Dimensional Calculations of Knuckle Joint Assembly by Using C Programming
(For Academic problem purpose)

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Abstract: Designing mechanical components is repetitive and time consuming procedure. To reduce monotony and time in design process various programming tools are used now a days. The source code in C basic programming language is employed in this paper to calculate dimensions of knuckle joint assembly by providing some input parameter. Study is carried out to solve simple academic problem to develop programming approach among students. Flowchart was prepared from convectional design procedure followed by code in C. Simple design is illustrate and output is compare with manual calculations.

Index Terms **- C Programming, Design, Knuckle Joint.**

I. INTRODUCTION

The machine design process of any system component is check safety against failure and evaluate dimensions of parameters. It involves calculation of numbers difficult equations for couples of time until desire results are obtain. Manual calculations required a lot of time for calculation, so C programming is used as tool to reduce time and avoid calculation error. The C programming is basic programming language with higher programming capabilities having wide applications in engineering. Set of only 32 keywords prove the C as small language and easy to learn at beginner level of programmer. Also the C is structured language having standard functions in its library which lead to decide C as programming tool for this work [1].

A knuckle joint is used to transfer power from one rod to other which are slightly misaligned and subjected to tensile or compressive load. A knuckle joint is used in applications like bridge structure, roller chain, tractor to form permanent or temporary joint; where small flexibly and or angular moment is required. The knuckle joint assembly have major components as: knuckle pin, single eye and double (fork) eye; as shown in figure 1. One end of one rod is connected to single eye and other rod end to forked eye. Single and forked rod are connected by means of knuckle pin which passing through the holes and secured by split pin [2].

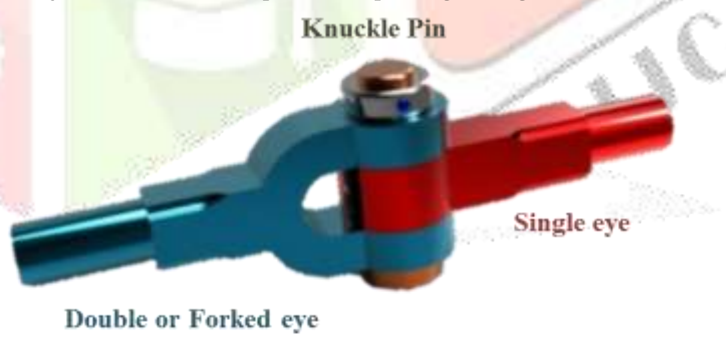

Figure 1: A knuckle joint assembly

II. DESIGN OF KNUCKLE JOINT

Dimension of knuckle pin and holes of single and forked eyes should be accurate to ensure proper functioning of assembly. Material section of a knuckle pin and assembly is important. The design process of major parts of knuckle joint assembly is discussed as below [2].

2.1. Design of Solid rod

Dimensions - Diameter of rod = d;

Failure check –for tension in rod, Transmission load (P) = $\frac{\pi}{4} \times d^2 \times$ Allowable tension stress (σ_t).

2.2. Design of Knuckle Pin

Dimensions - Diameter of pin (d_1) = d;

Diameter of pin head (d_3) = 1.5×d;

Thickness of pin head (t_2) = 0.5× d;

Failure check – Shear - P = $\frac{\pi}{4} \times {d_1}^2 \times$ Shear stress (τ).

2.3. Design of Single Eye

Dimensions – Outer diameter (d_2) = 2 × d;

Inner diameter (d_1) = d;

Thickness of eyes (t) = 1.25 × d;

Failure check – for shear, P = $(d_2 - d_1) \times t \times \tau$;

for tension, P = $(d_2 - d_1) \times t \times \sigma_t$;

for crush, P = $d_1 \times t \times \sigma_c$.

2.4. Design of Single Eye

Dimensions – Outer diameter (d_2) = 2 × d;

Inner diameter (d_1) = d;

Thickness of eyes (t) = 0.75 × d;

Failure check – for shear, P = $(d_2 - d_1) \times 2 \times t_1 \times \tau$;

for tension, P = $(d_2 - d_1) \times 2 \times t_1 \times \sigma_t$;

for crush, P = $d_1 \times 2 \times t_1 \times \sigma_c$.

