangle. Flexible coupling allows Reuleaux triangle to rotate in eccentric manner to produce square hole. Reuleaux triangle restricted to stay inside the square guide, and that will create a perfectly square locus and this can be turned into working square hole drill. In actual practice driving end is connected to the vertical drilling machine and driven end is assembled with special drill bit.

Key words: Reuleaux triangle; Flexible coupling; Special drill bit; Vertical drilling machine

I. Introduction

The drill bit which produces square hole with the help of rotating cutting edges in previously drilled hole. The drill bit which has straight flutes instead of helix angled flutes. Also it rotates in eccentric motion instead of concentric motion. The Reuleaux triangle is also known as constant width triangle; it is developed from equilateral triangle by drawing three circular arcs from the vertices of triangle.

The German mechanical engineer Franz Reuleaux was the inventor of the Reuleaux triangle; therefore, from 1875 this curvy triangle is known as Reuleaux triangle. The Franz Reuleaux was not the first to draw and consider the shape of curvy triangle and its constant width properties, but it first to use the triangle in real world mechanism. A set of constant width ‘b’, has the same width in all direction i.e., a set in our square whose boundary consist of three circular arc of ‘b’

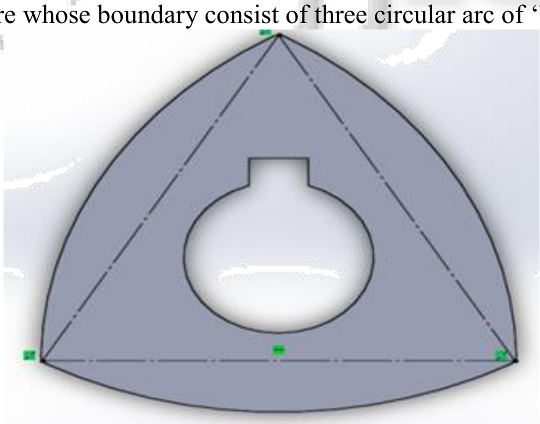

Fig. 1: Reuleaux triangle

II. Literature review

A Reuleaux triangle is a shape made from arcs of circles centered at the vertices of an equilateral triangle. To construct a Reuleaux triangle, firstly, we make an equilateral triangle of side’s see in fig. 1. Now, with a radius equal to‘s’ and the center at one the end points of the other two sides. These three arcs form the ‘classic Reuleaux triangle’. One of its properties is that of constant width, meaning the figure 1 could be rotated completely around between two parallel lines separated by distance‘s’. We got properties of Reuleaux triangle from paper of Procedia material science 6(2014) 1823-36 from science direct.

III. Consrtuction of Reuleaux Triangle

To construct Reuleaux triangle start with an equilateral triangle of sides with radius equal to ‘s’ and the center at one of the vertices draw an arc containing the other two vertices. Similarly, draw arcs connecting the end points of other two sides this three arcs of Reuleaux triangle. One of its properties of constant width, meaning that figure could be rotated completely between two parallel lines separated by distance and always be tangent to each other.

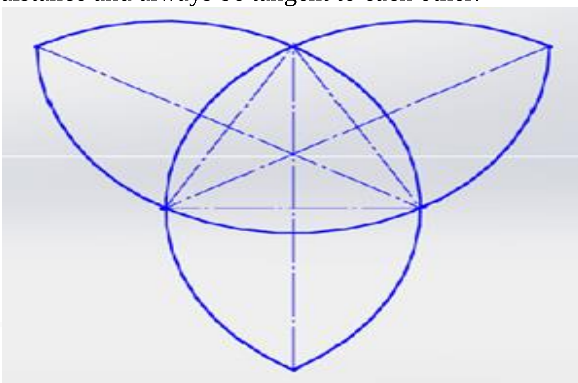

Fig. 2: Construction of Reuleaux triangle

IV. Determination of Distance of Center from Sides

The centroid of the triangle from which Reuleaux triangle 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 sides as shown in the figure. In the right angled triangle ACR,

