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Design of Transmission Shafts Using C Programming Language

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Abstract: ***This paper deals with design of transmission shafts using C programming code. In most practical applications, gears and pulleys are mounted in large number on shafts. Thereby, the process of determining suitable diameter of shaft by traditional methods becomes tedious and time consuming. A program code is written which determines diameter by considering length of shaft, power transmitted, rpm of shaft, diameter of pulleys and gears, tension ratios of pulleys, pressure angles of gear and position of gears and pulleys on shaft. The main objective of the paper is to write a generalised program using C programming language applicable for design of all transmission shafts with mountings.***
Keywords: transmission shafts, gears, pulleys, C programming, design.

I. NOMENCLATURE

M - Maximum bending moment
T - Torque (Twisting moment)
τ_{max} – Maximum allowable shear stress
σ_{max} – Maximum allowable normal stress
C_m – Shock factor
C_t – Fatigue factor
d – Diameter of shaft
P – Power (kW)
N – Speed in rpm
r_g – radius of gear
r_p – radius of pulley
T_1, T_2 – tensions on pulley on tight and slack side
L – length of shaft (mm)
G – Rigidity modulus

II. INTRODUCTION

A *shaft* is a rotating member of circular cross section, used to transmit power or motion. It provides the axis of rotation, or oscillation, of elements such as gears, pulleys, flywheels, cranks, sprockets, and the like and controls the geometry of their motion [3]. Shafts can be broadly classified into machine shafts and transmission shafts.Machine shafts are those, integral with the machine itself.Transmission shafts are shafts used to transmit power between the source and the machine, and these include line shafts, counter shafts, overhead shafts, etc. Shaft design involves determination of the correct shaft diameter to ensure satisfactory *strength* and *rigidity* when the shaft is transmitting power under various loading conditions.

A. Shafts are subjected to variety of loading conditions. These include

1) Shafts subjected to pure twisting moment.
2) Shafts subjected to pure bending moment.
3) Shafts subjected to bending moment and twisting moment.
4) Shafts subjected to bending moment, twisting moment and axial loads.

B. Applications

Shafts are the most common mechanical components of any machine. Shafts are mainly used to transmit power from one component to other. Shafts are used in textile industries, watch and clock making industry, automobile industries (crankshaft or drive shaft, propeller shafts), horizontal and vertical milling machines, manual transmission gearbox, etc.

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Fig 1: Transmission shafts in gear box

C. Engineering Design Process

Engineering design is a process of converting resources or energy to useful mechanical forms. Fig. 2 represents the stages involved in engineering design.

This paper mainly concentrates on preliminary design stage where sizing of component (shafts) is carried out.

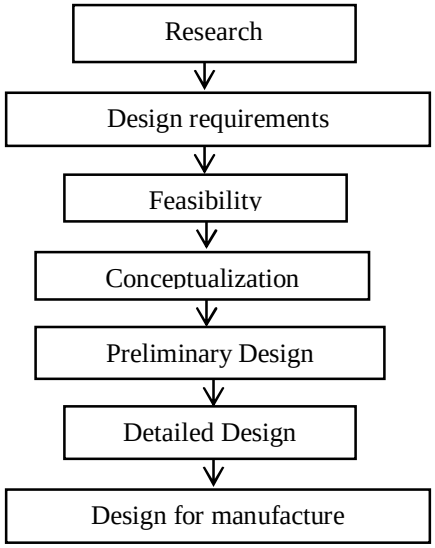


Fig 2: Stages of Engineering Design Process

III. DESIGN OF SHAFTS

In most of the practical applications, parameters like material properties, power requirements, speed of rotation, specifications of gears, pulley and other mountings are known. Using these available parameters, diameter of the shaft should be determined to withstand the load coming on it.

The design of shafts subjected to combined loading is based on maximum shear stress theory and maximum normal stress theory

A. Maximum Shear stress theory

According to this theory, diameter of shaft is given as,

$$d = \left[\frac{16\sqrt{(C_m M)^2 + (C_t T)^2}}{\pi \tau_{max}}\right]^{1/3}$$

Where $\sqrt{(C_m M)^2 + (C_t T)^2}$ is equivalent torque.

B. Maximum Normal stress theory

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According to this theory, diameter of shaft is given as,

$$d = \left[\frac{16\left(C_m M + \sqrt{(C_m M)^2 + (C_t T)^2}\right)}{\pi \sigma_{max}}\right]^{\frac{1}{3}}$$

Where $C_m M + \sqrt{(C_m M)^2 + (C_t T)^2}$ is equivalent bending moment.

