A SOFTWARE DEVELOPMENT IN GEAR DESIGN

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ABSTRACT: Power or energy production is improbable everywhere due to various factors. For assorted applications, people depending source of power. This shows the need of transmission of power. Considering power transmission of mechanical drives, mesh type of drives are largely used to maintain the velocity ratio. Among mesh type, gears transmitting the power by means of successive engagement of their teeth. Design of gears either by manually or using computers has become a highly convoluted and comprehensive subject. Therefore, this study present a new method of how the gears can be designed and detailed with computer, previously, highlighting the design process which involves prolong time. A reliable software package developed with a help of Visual Basic 6.0 (VB) provides significant saving time reduces its convolution.

Keywords- Power transmission, Design, Gear, Package, VB.

1. INTRODUCTION

Gears are the drives which transmit power between the shafts by means of successive engagement of teeth. Among mesh type drive, gears are preferable when a constant speed ratio that is velocity ratio is desired and the distance between the shafts is comparatively small. Gears operate in pairs the smaller of the pair being called the pinion and the larger one the gear. Usually the pinion drives the gear and then it can act either as a speed reducer or speed accelerator and a torque converter. Generally gears are designed either by considering gear life or beam strength which is based on American Gear Manufactures Association (AGMA).

Nordiana et al presented a new method of spur gear design detailed with computer aided design [1]. The presenters developed a package namely “Cadgear (2007)” which enhances the analytical and logical power of the designer of gear system. Varatharajulu and Rajendran developed a visual basic package to do the design of coupling and knuckle joint, which has the ability to reduce the burden of designer [2]. Researcher concluded that, the design of machine elements, transmission systems and jigs and fixture is possible by visual basic.

This attempt concentrates on design of spur, helical, bevel and worm gear design based on two conventional techniques, with a help of computer aided design. A machine language is needed to make the computer to understand. Here coding written in visual basic, the computer processes these statements into visual basic language.

1.1 Software Development

Visual Basic project explorer window has the tool box. From the tool box the label, text box and command box were dragged and then dropped in the appropriate position. Then code was written in the respective page according to the design parameters. Properties window helps to make the changes.
1.2. Sample source code

With the help of Visual Basic authors, developed the software which will reduce the complication in gear design. Sample source code given, for reader’s reference.

```vbnet
Public dbcon As New ADODB.Connection
Public rs As New ADODB.Recordset
Dim pi As Integer
Dim p As Double
Dim i As Double
Dim n1 As Double
Dim n2 As Double
Dim s1 As Double
Dim s2 As Double
Dim s3 As Double
Dim s4 As Double
Dim e1 As Double
Dim e2 As Double
Dim e As Double
Dim m1 As Double
Dim m2 As Double
Dim sai As Double
Dim saim As Double
Dim m As Double
Dim m3 As Double
Dim y As Double
Private Sub Combo3_Click()
If Combo3.Text = "Speed ratio, Pinion speed" Then
    Label2.Visible = True
    Label3.Visible = True
    Label13.Visible = True
    Text2.Visible = True
    Text3.Visible = True
    Label47.Visible = False
    Text8.Visible = False
    Label51.Visible = False
End If
If Combo3.Text = "Speed ratio, Gear speed" Then
    Label2.Visible = True
    Label47.Visible = True
    Label51.Visible = True
    Text2.Visible = True
    Text8.Visible = True
    Label3.Visible = False
    Text3.Visible = False
    Label13.Visible = False
End If
```
End If
If Combo3.Text = "Pinion speed, Gear speed" Then
  Label47.Visible = True
  Text8.Visible = True
  Label13.Visible = True
  Label3.Visible = True
  Text3.Visible = True
  Label51.Visible = True
  Text2.Visible = False
  Label2.Visible = False
End If
End Sub

Private Sub Command3_Click()
  Form17.Show
  Me.Hide
End Sub

Private Sub Command_Click()
  Me.PrintForm
End Sub

Private Sub Command4_Click()
  Me.Hide
  Form2.Show
End Sub

Private Sub Command5_Click()
  End
  End
End Sub

Private Sub Form_Load()
  dbcon.ConnectionString = "Provider=Microsoft.Jet.OLEDB.4.0;Data Source=\" + App.Path + \"Database.mdb"
  dbcon.Open
End Sub