AC= s

AR= s/2

CR= $s/2\times\sqrt{3}$

Considering ▲ACD,

AP= 2/3 CR = $2/3\times s/2\times\sqrt{3}$ = 0.577s.... (1.1)

Considering Reuleaux triangle,

BP= s-AP = s-0.577s = 0.423s

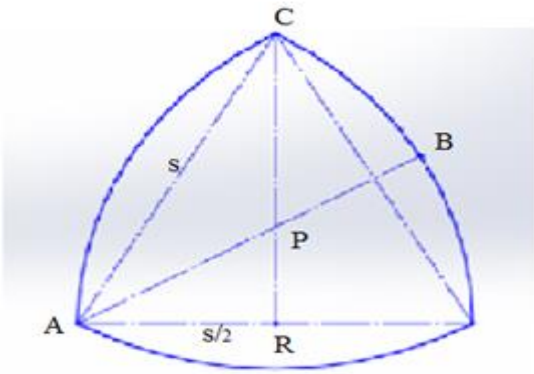

Fig. 3: Geometrical construction of Reuleaux triangle

V. DESIGN

A. *Design Of Coupling*

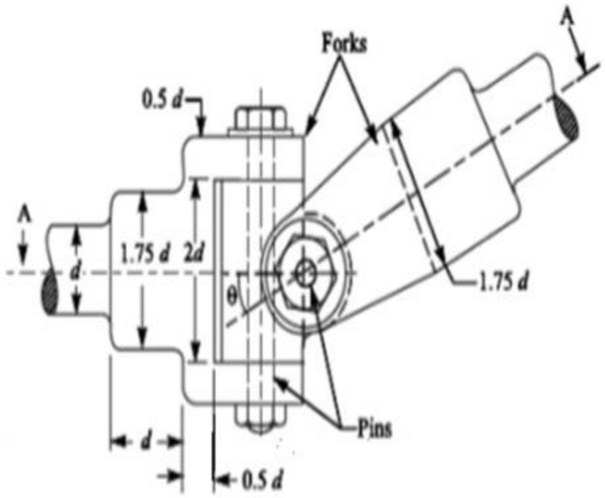

Fig. 4: Double Universal Joint

Type: Double universal joint

B. *Calculation Of Torque*

T=0.000025×KD×Ff×Fm×a×W …. (2.1)
Where,
KD= work material factor
FF= feed factor
FM= torque factor for drill diameter
a= chisel edge factor for torque
W= Tool wear factor, for normal drilling.

From this equation we will get torque and with the help of torque we can easily determine the diameter of shaft. From diameter we will select universal joint from standard available sizes.

C. *Calculation Of Shaft Diameter*

T= (π/16) ×τ×d3 …. (2.2)
Where,
T= Torque
d= Diameter of shaft
τ = Shear stress

VI. DOUBLE UNIVERSAL JOINT

Fig. 5: Double universal joint Calculation of driving and driven speed

$$N1 = \frac{N \times \cos\alpha}{1 - \cos^2\theta \times \sin^2\alpha} \quad (3.1)$$

Where,
N= Speed of driving shaft in rpm
N1=Speed of driven shaft in rpm
α=Angle of inclination of shaft
θ=Angle of driving shaft where the pin of driving shaft fork are in plane of two shaft.

The main aim of using double universal joint is to allow the eccentricity and provide 1:1 speed ratio. The below fig. 5 shows the double universal joint.