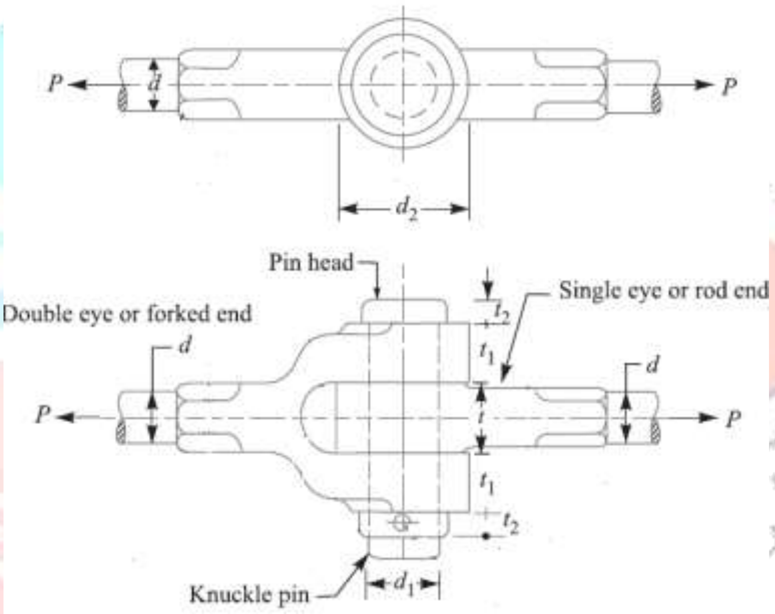

Figure 2: Designing of knuckle joint

III. FLOWCHART FOR DESIGN OF KNUCKLE JOINT

The design process is break into number of small steps and flow of process is represented in flowchart. The flowchart (refer figure 3) is drawn with help of drawing tool available at http://www.draw.io. [3].