C programming for design of shafts

C programming language is generic purpose programming language most widely used across the globe. C program was developed at bell labs by Dennis Ritchie between 1969 and 1973.

An algorithm was written for design of shafts with combined loading and later, implemented the algorithm using C code. The C code is indicated in appendix C.

IV. DEMONSTRATION- PROBLEM DEFINATION

A horizontal piece of commercial shafting is supported between two bearings 1.5 m part. A keyed gear 20^0 involute gear of 175 mm diameter is located 400 mm to the left of the right bearing and is driven by a gear directly behind it. A 600 mm diameter pulley is keyed to the shaft 600 mm to the right of the left bearing and drives a pulley with a horizontal belt directly behind it. The ratio of tensions of the belt drive is 3:1. The shaft rotates clockwise when viewed from the right side bearing. The drive transmits 45 KW at 330 rpm. Assuming that K_b =1.0, K_t=1.5, calculate the necessary shaft diameter of the shaft and angular twist in degrees. Use allowable shear stress 40 Mpa& G=80 Gpa.

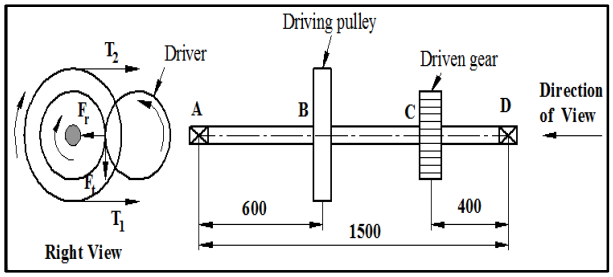


Fig 3: Front and Right side view of shaft

A. Analytical (theoritical) method:

1) Data: P= 45kW; N=330rpm; C_m= 1.0; C_t= 1.5; G=80GPa; L=1500mm; Pressure angle $\alpha = 20^0$; $\tau_{max} = 40MPa$; r_p = 300mm, r_g = 87.5mm, $\frac{T_1}{T_2} = 3$

2) Solution:

a) The torque transmitted by the shaft

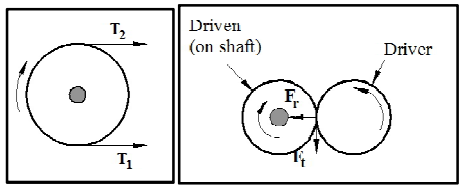
$T = \frac{9.55 \times 10^6 P}{N}\ N - mm$ => T=1.30210^6 $N - mm$

b) Forces on pulley (i.e at B)

T= $(T_1 - T_2)\ r_p$

$T_1 - T_2$ = 4341N and $\frac{T_1}{T_2} = 3$

Since, pulley is horizontal, the total force at B is (T_1+T_2) = 8682N ( )



(a) (b)

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Fig 4: (a) Forces on pulley (at B),
(b) forces on gear (at C)

c) Forces on gear (i.e. at C)

Tangential force $F_t = \frac{T}{r_g}$ = 14880N ($\downarrow$)

Radial force $F_r = F_t \tan\alpha$ = 5416 ($\leftarrow$)

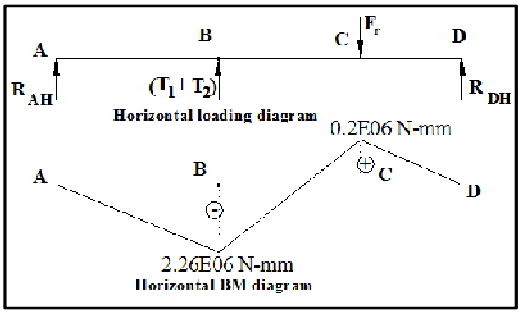


Fig 5: Horizontal loading and bending moment diagram

d) Determination of reaction forces from horizontal loading diagram

Taking moment about A, R_{DH} = 499N and R_{BH}= -3765 N

Bending moments at point of application of loads

$$M_{AH} = M_{DH} = 0$$
$$M_{BH} = -2.26\times10^6 \text{ N-mm}$$
$$M_{CH} = 0.2\times10^6 \text{ N-mm}$$

