DESIGN AND FABRICATION OF CAN CRUSHING MACHINE

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A B S T R A C T

At present can is being crushed manually which employs more time and more man power. This can crusher can crush the aluminium can and an operator is required to handle the machine during the crushing process. It can be used to crush two cans in single rotation of the pulley. This consists of V-belt pulley, one piston, connecting rod, slotted lever and base frame. In this there is one piston in which one half of the piston crushes the can for half rotation of the pulley and the second half the piston crushes the can for next half rotation. Quick return mechanism is used to convert the rotary motion into linear reciprocating motion. The cane is crushed with help of piston which is connected with the connecting rod, slider, V - belt pulley with slotted bar. Fabrication of "Can crusher" is done by assembling the parts.

Keywords: Cane crusher machine, Components, Belt Pulley, Quick return mechanism

1. INTRODUCTION

The Can crushing machine which is fabricated incorporates the use of the "QUICK RETURN MECHANISM" for crushing two cans simultaneously in one stroke, i.e.; one can is crushed during the forward stroke of the piston and the other can is crushed during the return stroke of the piston. This mechanism is most commonly used in shaping machines and slotted machines. The quick return mechanism is an inversion of the slider crank which converts rotary motion into reciprocating motion. All parameters related to the design aspects were considered and calculated as per requirements. As the use of motor was avoided, design calculations were done for manually applied load.

Various stress factors were also considered and suitable tolerances and factor of safety was accordingly employed to reduce chances of failure and increase the life and durability of the machine. Care was also taken to ensure minimum or negligible slipping of the belt to achieve maximum efficiency.

The objective of this project is to design and fabricate the can crusher which incorporates the use of " QUICK RETURN MECHANISM". This can crusher is used to crush Aluminium cans for (200ml) its suitable disposal and subsequent recycling.

The Quick return mechanism is a mechanical device which is used for crushing cans. The can crusher on crushing the cans reduces the size of the cans and hence space is used less and also since the mechanism is fast moving process, so the work time is reduced for men.

The reason for the development and the introduction of the quick return mechanism for can crushing is given below. The quick return mechanism is one the improved devices used for crushing cans.

2. PART DESCRIPTION

2.1 Smaller pulley

Smaller pulley (Fig 1) is used to connect the handle and the larger pulley. V-belt is used to transfer the power from the handle to the larger pulley. This pulley is connected to the handle through bearing. The handle joint is used to transfer the power from the handle and the larger pulley without any power loss. This part is mainly used for the purpose of power transmission from the handle to the belt to the pulley for the effective reciprocating motion of the piston to crush the cans during the forward and the return stroke.

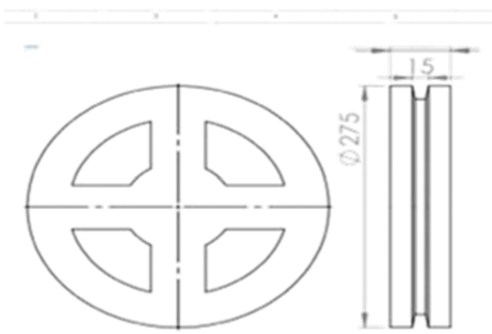

Fig .1. Smaller Puller

2.2 Larger pulley

Larger pulley (Fig 2) is operated by the power which is transferred from the smaller pulley by using handle from belt these two pulleys are connected by the V-belt.The power transferd from this pulley used to crush the can by using the QUICK RETURN MECHANISM. This pulley is connected to the slot by which the cylinder is operated to crush the can. This part is used to maintain the tension between the belt and the pulley to prevent the power loss due to the slipping of the belt.