Private Sub Combo1_Click()
  rs.Open "select * from Table6 where Material = " & Combo1.Text & " ", dbcon, adOpenDynamic, adLockOptimistic, -1
  Text5.Text = rs.Fields(2)
  Text6.Text = rs.Fields(1)
  Text7.Text = rs.Fields(3)
  rs.Close
End Sub

Private Sub Combo2_Click()
  rs.Open "select * from Table6 where Material = " & Combo2.Text & " ", dbcon, adOpenDynamic, adLockOptimistic, -1
  Text9.Text = rs.Fields(2)
  Text10.Text = rs.Fields(1)
Text11.Text = rs.Fields(3)
rs.Close
End Sub

Private Sub Command1_Click()
p = Val(Text1.Text)
If Combo3.Text = "Speed ratio, Pinion speed" Then
i = Val(Text2.Text)
n1 = Val(Text3.Text)
n2 = n1 / i
End If
If Combo3.Text = "Speed ratio, Gear speed" Then
i = Val(Text2.Text)
n2 = Val(Text8.Text)
n1 = i * n2
End If
If Combo3.Text = "Pinion speed, Gear speed" Then
n1 = Val(Text3.Text)
n2 = Val(Text8.Text)
i = n1 / n2
End If
s1 = Val(Text5.Text)
s2 = Val(Text6.Text)
s3 = Val(Text9.Text)
s4 = Val(Text10.Text)
e1 = Val(Text7.Text)
e2 = Val(Text11.Text)
Text12.Text = (60 * p * 10 ^ 3) / (2 * 3.14159265358979 * n1)
Text12.Text = Round(Val(Text12.Text), 5)
m1 = Val(Text12.Text)
Text13.Text = m1 * 1.3
m2 = Val(Text13.Text)
e = Val(Text14.Text)
Text15.Text = ((0.74 / s3) ^ 2 * e * m2 * 10 ^ 3 / (i * 0.3)) ^ (1 / 3)
Text15.Text = Round(Val(Text15.Text), 0)
m = (1.26) * (m2 * 10 ^ 3 / (0.389 * s4 * 10 * 20)) ^ (1 / 3)
Text16.Text = Round(m, 2)
m4 = Val(Text28.Text)
If Round(m4, 0) - m4 < 0 Then
Text28.Text = Round((m4 + 1), 0)
Else
Text28.Text = Round(m4, 0)
End If
    rs.Open "SELECT * FROM Table5 WHERE FIRST = " & Text28.Text & "," & "," & "", dbcon, adOpenDynamic,
adLockOptimistic, 1
    Text17.Text = rs.Fields(1)
    rs.Close
    sai = 0.3
    saim = 10
    Text18.Text = ((2 * Val(Text15.Text)) / (Val(Text17.Text) * (i + 1)))
    rs.Open "SELECT * FROM Table7 WHERE pinion = " & Text18.Text & "," & "", dbcon, adOpenDynamic,
adLockOptimistic, 1
    Text4.Text = rs.Fields(1)
y = rs.Fields(2)
    rs.Close
    Text20.Text = Round((Text20.Text), 3)
    b = sai * Val(Text22.Text)
b1 = saim * Val(Text17.Text)
    If b > b1 Then
        Text23.Text = b
    Else
        Text23.Text = b1
    End If
    Text25.Text = Round(Val(Text25.Text), 3)
                    Val(Text23.Text) * y)
    Text29.Text = Round(Val(Text29.Text), 3)
    If Val(Text29.Text) < Val(Text6.Text) Then
        Text26.Text = "Design is safe"
    Else
        Text26.Text = "Design is not safe"
    End If
                    1000 / (i * Val(Text23.Text))) ^ (1 / 2)
    Text24.Text = Round(Val(Text24.Text), 3)
    If Val(Text24.Text) < Val(Text5.Text) Then
        Text27.Text = "Design is safe"
    Else
        Text27.Text = "Design is not safe"
Private Sub Command2_Click()
    Text18.Text = ((2 * Val(Text15.Text)) / (Val(Text17.Text) * (i + 1)))
    rs.Open "select * from Table7 where pinion = " & Text18.Text & "", dbcon, adOpenDynamic, adLockOptimistic, -1
    Text4.Text = rs.Fields(1)
    y = rs.Fields(2)
    rs.Close
    Text20.Text = Round((Text20.Text), 3)
    b = sai * Val(Text22.Text)
    b1 = saim * Val(Text17.Text)
    If b > b1 Then
        Text23.Text = b
    Else
        Text23.Text = b1
    End If
    Text25.Text = Round(Val(Text25.Text), 3)
    Text29.Text = Round(Val(Text29.Text), 3)
    If Val(Text29.Text) < Val(Text6.Text) Then
        Text26.Text = "Design is safe"
    Else
        Text26.Text = "Design is not safe"
    End If
    Text24.Text = Round(Val(Text24.Text), 3)
    If Val(Text24.Text) < Val(Text5.Text) Then
        Text27.Text = "Design is safe"
    Else
        Text27.Text = "Design is not safe"
    End If
End Sub
2. SOFTWARE DEVELOPMENT

