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STRESS ANALYSIS OF SPUR GEAR FOR VARIOUS PRESSURE ANGLES BY USING FINET ELEMENT ANALYSIS

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ABSTRACT

Deviations from the ideal gear geometries and unfavorable deformations during the operation may cause serious defects called interference. Conjugate action should be maintained, which does not happen during interference. Due to this, tip of one tooth of the gear will tend to dig in to the portions of the flank of the tooth of the other member of the pair, weakening the teeth. While generation of the gear teeth, if there is interference of the cutter, then a recess is cut at the root of the tooth. The profile thus generated deviates from the theoretical tooth profile. The removal of the material at the root of the gear tooth results in undercutting, which weakens the spur gear tooth. So to reduce the interference and undercutting the profile modification or profile shift or addendum modification should be used. In this work, at the outset, a C-PROGRAM is created for the development of the standard spur gear tooth and a profile corrected tooth, The C-PROGRAM output file is converted to DXF file conversion...These models are imported to an analysis software ANSYS .for the proposed stress analysis. The comparisons are carried out for the standard spur gear tooth and the profile corrected spur tooth for various pressure angles

Keywords: Profile correction; pressure angles; von mises stresses.

1. INTRODUCTION

The gears are used for motion and transmission in large number of engineering applications. One of the first documented uses of gears can be dated back to more than forty centuries ago, when the Egyptians used gear transmissions in their camel driven water facilities. Today gear transmissions are used in wide variety of products from Xerox machines and watches to power plants and vehicle transmissions. For vehicle transmission in passenger cars, but especially in heavy trucks, traditional gear transmissions are the dominant type of power transmission. For higher torque and higher efficiency, application of traditional gear transmission are still competitive and will be a problem so far for the next few decades. Huseyin filiz et al (4) developed the mathematics to generate the involute as well as the fillet regions of the standard gear tooth profile. The shape of the fillet curve is a function of the geometry of the cutting tool, and the method used to produce the gear. They used the rounded tip rack cutter to generate the trochoidal fillet. According to him, the following equations are used to calculate the co-ordinates on the involute profile by specifying the value of ‘R’$X = R \sin \alpha, Y = R \cos \alpha$.

Buckingham [2] explained the different methods to develop the involute and the trochoidal fillet of the spur gear tooth. He had given the equations to calculate the co-ordinates on trochoidal fillet for sharp cutter as well as the rounded tip rack cutter. His presentation clarifies two things, the primary and the secondary trochoid. The curve traced by the centre of rounding of cutter is called primary trochoid and the curve traced by the edge of the rounded tip cutter is called as the secondary trochoid. This secondary trochoid is the actual curve, which are focusing on the spur gear tooth fillet. According to this method the co-ordinates of the trochoidal fillet is calculated by using the following equations for sharp cutters and the same equations are further used for the trochoid generated by the rounded tip rack cutter.

FINITE ELEMENT MODELLING OF SPUR GEAR TOOTH

Finite element procedures are at present very widely used in engineering analysis. The procedures are employed extensively in the analysis of solids and structures and of heat transfer and fluids, and indeed, finite element methods are useful in virtually every field of engineering analysis.

Steps involved in analysis:

1. Discretization of the given domain into a collection of pre-selected elements.
2. Derivation of element equations for all typical elements in mesh.
3. Imposition of boundary conditions
4. Solution
5. Post processing of results

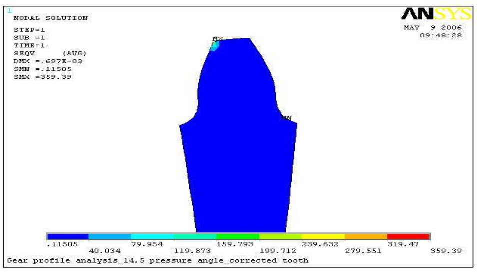
2D- Static stress analysis:

The main objective of the above program is to import the standard and the profile corrected tooth is to ANSYS and to find out the nodal displacements, normal stresses principle stresses and von mises stress analysis. The input required for this is the nodal co-ordinates, material data, loading conditions and boundary conditions (imposition of constraints. Here the single standard gear tooth is described in 161 elements and profile corrected tooth is described with 131 elements for stress analysis. It is assumed that the gear rim is fully supported so that the nodal degrees of freedom at the radial and at the base of the rim are taken as zero. During the running of the gear, the normal load varies along the tooth profile. Here the analysis has been carried out for the load cases considering horizontal and vertical components of the force. The point of application of the load on the gear tooth is assumed at the tip.