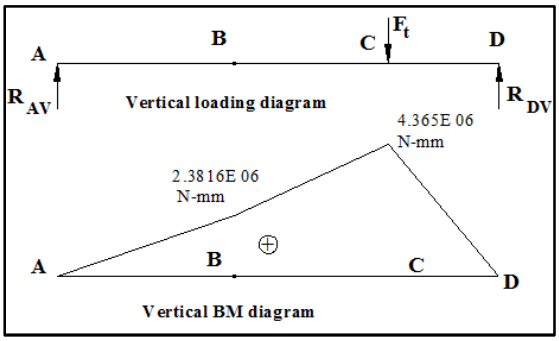


Fig 6: Vertical loading and bending moment diagram

i) Determination of reaction forces from vertical loading diagram

Taking moment about A, R_{DV} = 10912N and R_{BV}= 3968 N

ii) Bending moments at point of application of loads

$$M_{AV} = M_{DV} = 0$$
$$M_{BV} = 2.381\times10^6 \text{ N-mm}$$
$$M_{CV} = 4.365\times10^6 \text{ N-mm}$$

3) Determination of maximum bending moment

$$M = \sqrt{M_H{}^2 + M_V{}^2}$$
$$M_A = M_D = 0$$
$$M_B = 3.283\times10^6 \text{ N-mm}$$
$$M_C = 4.37\times10^6 \text{ N-mm}$$

Maximum bending moment is at C

Therefore, M= 4.37×10^6 N-mm

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and T = 1.032×10^6 N-mm

4) Diameter of shaft

Acccording to maximum shear stress theory,

$$d = \left[\frac{16\sqrt{(C_m M)^2 + (C_t T)^2}}{\pi \tau_{max}}\right]^{1/3}$$

$$d = 94.8mm$$

Referring to appendix B, standard diameter of shaft is d=100 mm

```
power in kw= 45
Allowable shear stress(MPa)= 40
speed in rpm= 330
type of load
1-steady loads
2-minor shock loads
3-heavy shock loads
1
Cm=1.500000
Ct=1.000000
total length of shaft(mm)= 1500
total number of pulleys= 1
total number of gears= 1
Torque transmitted T = 1302272.727273 N-mm


 pulley 1
-----------------
radius of pulley(mm)= 300
power given by pulley 1= 45
angle made by pulley 1 with horizontal= 0
tension ratio of pulley= 3
point of application of load= 600

 gear 1
-----------------
radius of gear(mm)= 87.5
power given to gear 1= 45
pressure angle of gear= 20
point of application of load(mm)= 1100
------------------------------------------------
The reaction forces of left bearing RH1=6653.627
The reaction forces of right bearing RH2=7445.20
maximum bending moment MTmax=5284735.321608 N-mm
the standard diameter of shaft d=100.000000 mm
End of program
------------------------------------------------
```

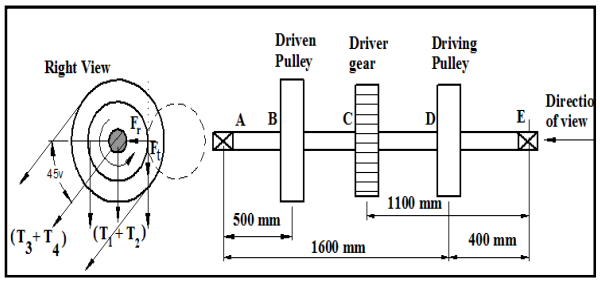
Fig 7: C Program output window

B. Result

The problem was solved theoretically and by C code. The standard diameter of shaft is found to be 100 mm by both methods.

A solid shaft is supported on two bearings 2m apart and rotates at a speed of 300 rpm. Two pulleys B & D of diameter 500 mm & 400 mm respectively are mounted on the shaft at distances 500 mm and 1600 mm to the right of left bearing. A 4 mm module & 100 teeth gear C is located on the shaft at 1100 mm to the left of the right bearing & drives a gear directly behind it. 20 KW is supplied to the pulley at B and the machine take 12 KW from gear C and the remaining from pulley D. The drive from pulley B is vertically downward, while the drive from pulley D is downward at an angle of 45^0 to the horizontal, towards the observer. In both pulleys, the tension ratio is 2.5. Design a suitable shaft having allowable stress 42 MPa in shear. Take C_m=1.75 and C_t=1. 25.

