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An Application of Numerical Methods to Find Outer Diameter of a Socket in the Cotter Joint

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Abstract: Cotter joint is a mechanical component which is used in connecting a piston rod to the cross-head of a reciprocating steam engine, a piston rod and its extension as a tailor pump rod, strap end of connecting rod etc. socket is a important component of cotter joint. In this research paper, outer diameter of the socket is calculated using mathematical modeling and result obtained by mathematical modeling is validated using bisection method.
Keywords: Machine Design , Numerical Methods

I. INTRODUCTION

A cotter is a level wedge molded bit of rectangular cross-area and its width is decreased (either on one side or both sides) from one end to another for a simple adjustment. The cotter is typically made of gentle steel or created press. A cotter joint is a brief affixing and is utilized to interface unbendingly two co-axial rods or bars which are subjected to pivotal tractable or compressive powers. It is typically utilized as a part of associating a cylinder bar to the cross-leader of a reciprocating steam motor, a cylinder pole and its augmentation as a tailor pump pole, strap end of interfacing pole and so forth.

II. RELATED WORK

To Find the inward and external measurement of attachment in the cotter joint if stack connected on it is 30KN. The material utilized is carbon steel for which taking after reasonable anxieties might be utilized.
To Find the inner & outer diameter of socket in the cotter joint if load applied on it is 30KN. The material used is carbon steel for which following allowable stresses may be use

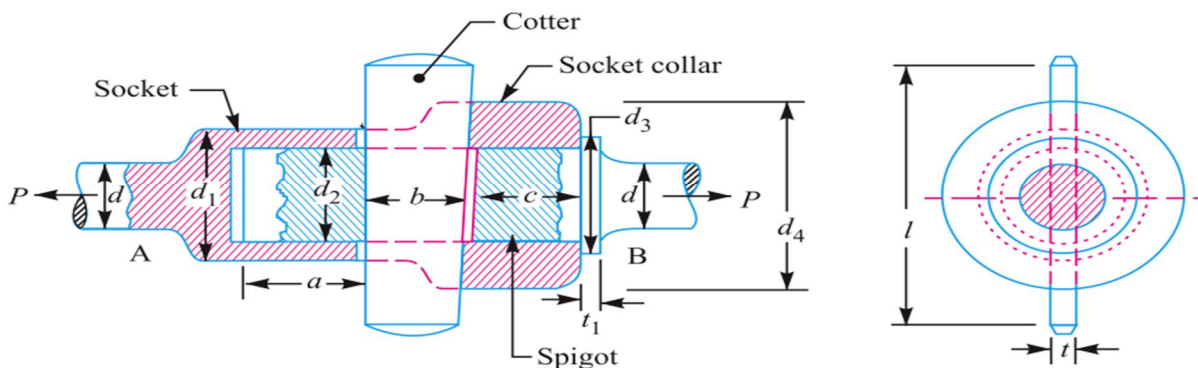| Tensile stress	Crashing stress	Shear stress
15Mpa	90Mpa	35Mpa

Fig. 1 A Cotter joint

Here we want to find the inner & outer diameter of socket: So from the above figure let us consider
d_1 = Outer diameter of socket & d_2 = Inner diameter of socket.
Here we consider P=30KN. , τ = 35Mpa = 35N/mm^2, δt = 90Mpa = 90N/mm^2 & δc=90Mpa = 90N/mm^2 ,
*Inner diameter of socket (d_2) :
To find Inner diameter of socket we will take failure of spigot in Tension across weakest slot, So

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$$\delta t = \frac{P}{A} = \frac{P}{(\frac{\pi}{4}d_2^2 - d_2 t)}$$

But generally $t = \frac{d_2}{4}$

So $\delta t = \frac{p}{(\frac{\pi}{4}d_2^2 - \frac{d_2^2}{4})}$ ------------------------------------(1)

Now by using the following values of p = 30KN, δ_t = 90Mpa = 90N/mm^2 & t = 6.25

d_2 = 25 with t = 6.25

$\Rightarrow d_2$ = 25 mm (this is called Inner diameter) & t=6.25mm

* Outer diameter of socket (d_1): Now we take Failure of socket in tension across weakest slot.If we apply direct values of δ_t = 90Mpa = $\frac{90N}{mm^2}$ & t = 6.25& d_2 = 25 in below equation then the outer dimeter of socket d_1 = 33.42

$\delta t = \frac{P}{A} = \frac{P}{\frac{\pi}{4}(d_1^2 - d_2^2) - (d_1 - d_2)t}$ _____(2)by putting these value we will get final out come in term of a equation for more accuracy of result

$\qquad d_1^2 - 7.96d_1 - 851.06 = 0$
$\qquad$ OR approximate equation is $d_1^2 - 8d_1 - 851 = 0 - - - - - - - - -3$

Now we will solve this equation by using Numerical method named as Bisection method Because factorization method fails here:
Let us consider $d_1 = x$ in equation no. (3) ,so above equation becomes

$f(x) = x^2 - 8x - 851$

here $f(33) = -26 < 0$ & $f(34) = 33 > 0$,

root lies between (65 to 66) so $x_1 = \frac{33 + 34}{2} = 33.50$

hence $f(x_1) = f(33.5) = 3.25 > 0$

Now root $f(33) < 0$ & $f(33.5) > 0$ lies between (33 to 33.5) so,

$x_2 = \frac{33 + 35.5}{2} = 33.25$, $f(33.25) = -11.43 < 0$

here $f(33.50) > 0$ & $f(33.25) < 0$, so root lies between (33.25 to 33.50)

$x_3 = \frac{33.25 + 33.50}{2} = 33.37$ & $f(33.37) = -4.40 < 0$,

here $f(33.50) > 0$ & $f(33.37) < 0$

so root lies between (33.37,33.50),

$x_4 = \frac{33.37 + 33.50}{2} = 33.43$,

$f(33.43 < 0) = -0.87$, $f(33.50) > 0$ so root lies between (33.43 to 33.50),

$x_5 = \dfrac{33.43 + 33.50}{2} = 33.46$, $f(x_5) = f(33.46) = 0.89 > 0$,

so root lies (33.43 to 33.46),

$x_6 = \dfrac{33.43 + 33.46}{2} = 33.44$, $f(x_6) = f(33.44) = -0.28 < 0$.

$f(33.44) < 0$ & $f(33.46) > 0$, so root lies between (33.44 to 33.46),

$x_7 = \dfrac{33.44 + 33.46}{2} = 33.45$, $f(x_7) = 0.30 < 0$,

$f(33.44) < 0$ & $f(33.45) > 0$, so root lies between (33.44 to 33.45)

$x_8 = \dfrac{33.44 + 33.45}{2} = 33.44$,

clearly two consecutive value x_7 & x_8 are near to same and values of x_6 & x_8 are same so

Hence x = 33.44 till two decimal accuracy which is the Outer diameter

$$d_1 = x = 33.44 \text{ mm.}$$

III. CONCLUSION

From the above two result we can conclude that the value of outer diameter have approximately near to same for the point of accuracy by using design equation verified by numerical method (Bisection method). So result gives the validation of the numerical method.

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