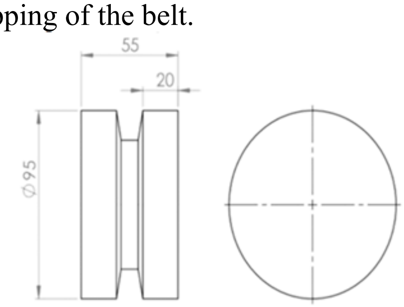

Fig.2. Larger Pulley

2.3 Slider

Slider (Fig 3) is used to transfer the power from the larger pulley the slot is used to connect both the larger pulley and slider and this slider is used to connect the both the larger pulley and connecting rod of the piston. Slider will slides over the slot to transfer the energy the connecting rod is pivoted to the slider and the power is tranfered to the piston. Slider is the main part which transmits the power to the piston to crush the can by converting rotary motion to reciprocating motion.

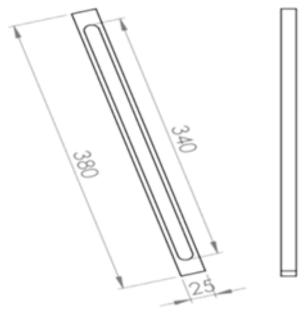

Fig .3. Slider

2.4 Connecting rod

Connecting rod (Fig 4) is used to transfer the load from the slider to the piston and it should bear the high load so it should be very strong. This part plays a important role in transfering the load. Construction of each part is mainly depent upon this component this part plays an important role in the transfer of load from the slider to the piston. The connecting rod is connected to the crank which facilitates the working of the can crushing machine. The connecting rod is essential as it forms the backbone of this device.

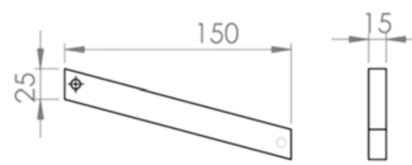

Fig.4. Connecting Rod

2.5 Cylinder

Cylinder (Fig 5) act as a frame which carries the can and the piston over it is cutted partially and there will be two holes on the two end of the cylinder. The piston will slides over this cylinder hence it should be lubricable the can after crushing is will fall through hole which is present in both end of the cylinder. The cylinder must be made of a suitable material hard enough to crush the Aluminium cans. The cylinder is made solid at its ends and hollow inside to provide sufficient force to crush the cans as well as reduce the total cost of the product.

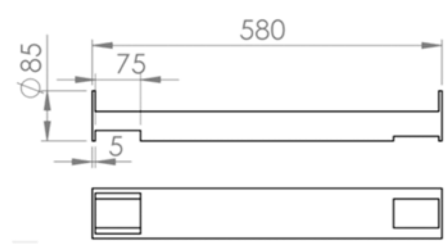

Fig.5. Cylinder

2.6 Piston

Piston (Fig 6) component is used to crush the can with the help of load transferd from the connecting rod with the help of cylinder. The piston slides over the cylinder and it travels from the one end to the other end of the cylinder.The cylinder is connected to to the connecting rod through welding.

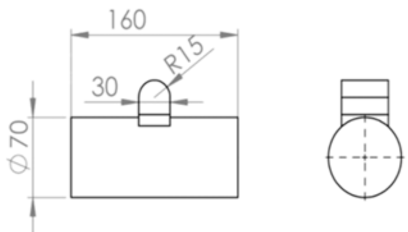

Fig.6. Piston

3. DESIGN CALCULATION

3.1 Design Calculation for pulley and V-belt drive

Assume The Load is below 1KW Power

To Select'A' Grade belt drive(Refer PSGDB Page no 7.58)

To take dmin diameter pulley

dmin= 75mm (Refer PSGBD Page no 7 .62)

Where, demax =dmax *Fb mm

The smaller diameter factor Fb is Assume 1.14

STEP:1 SPEED RATIO (i)

The speed Ratio i=2.949

dmax = 125/1.14

dmax =110mm

Let us take mean diameter d_{mean}=90mm

STEP: 2 LARGER PULLEY DIAMETER (D)

i=D/d

2.949=D/90

D=2.949*90

D=270mm

STEP: 3 CENTER DISTANCE (C)