The analysis has been carried out for different modules such as 7, 8, 9, and 10mm. The results obtained for the solid gear tooth and the profile corrected tooth for various modules are compared and the graphs are drawn. The complete stress analysis has been done in two stages

1. Stress analysis for standard tooth
2. Stress analysis for profile corrected tooth

Fig.1 **Stress analysis of standard tooth and corrected tooth for $14^1/_2{}^0$ pressure angle**



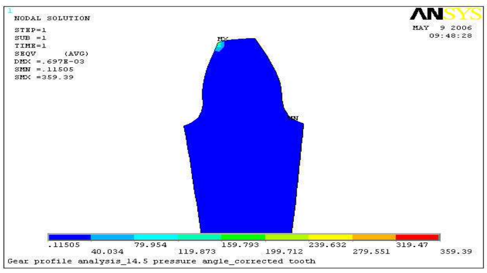
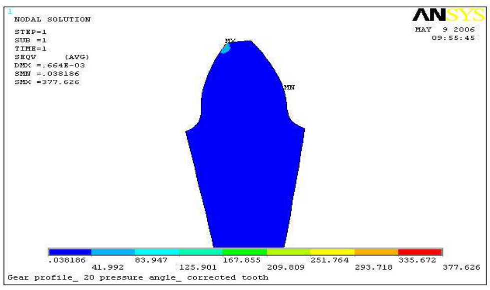


Fig.no.2 stress analysis of standard tooth and corrected tooth for 20^0 pressure



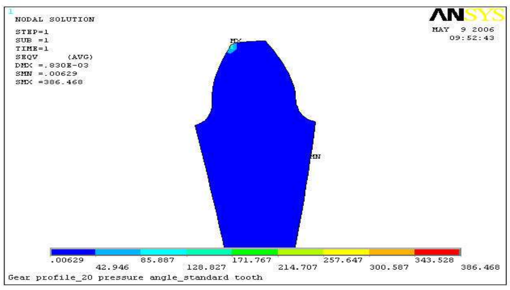


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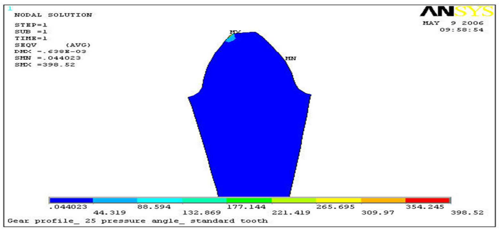
Fig. no.3 Stress analysis of standard tooth and corrected tooth for 25^0 pressure angle



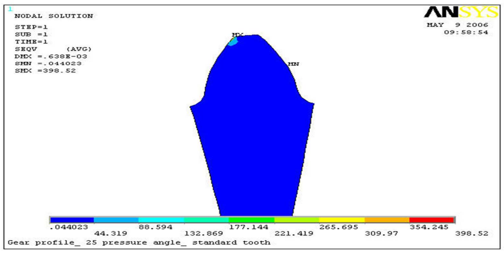
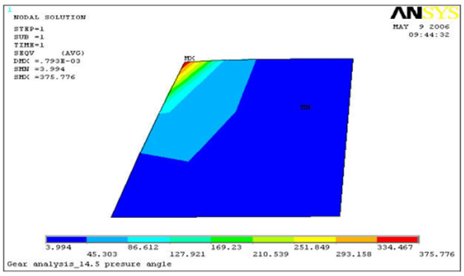