2.1. Execution of the Software

The software consists of the following pages. First page has the classification of gears. Selection of gear using, the combo box lead to next page. The task in the first page is shown in figure 1. From clicking the command box ‘Click Here’ will bring the next page.

![Fig. 1. Very first page of the software having the combo box, to select the needed design](image1)

![Fig. 2. Respective design page, having its classification in the combo box.](image2)

Selection of required gear design either based on gear life or based on beam strength is in the second page. The tasks in the second page are shown in figure 2. From clicking the command box ‘Click Here’ will bring the next page.

2.2. Justification

Justification is the very significant portion in the software development. Software developer has to validate, whether the software will give the appropriate design or not. With the help of the manual calculation alone validate possible while the package is in developing stage. Preprocessing work, that is manual calculation of various gear design made to formulate the coding. Here, an example calculation presented to highlight the tediousness of design process and to justify the software.

2.1.1. Justification (Spur gear design based on gear life)

\[
\begin{align*}
\alpha & \geq \left(i \pm 1\right) \sqrt[3]{\frac{0.74 \nu_i^2}{\sigma_c}} \frac{E[M_t]}{i \Psi} \\
I & = 4 \\
[\sigma_c] & = 500 \text{ N/mm}^2 \\
E & = 2.15 \times 10^5 \text{ N/mm}^2 \\
\Psi & = \frac{b}{a} = 0.3 \text{ (initially assume)} \\
[M_t] & = M_t \times k \times k_d \\
P & = \frac{2 \times \pi \times n \times M_t}{60} \\
M_t & = \frac{60 \times P}{2 \times \pi \times n}
\end{align*}
\]

Given

Minimum value among pinion and gear

PSGDD 8.13

PSGDD 8.14

PSGDD 8.1, 8.14

PSGDD 8.15
Design a pair of spur gear to transmit 20kW at pinion speed is 1400 rpm, transmission ratio is 4. Assume suitable material and stresses [3-7].

Given

\[ P = 20 \text{ kW} = 20 \times 10^3 \text{ W}, \quad n = 1400, \text{ rpm}; \quad i = 4 \]

1. Material selection

<table>
<thead>
<tr>
<th>Material</th>
<th>([\sigma_b])</th>
<th>([\sigma_c])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinion</td>
<td>15Ni2Cr1Mo15</td>
<td>320</td>
</tr>
<tr>
<td>Gear</td>
<td>C45</td>
<td>140</td>
</tr>
</tbody>
</table>

From PSG Design data book: 1.40, 8.4 & 8.5

2. Minimum centre distance

\[
a \geq (i \pm 1) \left( \frac{0.74}{[\sigma_c]} \right)^2 \frac{E [M_t]}{4 \times 0.3 \Psi} \]

\[
a = 205.669 \approx 206 \text{ Mm} \quad \text{Mm}
\]

\[
K. K_d = 1.3 \text{ (initially assume)} 
\]

\[
[M_t] = 136.418 \times 1.3 \text{ N-m}
\]

\[
P = 2 \times \pi \times n \times M_t
\]

\[
M_t = \frac{60 \times P}{2 \times \pi \times n}
\]

\[
= 60 \times 20 \times 10^3 \quad 2 \times \pi \times 1400
\]

\[
= 136.418 \text{ N-m}
\]

\[
K. K_d = 1.3 \text{ (initially assume)}
\]