Let us take for i=2.949

Where,C/D=1.0 (Refer PSGDB Page no 7.62)

C=270mm

STEP:4 MINIMUM CENTER DISTANCE (Cmin)

C_{min}=0.55(D+d)+T

mm

=0.55(270+90)+8

C_{min} =206mm

STEP:5 MAXIMUM CENTER DISTANCE (Cmax)

Where, Cmax=2(D+d) mm

=2(270+90)

Cmax=720mm

Hence the design is safe

STEP:6 LENTGH OF THE BELT (L)

L=2C+ /2(+)+(−) ^{2}/4C

mm

L=2*270+π/2(270+90)+$(270-90)^2$/4*270

L=540+565.2+30

L=1135.2mm

(Refer PSGDB Page no 7.59)

The next standard value L=1219mm for A grade belt length L=1255mm

STEP:7 NEW CENTER DISTANCE (C)

Where,C=A+√ ^{2} −mm

Where, A=L/4- /8(D+d) mm

A =1255 /4-3.14/8(270+90)

A=313.75-141.3

A =172.45mm

Where, B = $(D-d)^2$/8 mm

B = $(270-90)^2$/8

B=4050mm

C=172.45+ √172.45^2 – 4050

C=332.72mm

(or)

C=340mm

ASSUME, Speed for smaller pulley N1=356rpm

Speed for larger pulley N2=120rpm

STEP:8 BELT RATING FOR V-BELT DRIVE (Br)

'A' GRADE BELT

Where, Br=(0.45$V^{-0.09}$-19.62/de-0.765X$10^{-4}V^2$)V125 KW

De=90x1.14

De=102.6mm

STEP: 9 VELOCITY (V)

Where, V= 1/60 M/S

V =3.14X0.090X356/60

V=1.67 M/S

Br= (0.45X $(1.67)^{-0.09}$-19.62/102.3-0.765X$10^{-4}(1.67)^2$)1.67

Br= 0.109KW[FOR 180^0]

STEP:10 ARC OF CONTACT (ka)

Where,k_a= 180-(D-d) X 60/C

K_a = 180 - (270-90) X 60/270= 140'

For =140 in (PSGDB Page no 7.65) to take Ka=0.9

Required 140 for belt rating= Br* /180

= 0.109 x 140/180

Required belt rating 140= 0.0847 KW

Take correction factor Ks=1.2

STEP:11 DESIGN POWER (Dp)
Where,Dp = Rp * Ks/Kl * Ka KW
Dp = 0.368*1.2/0.93*0.9
Dp = 0.527 KW

STEP:12 NUMBER OF BELTS
Where,N = Dp/Required for belt rating
N =0.527/0.337
N=1.56
NUMBER OF BELT N=1
Where, Pw=(N-1) e+2f
Pw= (1-1) 15+ 2X1
Pw =20mm

STEP:13 BELT TENSION (T)
T1 = Tight side of the Belt
T2 = slack side of the Belt
POWER , P=(T1-T2)V
T1/T2=θ=140X3.14/180 =2.44radians/sec
P=527W
V=1.67M/S 527/1.67 = T1-T2 T1-T2 = 315.55
T1/T2= 0.3∗2.44
T1/T2 = 2.08
2.08T2-T2 = 1.08T2 T2=292.19N
T1=2.08X292.19
T1= 607.76 N

STEP:14 DESIGN OF SHAFT (SMALLER PULLEY dS)
Where,Mt = P*60/2
N1 N-m
Mt= 527*60/2*3.14*356
Mt = 14.14 N-M
Mt = $14.14X10^3$ N-mm
Twisting Moment
Mt
$=/16*d^3$

N-m
{For Mild steel Material τ=50N /mm^2&= 120 N/mm^2 }
$d^3=14.14x10^3x16/50x3.14$
d = 15mm

STEP:15 DESIGN OF KEY (REACTANGULAR SUNK KEY)
Diameter of the shaft d =15mm, (Refer PSGDB PAGE NO :5.16)
To take b = 5mm,
For
L = 22.5mm