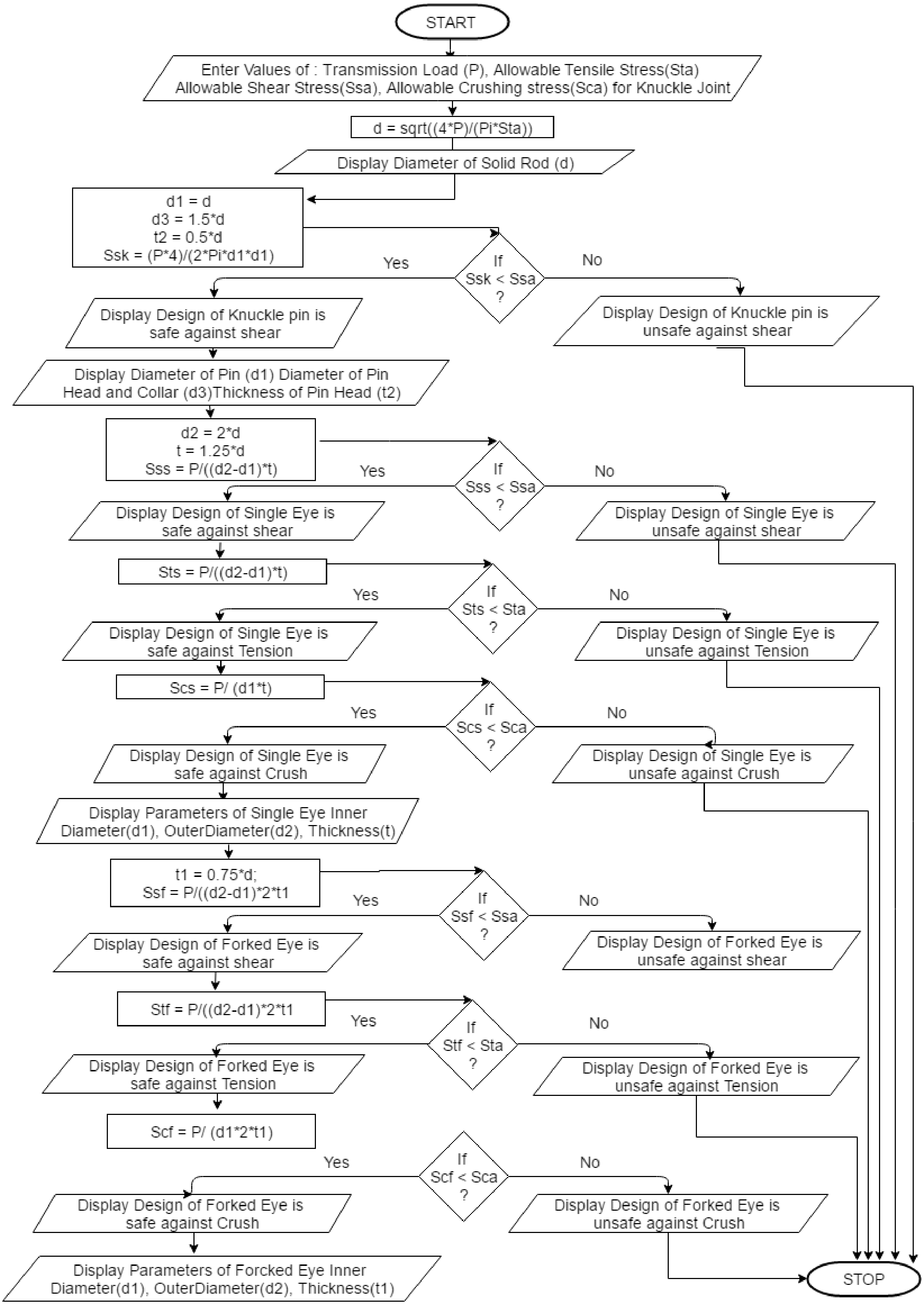

Figure 3: Flowchart for designing knuckle joint

IV. C PROGRAM

Program is written with Notepad as shown in figure 4 and executed on the TurboC compiler [4]. The source code of knuckle joint assembly is given below.

```
File Edit Format View Help
/// Program for design of Knuckle Joint
#include<stdio.h>
#include<conio.h>
#include<math.h>
#define Pi 3.141593
void main()
{ int d;
float P,Sta,Ssa,Sca,d1,d3,t2,d2,t,t1,Ssk,Sss,Sts,Scs,Ssf,Stf,Scf;
clrscr();
///Input Data
printf ("\nFor Knuckle Joint\n\tTransmission Load (N)=\n\tAllowable Tensile Stress(MPa)=\n\tAllowable Shear Stress(MPa)=\n\tAllowable Crushing stress(MPa)=\n");
scanf ("%f%f%f%f",&P,&Sta,&Ssa,&Sca);
///Design of Solid Rod
d = sqrt((4*P)/(Pi*Sta));
d=d+1;
printf("\nParameters of Solid Rod\n\tDiameter(d)= %d (mm)",d);
///Design of Knuckle Pin
d1 = d;
d3 = 1.5*d;
t2 = 0.5*d;
Ssk = (P*4)/ (2*Pi*d1*d1);
if (Ssk<Ssa)
{printf("\nDesign of Knuckle Pin is safe against Shear");
printf("\nParameters of Knuckle Pin\n\tDiameter of Pin(d1)= %f (mm)\n\tDiameter of Pin Head and Collar(d3)= %f (mm)\n\tThickness of Pin Head(t2)= %f (mm)",d1,d3,t2);
}
else
printf("\nDesign of Knuckle Pin is Unsafe against Shear");
///Design of Single Eye
d2 = 2*d;
t = 1.25*d;
Sss = P/((d2-d1)*t);
if (Sss<Ssa)
{printf("\nDesign of Single Eye is safe against Shear");
Sts = P/((d2-d1)*t);
if (Sts<Sta)
{printf("\nDesign of Single Eye is safe against Tension");
Scs = P/ (d1*t);
```