Fig.no.4 Von mises stress at tip of the tooth for standard profile and corrected profile for 14$^1/_2{}^0$ pressure angle



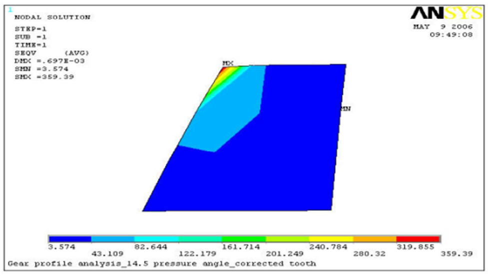
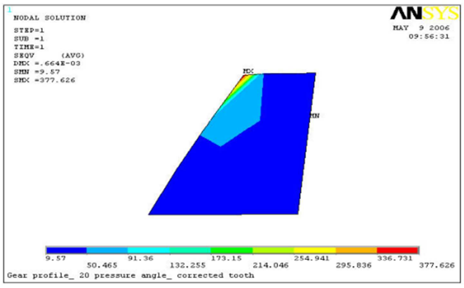


Fig.no.5 Von mises stress at tip of the tooth for standard profile and corrected profile for 20^0 pressure angle



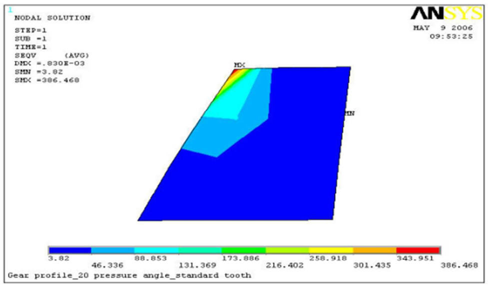
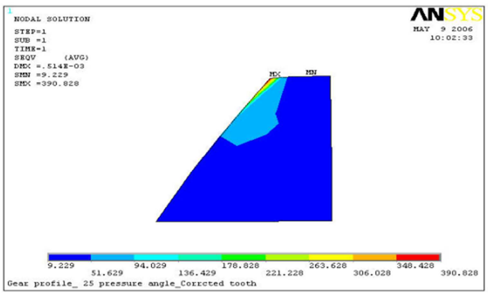
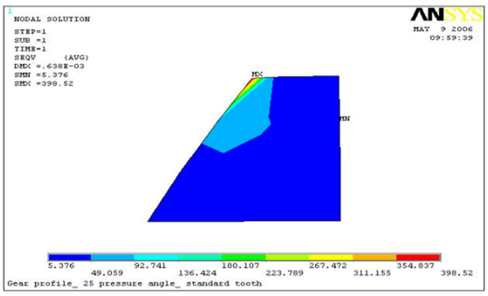
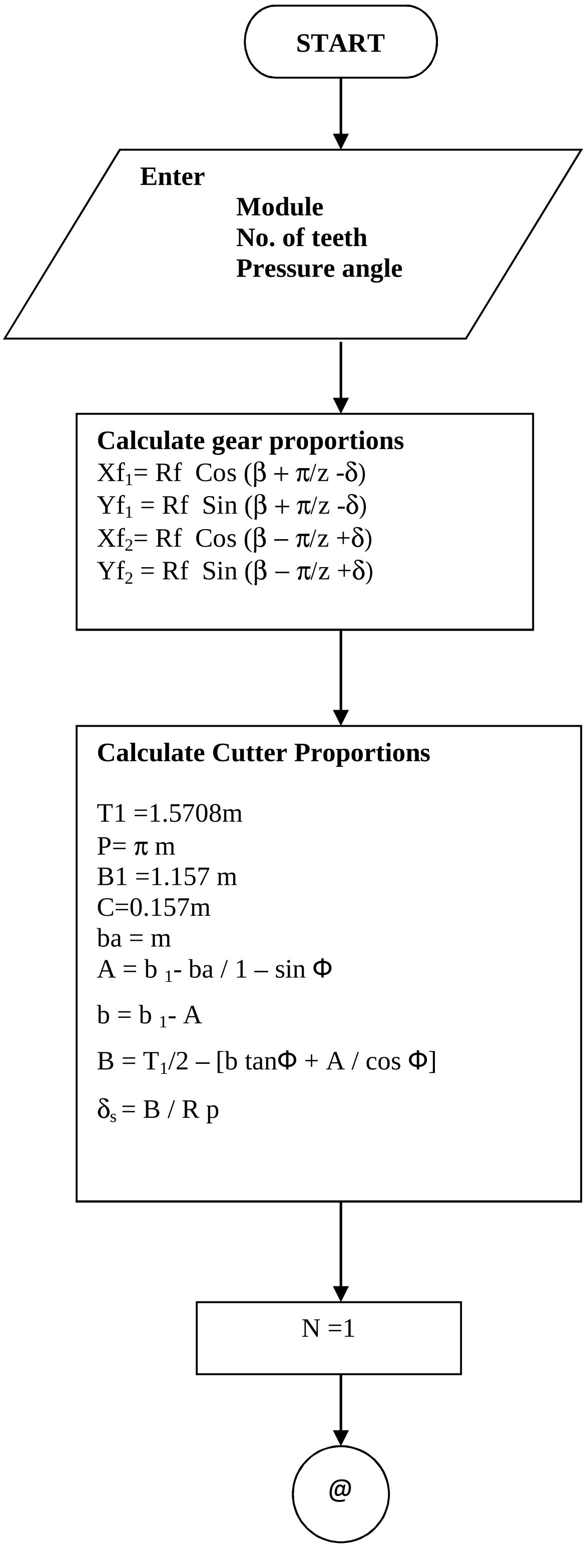