CHECKING FOR SHEAR STRESS (τ)
L = 1.5xd
L = 1.5x15
Mt = L* τ*bd/2
=Mt*2/L*d
= $14.14X10^3X2/22.5X5X15$
=16 .96N /mm^2<50N/mm^2
Hence the design is safe

CHECKING FOR CRUSHING STRESS (σ)
h/2)*(d/2)
σ= MtX4/L *h*d
σ=14.14X103X4/22.5X5X15
σ=33.9N/mm2<120N/mm^2
Hence the design is safe

STEP:16 DIAMETER OF SHAFT (LARGER PULLEY DS)
Mt = P*60/2πN2
Mt = 60 x 527/ 2 x 3.14 x 120
Mt =41.95x103N-mm
Twisting Moment
h = 5mm
L=10 to 56mm
Mt= σ
Mt =π/16*d3 τ
{For Mild steel Material τ=50N /mm2 & σ = 120 N/mm2 } d3 = 41.95 x 103x16/50x3.14 d = 20mm
DESIGN OF KEY (REACTANGULAR SUNK KEY)
Diameter of the shaftd =20mm,(Refer PSGDB PAGE NO :5.16)
To takeb = 6mm,
h = 6mm
L=10 to 56mm
ForL = 1.5xd
L = 1.5x20
L = 30mm
CHECKING FOR SHEAR STRESS (τ)
Mt = L* τ*b*d/2
τ =Mt*2/L*d
τ = 41.95x103x2/30x6x20
τ =23 N /mm2<50N/mm2
Hence the design is safe
CHECKING FOR CRUSHING STRESS (σ)
Mt= σ*L*(h/2)*(d/2)
σ= MtX4/L *h*d
σ=41.95X103X4/30x6x20
σ=46.6N/mm2<120N/mm2
Hence the design is safe

3.2 Design calculation for slotted lever

STEP:1 DESIGN OF SLOTTED LEVER
From Fig 7,
Time of cutting stroke / Time of return stroke is given by α / β
Assume cutting ratio = 5:3
(α)/(360- α) = 5:3, (360- β)/ β =5:3
α =2250, β =134.980
α +β=360
Radius
CB1=CB1=CB=120mm

sin90−(β /2)=(CB1/ AB)
sin90−(134.98/2)=(CB1/ AB)
AB=313.44mm

STEP: 2 SLOTTED LEVER

AC=CQ
AQ=AC+CQ
AQ=313.44+313.44
AQ=AR1=AR2=626.8mm

STEP:3 TOTAL DISTANCE OF CONNECTING ROD

R1R2 =2QA X CB/AC
R1R2= 2X626.8X120/313.44
R1R2 =480mm
AQ1=2ED
ED=626.8/2
ED=313.4mm

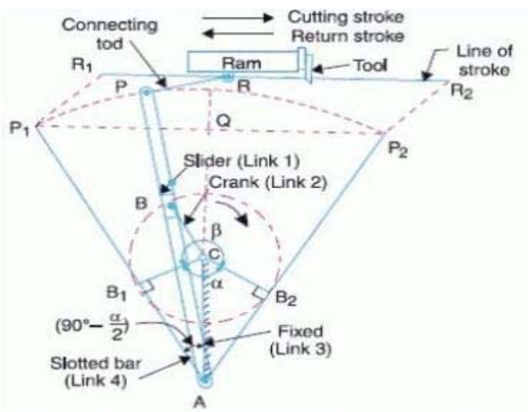

Fig.7. Slotted lever mechanism

STEP:5 BENDING MOMENT OF THE SLOTTED LEVER

Section modulus, Z = I/Y
Where, I=Moment of inertia
$I=bd^3/12$
ASSUME
d=h
h=b/2
$I=b*b^3/96$
$I=b^4/96$
M_b=LOAD X DISTANCE
M_b =527X626.4
$M_b=0.379X10^6$N-mm