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```
C:\Users\likhitha\Documents
power in kw= 20
Allowable shear stress(MPa)= 42
speed in rpm= 300
type of load
1-steady loads
2-minor shock loads
3-heavy shock loads
2
Cm=1.750000
Ct=1.250000
total length of shaft(mm)= 2000
total number of pulleys= 2
total number of gears= 1
Torque transmitted T = 636666.666667 N-mm


 pulley 1
-----------------
radius of pulley(mm)= 250
power given by pulley 1= 20
angle made by pulley 1 with horizontal= 90
tension ratio of pulley= 2.5
point of application of load= 500

 pulley 2
-----------------
radius of pulley(mm)= 200
power given by pulley 2= 8
angle made by pulley 2 with horizontal= 45
tension ratio of pulley= 2.5
point of application of load= 1600

 gear 1
-----------------
radius of gear(mm)= 200
power given to gear 1= 12
pressure angle of gear= 20
point of application of load(mm)= 900
------------------------------------------------
The reaction forces of left bearing RH1=802.529
The reaction forces of right bearing RH2=1993.5
maximum bending moment MTmax=3044634.870639 N-m
the standard diameter of shaft d=90.000000 mm
End of program
------------------------------------------------
```

Fig 8: C Program output window

Result: Similar theoretical procedure as previous problem was followed and was found that results obtained from C code and theoretical calculations were same.

V. CONCLUSION

A generalized C program code was written for computing shaft diameter for simply supported shafts on bearings with any number of gears and pulleys. The results obtained by C code was verified and validated with analytical solution. Thus, use of programming for design of shafts reduces the need of tedious calculations, computation time and eliminates calculation errors.

REFERENCES

[1] GopichandGllaka, Prasad RajuKalidindi,KoteswaraRao S, "Design of SolidShafts using MATLAB", *Int J MechEngTechnol (IJMET)*. September – December2012; 3(3): 645–653p

[2] Mahadevan K and Reddy K.Balaveera, (2015), 'Design data hand book', CBS publishers and Distributors (P) ltd., New-Delhi, ISBN9788123923154.

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[3] Shigley's "Mechanical Engineering Design" (Ninth edition)
[4] Ketan D. Saradava, Piyush J. Mandaliya, Pratik P. Parsania, "Design of Machine Shaft in Fatigue Loading by Using C++ Programming Language" in Trends in Machine Design ISSN: 2455-3352 (online), Volume 3, Issue 1.

APPENDIX A

Table: Shock and fatigue factors

Nature of Loading	C_m	C_t
Rotating shafts		
1. Steady or gradually applied loads	1.5	1.0
2. Suddenly applied loads, minor shocks only	1.5 to 2.0	1.5 to 2.0
3. Suddenly applied loads, heavy shocks	2.0 to 3.0	1.5 to 3.0

APPENDIX B

Standard shaft sizes in mm

6	8	10	12	14	16	18	20	22	25	28	32	36	40	45
56	63	71	80	90	100	110	125	140	160	180	200	220	260	280
300	320	340	360	380	400	420	440	450	480	500	530	560	600	

APPENDIX C

C Program code for design of shafts:

```
#include<stdio.h>
#include<math.h>
int main()
{
START: inti,j,m,n,Z,load,q;
char driver, driven, pos;
double T,Cm,Ct,N,ss,Lt,d,P,PI,pa,RH1,RH2,RV1,RV2, MH1, MH2, MV1, MV2, Mtmax, Meq,
H, B, C, D,
k[10], p[10], rp[10], rg[10],lp[10], lg[10], t[10],ang[10],t1[10],t2[10], ft[10],
fr[10],
RHp[10],RHg[10],RVg[10],RVp[10],MH[10],MV[10],Mt[10];
PI=3.14159265;
//input parameters
printf("power in kw= ");
scanf("%lf",&P);
printf("Allowable shear stress(MPa)= ");
scanf("%lf",&ss);
printf("speed in rpm= ");
scanf("%lf",&N);
printf("type of load\n");
printf("1-steady loads\n");
printf("2-minor shock loads\n");
printf("3-heavy shock loads\n");
scanf("%d",&load);
if(load==1)
{
Cm=1.5;
Ct=1.0;
```

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```
}
elseif(load==2)
{
Cm=1.75;
Ct=1.25;
}
else
{
Cm=2.5;
Ct=2.25;
}
printf("Cm=%f\n",Cm);
printf("Ct=%f\n",Ct);
printf("total length of shaft(mm)= ");
scanf("%lf",&Lt);
printf("total number of pulleys= ");
scanf("%d",&n);
printf("total number of gears= ");
scanf("%d",&m);
T=(9.55e+06*P)/N;
printf("Torque transmitted T = %f N-mm\n\n",T);   //torque

for(i=1;i<=n;i=i+1)                              // input parameters for pulleys
{
printf("\n pulley %d\n",i);
printf("-----------------\n");
printf("radius of pulley(mm)= ");
scanf("%lf",&rp[i]);
printf("power given by pulley %d= ",i);
scanf("%lf",&p[i]);
printf("angle made by pulley %d with horizontal= ",i);
scanf("%lf",&ang[i]);
ang[i]=(PI/180)*ang[i];
printf("tension ratio of pulley= ");
scanf("%lf",&k[i]);
printf("point of application of load= ");
scanf("%lf",&lp[i]);
t[i]=(9.55e+06*p[i])/N;   //torque
t1[i]=(t[i]/rp[i]/(k[i]-1));
t2[i]=((t[i]/rp[i])+t1[i]);
RHp[i]=0;
RVp[i]=0;
RHp[i]=(t1[i]+t2[i])*cos(ang[i]);
RVp[i]=(t1[i]+t2[i])*sin(ang[i]);
if (RHp[i]<0.1)
RHp[i]=0.0;
if (RVp[i]<0.1)
RVp[i]=0.0;
```