\[
[M_t] = 136.418 \times 1.3
\]
3. Minimum module

\[
m \geq \frac{1.26 \sqrt[3]{\frac{[M_t]}{y[\sigma_b]\Psi_mZ_1}}}{N\cdot m}\quad \text{PSGDD 8.13A}
\]

\[
[M_t] = 177.343 \times 10^3 \quad N\cdot m
\]

\[
y = 0.389 \quad \text{(assume } Z_1 = 20 \text{ and } X = 0) \quad \text{PSGDD 8.18}
\]

\[
[\sigma_b] = 140 \quad \text{N/mm}^2 \quad \text{Minimum value among pinion and gear}
\]

\[
\Psi_m = \frac{b}{m} = 10 \quad \text{(initially assume)} \quad \text{PSGDD 8.14}
\]

\[
Z_1 = 20 \quad \text{(initially assume)} \quad \text{PSGDD 8.18}
\]

\[
m = 1.26 \sqrt[3]{\frac{177.343 \times 10^3}{0.389 \times 140 \times 10 \times 20}} \quad \text{Minimum centre distance value rounded off from recommended series available in design data}
\]

\[
m = 3.194 \approx 4 \quad N\cdot m \quad \text{PSGDD 8.2}
\]

4. Calculation of number of teeth

\[
Z_1 = \frac{2a}{m(i+1)} = \frac{2 \times 206}{4 \times 4} \quad \text{PSGDD 8.22}
\]

\[
= 20.6 \approx 22 \quad \text{(Rounded off from table 18 in design data)} \quad \text{PSGDD 8.18}
\]

\[
Z_2 = iZ_1 = 4 \times 22 = 88
\]

5. Calculation of pitch circle diameter

\[
d_1 = mZ_1 = 4 \times 22 = 88 \quad \text{Mm} \quad \text{PSGDD 8.22}
\]

\[
d_2 = mZ_2 = 4 \times 88 = 352 \quad \text{Mm} \quad \text{PSGDD 8.22}
\]

6. Correction of center distance

\[
a = \frac{(d_1+d_2)}{2} = \frac{88+352}{2} = 220 \text{ mm} > 206 \text{ mm}
\]

Calculated center distance is greater than the early calculated one. Hence the design is safe.
7. Calculation of face width

\[ \Psi = \frac{b}{a} \]
\[ \Psi_m = \frac{b}{m} \]
\[ 0.3 = \frac{b}{a} \quad 10 = \frac{b}{m} \]
\[ \frac{b}{220} = \frac{b}{4} \]

Consider the larger among the above values. Therefore face width \( b = 66 \) mm

8. Revision of design torque

\[ [M_t] = M_0 \times k \times k_d \]  
PSGDD 8.15

\( k \) - Load concentration factor for steel gears of quality IS 8 having HB > 350 (assume bearings close to gears and symmetrical)

\[ \Psi_p = \frac{b}{d_1} = \frac{66}{88} = 0.75 \]

If \( \Psi_p = 0.6 \), \( k = 1.03 \)  
PSGDD 8.15

If \( \Psi_p = 0.8 \), \( k = 1.06 \), therefore \( k \) calculated based on interpolation

\[ \frac{0.75 - 0.6}{0.8 - 0.6} = \frac{k - 1.03}{1.06 - 1.03} \]

\( k = 1.0525 \)

\( k_d \) - Dynamic load factor (assumption IS 8 quality cylindrical gear)

\[ v = \frac{\pi d_1 n_1}{60000} = \frac{\pi \times 88 \times 1400}{60000} = 6.451 \text{ m/s} \]

If \( v = 3 \text{ m/s} \), \( k_d = 1.3 \)  
PSGDD 8.16

If \( v = 8 \text{ m/s} \), \( k_d = 1.6 \), therefore \( k_d \) calculated based on interpolation

\[ \frac{6.451 - 3}{8 - 3} = \frac{k_d - 1.3}{1.6 - 1.3} \]

\( k_d = 1.369 \)

\[ [M_t] = 136.418 \times 1.0525 \times 1.369 \]
\[ = 200.585 \text{ N-m} \]
\[ = 200.585 \times 10^3 \text{ N-mm} \]

9. Checking of bending stress

\[ \sigma_b = \frac{[M_t]}{[\sigma_b]} \]
PSGDD 8.13A
1. \[ I = 4 \]
2. \[ A = 220 \text{ Mm} \]
3. \[ M = 4 \text{ Mm} \]
4. \[ B = 66 \text{ Mm} \]
5. \[ Y = 0.402 (Z_1 = 22 \text{ and } X = 0) \]
6. \[ [M_t] = 196.563 \times 10^3 \text{ N-mm} \]
7. \[ \sigma_b = \frac{220 \times 4 \times 66 \times 0.402}{(4 + 1)} \times 196.563 \times 10^3 \text{ N/mm}^2 \]
8. \[ = 42.944 \leq 140 \text{ N/mm}^2 \]
9. Calculated bending stress is less than the design bending stress. Hence, Design is safe.