Figure 4: Source code written in Notepad

```
/// Program for design of Knuckle Joint
#include<stdio.h>
#include<conio.h>
#include<math.h>
#define Pi 3.141593
void main()
{ int d;
float P,Sta,Ssa,Sca,d1,d3,t2,d2,t,t1,Ssk,Sss,Sts,Scs,Ssf,Stf,Scf;
clrscr();
///Input Data
printf ("\nFor Knuckle Joint\n\tTransmission Load (N)=\n\tAllowable Tensile Stress(MPa)=\n\tAllowable Shear
 Stress(MPa)=\n\tAllowable Crushing stress(MPa)=\n");
scanf ("%f%f%f%f",&P,&Sta,&Ssa,&Sca);
///Design of Solid Rod
d = sqrt((4*P)/(Pi*Sta));
d=d+1;
printf("\nParameters of Solid Rod\n\tDiameter(d)= %d (mm)",d);
///Design of Knuckle Pin
d1 = d;
d3 = 1.5*d;
t2 = 0.5*d;
Ssk = (P*4)/ (2*Pi*d1*d1);
if (Ssk<Ssa)
{printf("\nDesign of Knuckle Pin is safe against Shear");
printf("\nParameters of Knuckle Pin\n\tDiameter of Pin(d1)= %0.2f (mm)\n\tDiameter of Pin Head and Collar(d3)= %0.2f
 (mm)\n\tThickness of Pin Head(t2)= %0.2f (mm)",d1,d3,t2);
}
else
printf("\nDesign of Knuckle Pin is Unsafe against Shear");
///Design of Single Eye
d2 = 2*d;
t = 1.25*d;
Sss = P/((d2-d1)*t);
```

```
if (Sss<Ssa)
{printf("\nDesign of Single Eye is safe against Shear");
Sts = P/((d2-d1)*t);
if (Sts<Sta)
{printf("\nDesign of Single Eye is safe against Tension");
Scs = P/ (d1*t);
if (Scs<Sca)
{printf("\nDesign of Single Eye is safe against Crush");
}
else
printf("\nDesign of Single Eye is Unsafe against Crush");
}
else
printf("\nDesign of Single Eye is Unsafe against Tension");
printf("\nParameters of Single Eye\n\tInner Diameter(d1)= %0.2f (mm)\n\tOuter Diameter(d2)= %0.2f
 (mm)\n\tThickness(t)= %0.2f (mm)",d1,d2,t);
}
else
printf("\nDesign of Single Eye is Unsafe against Shear");
///Design of Forked Eye
t1 = 0.75*d;
Ssf = P/((d2-d1)*2*t1);
if (Ssf<Ssa)
{printf("\nDesign of Forked Eye is safe against Shear");
Stf = P/((d2-d1)*2*t1);
if (Stf<Sta)
{printf("\nDesign of Forked Eye is safe against Tension");
Scf = P/ (d1*2*t1);
if (Scf<Sca)
{printf("\nDesign of Forked Eye is safe against Crush");
}
else
printf("\nDesign of Forked Eye is Unsafe against Crush");
}
else
printf("\nDesign of Forked Eye is Unsafe against Tension");
printf("\nParameters of Forked Eye\n\tInner Diameter(d1)= %0.2f (mm)\n\tOuter Diameter(d2)= %0.2f
 (mm)\n\tThickness(t1)= %0.2f (mm)",d1,d2,t1);
}
else
printf("\nDesign of Single Eye is Unsafe against Shear");
getch(); }
```

V. SAMPLE ILLUSTRATION

5.1 Problem Statement

Design a knuckle joint to transmit 150 kN. The design stresses may be taken as 75 MPa in tension, 60 MPa in shear and 150 MPa [2].

5.2 Output

The source code is executed on TurboC by providing input as shown in figure 5. Figure 6 shows the output screen; also shown below-