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```
}

for(j=1;j<=m;j=j+1)                    // input parameters for pulleys
{
printf("\n gear %d\n",j);
printf("-----------------\n");
printf("radius of gear(mm)= ");
scanf("%lf",&rg[j]);
printf("power given to gear %d= ", j);
scanf("%lf",&p[j]);
printf("pressure angle of gear= ");
scanf("%lf",&pa);
pa=(PI/180)*pa;
printf("point of application of load(mm)= ");
scanf("%lf",&lg[j]);
t[j]=(9.55e+06*p[j])/N;   //torque
ft[j]=(t[j]/rg[j]);
fr[j]=ft[j]*tan(pa);
RHg[j]=0;
RVg[j]=0;
RHg[j]=fr[j];
RVg[j]=ft[j];
if (RHg[i]<0.1)
RHg[i]=0.0;
if (RVg[i]<0.1)
RVg[i]=0.0;
printf("-----------------------------------\n");
}

// reaction forces at bearing
RH1=0;RH2=0;RV1=0;RV2=0;
for(i=1;i<=n;i=i+1)
{
RH1=RH1+((RHp[i]*(Lt-lp[i]))/Lt);
RH2=RH2+((RHp[i]*lp[i])/Lt);
RV1=RV1+((RVp[i]*(Lt-lp[i]))/Lt);
RV2=RV2+((RVp[i]*lp[i])/Lt);
}
for(i=1;i<=m;i=i+1)
{
RH1=RH1+((RHg[i]*(Lt-lg[i]))/Lt);
RH2=RH2+((RHg[i]*lg[i])/Lt);
RV1=RV1+((RVg[i]*(Lt-lg[i]))/Lt);
RV2=RV2+((RVg[i]*lg[i])/Lt);
}
printf("The reaction forces of left bearing RH1=%f N and RV1=%f N\n",RH1,RV1);
printf("The reaction forces of right bearing RH2=%f N and RV2=%f N\n",RH2,RV2);
MV[1]=0;MV[m+n]=0;MH[1]=0;MH[m+n]=0;
```

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```
if(lp[1]>lg[1])
{