10. Checking for compressive stress
\[
\sigma_c = 0.74 \frac{(4 + 1)}{220} \frac{((4 + 1)\text{E}[M_t])}{[\sigma_c]} \leq \frac{[\sigma_c]}{\text{PSGDD 8.13}}
\]
\[
E = 2.15 \times 10^5 \text{ N/mm}^2
\]
\[
B = 66 \text{ Mm}
\]
\[
[M_t] = 196.563 \times 10^3 \text{ N-mm}
\]
\[
\sigma_c = 0.74 \frac{(4 + 1)}{220} \frac{((4 + 1) \times 2 \times 10^5 \times 196.563 \times 10^3)}{4 \times 66} \text{ N/mm}^2
\]
\[
= 480.592 \leq 500 \text{ N/mm}^2
\]
Calculated compressive stress is less than the design compressive stress. Hence, Design is safe.

11. Checking for compressive stress
\[
\sigma_c = 0.74 \frac{(4 + 1)}{220} \frac{((4 + 1)\text{E}[M_t])}{[\sigma_c]} \leq \frac{[\sigma_c]}{\text{PSGDD 8.13}}
\]
\[
E = 2.15 \times 10^5 \text{ N/mm}^2
\]
\[
B = 66 \text{ Mm}
\]
\[
[M_t] = 196.563 \times 10^3 \text{ N-mm}
\]
\[
\sigma_c = 0.74 \frac{(4 + 1)}{220} \frac{((4 + 1) \times 2 \times 10^5 \times 196.563 \times 10^3)}{4 \times 66} \text{ N/mm}^2
\]
\[
= 480.592 \leq 500 \text{ N/mm}^2
\]
Calculated compressive stress is less than the design compressive stress. Hence, Design is safe.

12. Other parameters
\[ f_0 = 1 \text{ and } c = 0.25 \]
\[ h_a = f_0 m = 1 \times 4 = 4 \text{ Mm} \]
\[ l_h = (f_0+c) m = 1.25 \times 4 = 5 \text{ Mm} \]
\[ d_{11} = d_{1} + 2h_a = 88 + 2 \times 4 = 96 \text{ Mm} \]
\[ d_{21} = d_{2} + 2h_a = 352 + 2 \times 4 = 360 \text{ Mm} \]
\[ d_{1} = d_{1} - 2h_t = 88 - 2 \times 5 = 78 \text{ Mm} \]
\[ d_{2} = d_{2} - 2h_t = 352 - 2 \times 5 = 342 \text{ Mm} \]
### Table 1 – Specification

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Pinion</th>
<th>Gear</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Material</td>
<td>15Ni2Cr1Mo15</td>
<td>C45</td>
</tr>
<tr>
<td>2</td>
<td>Number of teeth</td>
<td>22</td>
<td>88</td>
</tr>
<tr>
<td>3</td>
<td>Pitch circle diameter</td>
<td>88 mm</td>
<td>352 mm</td>
</tr>
<tr>
<td>4</td>
<td>Tip circle diameter</td>
<td>96 mm</td>
<td>360 mm</td>
</tr>
<tr>
<td>5</td>
<td>Root circle diameter</td>
<td>78 mm</td>
<td>342 mm</td>
</tr>
<tr>
<td>6</td>
<td>Centre distance</td>
<td>220 mm</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Face width</td>
<td>66 mm</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Torque</td>
<td>196.563 × 10^3 N mm</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Module</td>
<td>4 mm</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Addendum</td>
<td>4 mm</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Dedendum</td>
<td>5 mm</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Height factor</td>
<td>1 mm</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Bottom clearance</td>
<td>0.25 mm</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Tooth depth</td>
<td>9 mm</td>
<td></td>
</tr>
</tbody>
</table>

Earlier two tasks, brings the respective design input page. Here, sample page i.e., design of spur gear based on gear life illustrating the inputs like power, speed ratio, material for pinion and gear, etc.