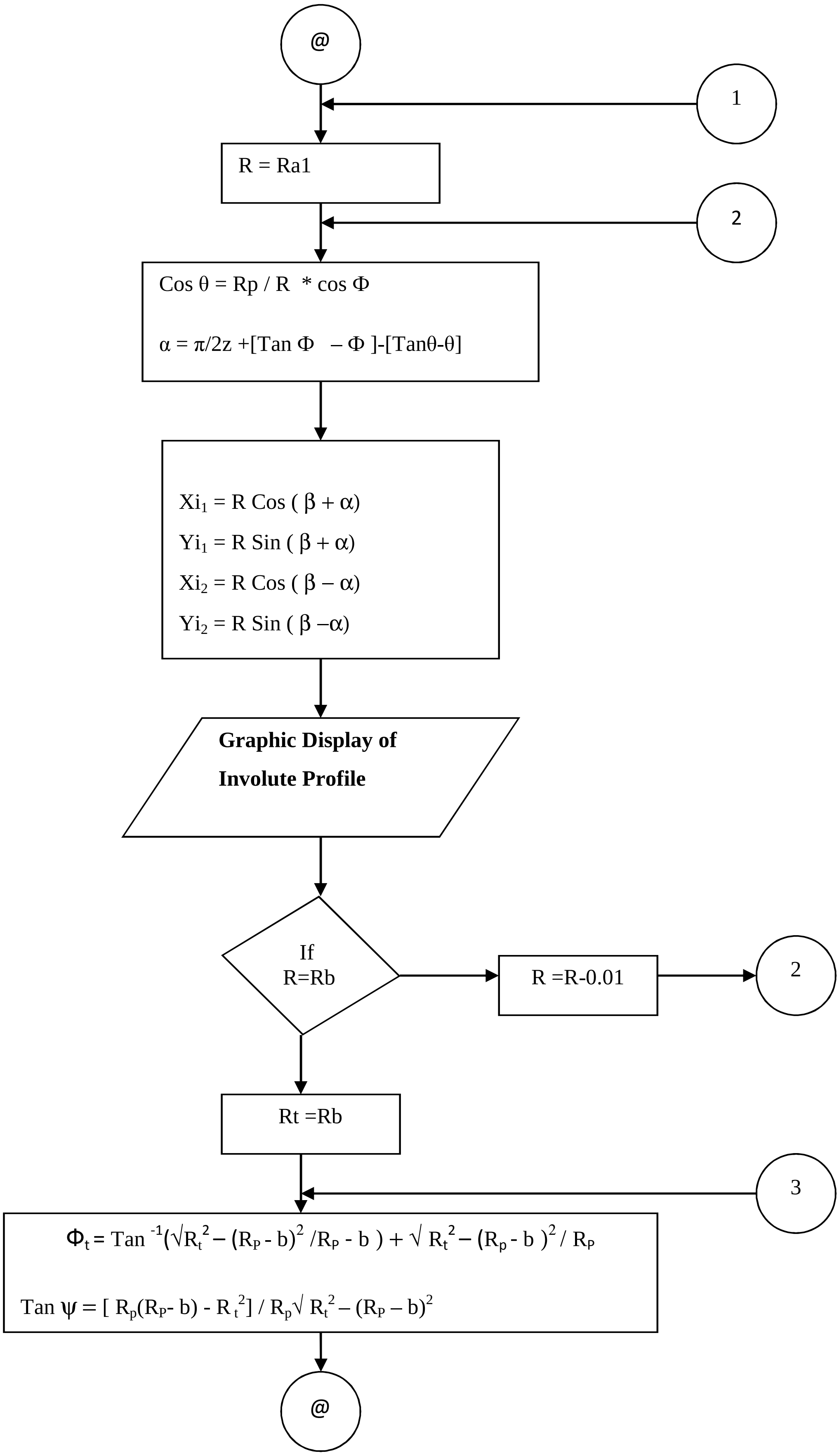
Fig.no.6.6 (a) Von mises stress at tip of the tooth for standard profile and corrected profile for 25^0 pressure angle