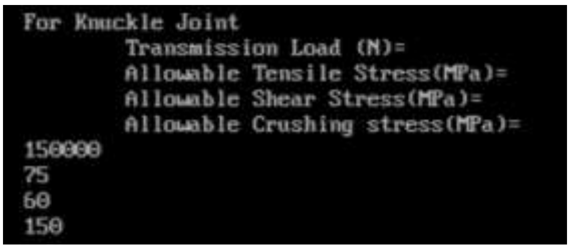

Figure 5: Input screen on TurboC

For Knuckle Joint
Transmission Load (N)=

Allowable Tensile Stress(MPa)=
Allowable Shear Stress(MPa)=
Allowable Crushing stress(MPa)=
150000
75
60
150
Parameters of Solid Rod
Diameter(d)= 51 (mm)
Design of Knuckle Pin is safe against Shear
Parameters of Knuckle Pin
Diameter of Pin(d1)= 51.00 (mm)
Diameter of Pin Head and Collar(d3)= 76.50 (mm)
Thickness of Pin Head(t2)= 25.50 (mm)
Design of Single Eye is safe against Shear
Design of Single Eye is safe against Tension
Design of Single Eye is safe against Crush
Parameters of Single Eye
Inner Diameter(d1)= 51.00 (mm)
Outer Diameter(d2)= 102.00 (mm)
Thickness(t)= 63.75 (mm)
Design of Forked Eye is safe against Shear
Design of Forked Eye is safe against Tension
Design of Forked Eye is safe against Crush
Parameters of Forked Eye
Inner Diameter(d1)= 51.00 (mm)
Outer Diameter(d2)= 102.00 (mm)
Thickness(t1)= 38.25 (mm)

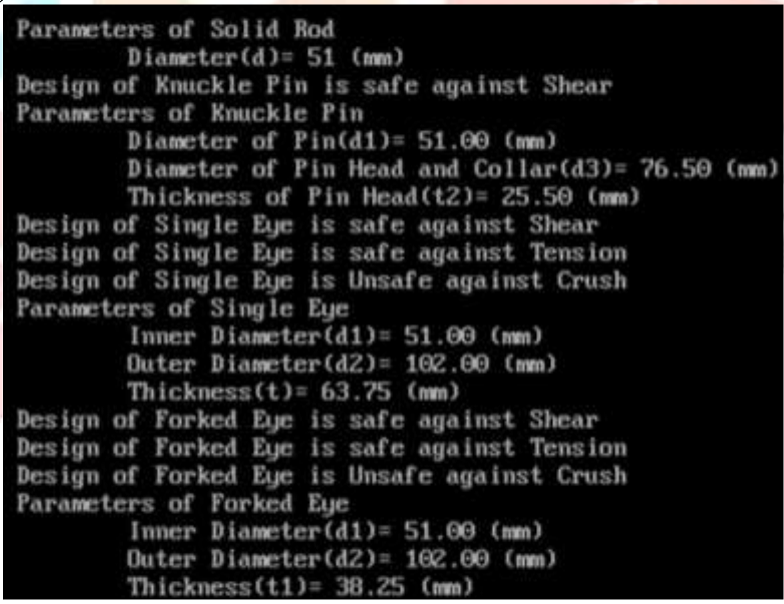

Figure 6: Output screen on TurboC

VI. RESULTS AND DISCUSSION

6.1 Results

Table 6.1 displayed dimensional values of parameters of knuckle joint assembly. The results received from program are compared with standard reference values [2]. In both cases design of shaft, pin, single eye and forked eye is safe. Dimensional parameters of standard reference and programmed are differ due to assumption in shaft size.

Table 6.1: Comparison of dimensional values obtained by program with standard reference value

Parameter	Solution given in reference (mm)	Solution obtained by program (mm)
Solid Rod Diameter	52	51

Diameter of knuckle pin	52	51
Diameter of knuckle pin head and collar	78	76.50
Thickness of knuckle pin head	26	25.50
Inner diameter of single eye	52	51.00
Outer diameter of single eye	104	102.00
Thickness of single eye	65	63.75
Inner diameter of forked eye	52	51.00
Outer diameter of forked eye	104	102.00
Thickness of forked eye	39	38.25

6.2 Discussion

It is good practice to develop source code for designing mechanical components which results into reduction in designing time and errors. Even person who is not aware with basic design knowledge can evaluate dimension and safety status of mechanical system. The obtained results are comparable with standard showing that source code is valid. This work is just an initiative to code design process of one assembly; future plan is to convert designs of convectional mechanical assemblies into C codes for simplification of design. Also automated drafting of mechanical assembly by providing input parameter using AutoCAD and AutoLISP is in future plan.

REFERENCES

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