MH[1]=RH1*lg[1];
MV[1]=RV1*lg[1];
}
else
{
MH[1]=RH1*lp[1];
MV[1]=RV1*lp[1];
}

if((Lt-lp[n])>(Lt-lg[m]))
{
MH[m+n]=RH2*(Lt-lg[m]);
MV[m+n]=RV2*(Lt-lg[m]);
}
else
{
MH[m+n]=RH2*(Lt-lp[n]);
MV[m+n]=RV2*(Lt-lp[n]);
}
q=m+n;

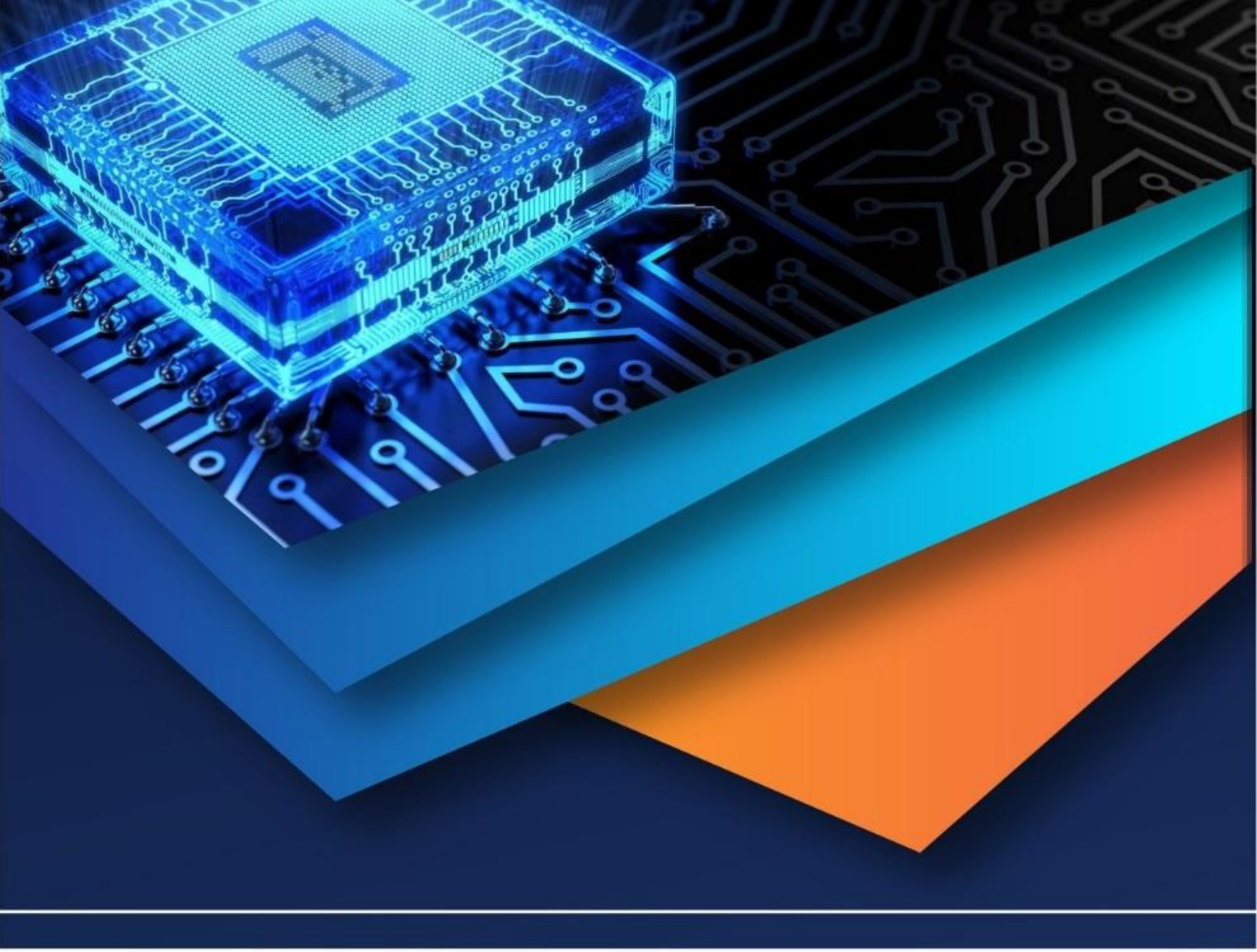
for(i=1;i<(m+n-1);i=i+1)
{
if(lp[i]>lg[i])
{
MH[i+1]=MH[i]-((RHg[i]-RH1)*(lp[i]-lg[i]));
MV[i+1]=MV[i]-((RVg[i]-RV1)*(lp[i]-lg[i]));
}
else
{
MH[i+1]=MH[i]-((RHp[i]-RH1)*(lg[i]-lp[i]));
MV[i+1]=MV[i]-((RVp[i]-RV1)*(lg[i]-lp[i]));
}
}
for(i=1;i<=(m+n);i=i+1)
Mt[i]=pow(((pow(MH[i],2))+(pow(MV[i],2))),0.5);
Mtmax= Mt[2];
for(i=3; i<=(m+n);i=i+1)
{
if(Mtmax<Mt[i])
Mtmax=Mt[i];
else
Mtmax=Mtmax;
}
printf("maximum bending moment MTmax=%f N-mm                                    \n",Mtmax);
Meq=pow((pow((Cm*Mtmax),2)+pow((Ct*T),2)),0.5);
```

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```
H=((16*Meq)/(PI*ss));
d=pow(H,0.33);

//find standard size
if (d<25)
d=(int((d-0.5)/2)+1)*2;
elseif (d<60)
d=(int((d-0.5)/5)+1)*5;
elseif (d<120)
d = (int((d-0.5)/10)+1)*10;
else
d = (int((d-0.5)/20)+1)*120;
printf("the standard diameter of shaft d=%f mm\n",d);
printf("End of program \n");
printf("-----------------------------------------\n");
printf("\n");
goto START;
return 0;
}
```

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