VII. ACTUAL VIEW OF CUTTING TOOL

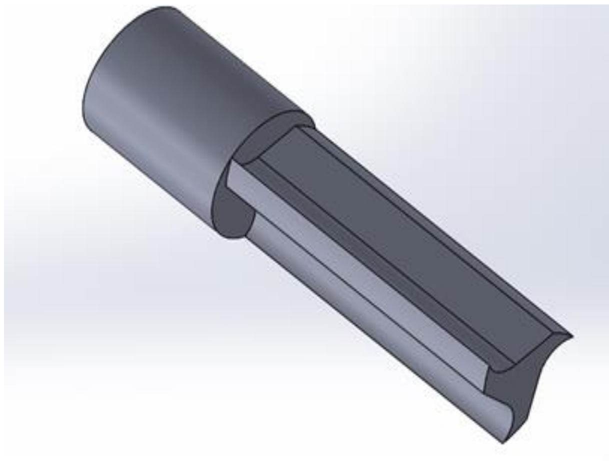

Fig. 6: Drill Bit

VIII. GEOMETRY OF CUTTING TOOL

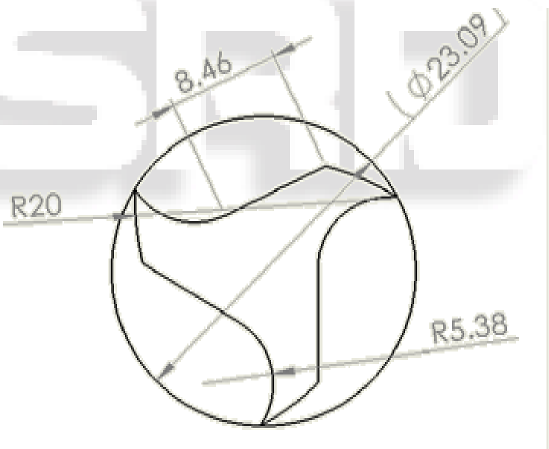

Fig. 7: Tool Profile

IX. PRINCIPLE

Main objective is to convert the circular motion into square motion by application of special drill bit to produces exact square hole. The important point is the square hole drilling mechanism has no fixed center of rotation, hence it moves in non circular path. Thus there is need of a flexible coupling, in order to transmit rotational motion. This rotational motion is transmitted to cutting tool and due to this flexible coupling; rotation of cutting tool is the same as that of input shaft.

X. Construction and Working

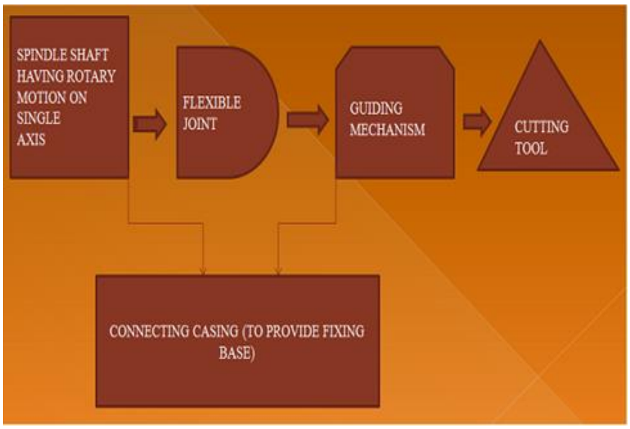

Fig. 8: Block Diagram of whole mechanism

The whole assembly is connected to the vertical drilling machine. The driving shaft or spindle is directly inserted in the drill chuck. Other end of the shaft is connected to the flexible coupling (Double Universal Joint), the main aim of using double universal joint is to provide 1:1 speed ratio. At the end of Universal joint guiding mechanism is connected, Universal joint is allow the guiding mechanism to rotate in eccentric manner. The Reuleaux triangle is rotate in square guiding mechanism therefore cutting tool which assembled with Reuleaux triangle cause to rotate in motion as same as Reuleaux triangle motion to cut exact square hole.

XI. Experimental Setup

The picture shows actual assembly of mechanism that used to produce square hole by using simply mechanical linkages on vertical drilling machine.

Fig. 9: Experimental Setup

XII. Result

The cutting tool developed is 60mm in length. Approximate weight of this unit is 4kg. Material used for fabrication of this cutting tool is WPS. The Cutting tool after proper assembly and installation on Vertical drilling machine is found to be accurate upto 97.72%. That is, it is able to cut a square profile with approximately 97.72% area of the original square with same dimensions as that of the cutting tool. The remaining 2.28% which is not cut is present on the four corner of the square in an arc form. By using this mechanism and special cutting tool we have got this square hole on wood material with prescribed accuracy.

XIII. Referances

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