![Fig. 3 Spur gear design based on gear life, calculation page](image-url)
Adopt all the primary inputs in the text box and then command box ‘Click Here’ will lead to get the calculated data’s in the right side column in the same page which was consisting mean torque, design torque, equivalent young’s modulus, module, number of teeth, pitch circle diameter and etc as illustrated in figure 3. The same page has the design status, whether calculated bending and surface stress is in safe zone of not so. If, the design is not safe, iteration is possible form the module dimensions. By means of many ways that is by changing the gear material or by changing the pinion material or increasing the centre distance or increasing module lead to safe design. Here, one can change their input of preliminary calculated values accordingly they can make safest design.

After the verification of the calculated data’s, the command box ‘Result’ leads to the next page i.e., final specification page. A database (Microsoft office access), recall the data’s with respect to the input and adapt for the further calculation.

The figure 4 has shown the final specification page for the spur gear. Design is an iterative process, aiming at reaching the best possible result. If the first design is not satisfactory, further modifications are to be carried out till the best performance is obtained. The software gives such a nice feasibility to the users.

Table 2: Justification of Results

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Manual Calculation</th>
<th>Software Result</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of teeth on pinion</td>
<td>$z_1$</td>
<td>21</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Number of teeth on gear</td>
<td>$z_2$</td>
<td>88</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Pitch circle diameter of pinion</td>
<td>$d_1$</td>
<td>88</td>
<td>88</td>
<td>mm</td>
</tr>
<tr>
<td>Pitch circle diameter of gear</td>
<td>$d_2$</td>
<td>352</td>
<td>352</td>
<td>mm</td>
</tr>
<tr>
<td>Tip circle diameter of pinion</td>
<td>$da_1$</td>
<td>96</td>
<td>96</td>
<td>mm</td>
</tr>
<tr>
<td>Tip circle diameter of gear</td>
<td>$da_2$</td>
<td>360</td>
<td>360</td>
<td>mm</td>
</tr>
<tr>
<td>Root circle diameter of pinion</td>
<td>$df_1$</td>
<td>78</td>
<td>78</td>
<td>mm</td>
</tr>
<tr>
<td>Root circle diameter of gear</td>
<td>$df_2$</td>
<td>342</td>
<td>342</td>
<td>mm</td>
</tr>
<tr>
<td>Calculated bending stress</td>
<td>$\sigma_b$</td>
<td>42.949</td>
<td>42.949</td>
<td>N/mm$^2$</td>
</tr>
<tr>
<td>Calculated surface stress</td>
<td>$\sigma_c$</td>
<td>480.592</td>
<td>480.592</td>
<td>N/mm$^2$</td>
</tr>
<tr>
<td>Face width</td>
<td>$B$</td>
<td>66</td>
<td>66</td>
<td>mm</td>
</tr>
<tr>
<td>Torque</td>
<td>$M_t$</td>
<td>200.535</td>
<td>200.535</td>
<td>N·m</td>
</tr>
<tr>
<td>Center distance</td>
<td>$A$</td>
<td>220</td>
<td>220</td>
<td>mm</td>
</tr>
</tbody>
</table>
Comparing (table 2) the manual calculation with the software results shows good agreement among results. Similar validation of each and every page i.e. helical, bevel and worm gear design based on gear life as well as beam strength, carried out to give fullness to the package.

2.3. **Features**
- Within a short span one can do the design without manual error.
- Even a semi skilled operator enough to do the design.
- User can do the optimum design, by changing the numerical in the respective design calculation pages.

2.4. **Future development**
At present the software includes the design of various gears. It is planned to include the other design such as machine elements, transmission system and jigs and fixture, etc. Integration of modeling software can generate graphical output. Further studies needed to incorporate those things.

3. **CONCLUSION**
This study presents a new method of gear design and detailed with computer. Developed system provides the user to perform repetitive and routine tasks involved in gear design, also provides a flexibility to optimize the design process which will improve the productivity by means of reducing manufacturing cost. It was evident that the developed system will successfully increase productivity by roughly twenty times over manual gear design at reduced cost, provides significant saving time reduces its convolution.

**REFERENCES**