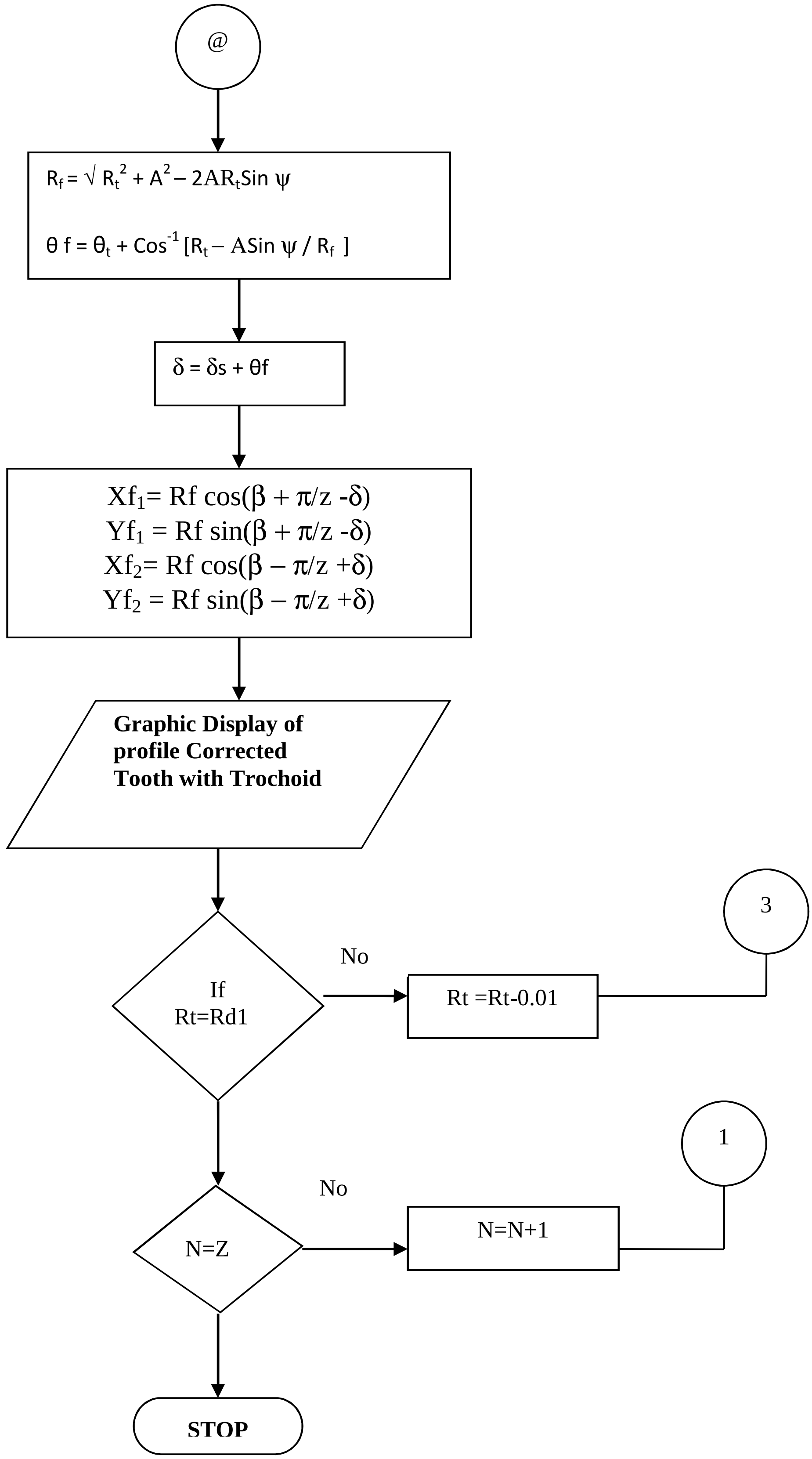




FLOW CHART FOR PROFILE CORRECTED GEAR TOOTH




@
1
R = Ra1
2
Cos θ = Rp / R * cos Φ
α = π/2z +[Tan Φ – Φ]-[Tanθ-θ]
Xi1 = R Cos (β + α)
Yi1 = R Sin (β + α)
Xi2 = R Cos (β – α)
Yi2 = R Sin (β –α)
Graphic Display of Involute Profile
If R=Rb
R =R-0.01
2
Rt =Rb
3
Φt = Tan -1(√Rt2 – (RP - b)2 /RP - b) + √ Rt2 – (Rp - b)2 / RP
Tan ψ = [Rp(RP- b) - R t2] / Rp√ Rt2 – (RP – b)2
@


@
$R_f = \sqrt{R_t^2 + A^2 - 2AR_t \sin\psi}$
$\theta f = \theta_t + \cos^{-1}[R_t - A\sin\psi / R_f]$
$\delta = \delta s + \theta f$
$Xf_1 = Rf\cos(\beta + \pi/z - \delta)$
$Yf_1 = Rf\sin(\beta + \pi/z - \delta)$
$Xf_2 = Rf\cos(\beta - \pi/z + \delta)$
$Yf_2 = Rf\sin(\beta - \pi/z + \delta)$
Graphic Display of profile Corrected Tooth with Trochoid
If Rt=Rd1
No
Rt =Rt-0.01
3
N=Z
No
N=N+1
1
STOP

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Comparisons of von mises stresses of standard tooth and profile corrected tooth:

Preassure angle (degrees)	Standard tooth stresses (Mpa)	Profile corrected tooth stresses (Mpa)
$14^{1}/_{2}^{0}$	375.776	359.31
20^{0}	386.468	377.626
25^{0}	398.52	390.828

Conclusion

By using the C-program the involute profile is created and the output of C-program is transferred to the DXF file conversion after that the models of the standard and corrected spur gear tooth is imported to the ANSYS through IGES file conversion. By using ANSYS the von mises stress is calculated for the standard and corrected spur gear tooth's. From the above discussion about the stress analysis, it is finalized that the maximum stress concentration occurs at the various pressure angles of the gear tooth. With the increasing pressure angle the load carrying capacity becomes more.

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