STEP:6 BREADTH (b)

$0.379X10^6/b^4/96=320/b$
B =46mm

STEP:7 THICKNESS OF SLOTTED LEVER

h =b/2
h=46/2=23
h=23mm

STEP:8 CALCULATION OF PISTON EFFORT (FP)

$F_P=F_L-F_I$
F_L=Net load On the piston
F_I=Acceleration of the piston

STEP:9 ACCELERATION OF THE PISTON (FI)

F_I=m r^2(COS +COS2 /n)N
m=Mass of the reciprocating parts
r=Radius of crank
n=length of connecting rod/Radius of the crank
$=2N_2/60$
=2X3.14X120/60
ω= 12.56rad/sec
W=50N m =5.09kg
r =120mm=0.120M l =240mm=0.240M
n =l/r=0.240/0.120 =2
F_I =5.09 x .140 x $(12.56)^2$ x (cos60-cos 2x60/2) x0.12 F_I =72.26N

STEP:10 NET LOAD ON THE PISTON (FL)

F_L=Pressure X Area
ASSUMEPressure of the piston=$1.5X10^5N/M^2$
Area of the piston =

$/4Xd^2$
Diameter of the piston, d=50mm=0.050M
$F_L =1.5X10^5X3.14X0.070^2/4$
F_L=576.98N

STEP:11 PISTON EFFORT (FP)

$F_P=F_L-F_I$
F_P = 576.98-72.26
F_P=504.77N

STEP:12 ANGLE OF CONNECTING ROD

Where,tanØ=sinØ/cosØ
tanØ= sin /$\sqrt{n^2-\sin^2\theta}$
tanØ= $\sin60/(2^2-\sin^2 60)^{0.5}$
tanØ=0.48
Ø=$\tan^{-1}(0.48)$
Ø=25.65’

STEP:13 FORCE ACTING THE ALONG THE CONNECTING ROD (FQ)

F_Q = F_P X n/ $(n^2-\sin^2 60)^{1/2}$
F_Q = 504.77X2/ $(2^2-\sin^2 60)^{1/2}$=559.9N

STEP:14 CRANK PIN EFFORT(FT)

$F_T=F_p$ X sin(θ+Ø)/ cosØ
F_T =504.77 X sin(25.65+60)/cos25.65
F_T=558.33N

STEP:15 THRUST ON CRANK SHAFT BEARING(FB)

$F_B=F_P$ X cos(θ+Ø)/)/cosØ
F_B=504.77 X cos(60+25.65)/cos25.65
F_B=42.47N

STEP:16 CRANK EFFORT (T)

$T=F_P[\sin\theta+\emptyset/\cos\emptyset]r$

T=504.77[sin(60+ 25.65)/cos25.65]0.120

T=67.00NM

STEP:17 DESIGN OF BOLT

Select the materials for bolt C50 steel=P/A

$\tau_{max} = S_{sy}/F.S$

Take C50 material ,(Refer PSGDB page no 1.9)

$\tau_y = 380N/mm^2$

S_{sy} =yield strength is shear = yield strain tension/2=S_{yt}/2 F.S= factor of safety

Assume factor of safety F.S=3

τ_{max} =380/2x3

τ_{max}=63.33N/mm^2

Load P=266.27N

P_1=P/n

n =Number of bolts P_1=266.27/1=266.27

P_1=266.27N

STEP:18 STRESS (σ)

$\sigma=P_2/A$ P_2=Pxexl/n(l^2)

P_2=266.27x275x50/1x$(50)^2$

P_2=1464.485N

σ =1464.48/A N/mm^2

STEP:19 SHEAR STRESS (τ)

τ =P_1/A

τ =266.27/A N/mm^2

$\tau_{max}= \sqrt{}(\sigma/2A)^2+ \tau^2$

$63.33=1/A\ ((1464.48/2)^2+266.27^2)^{1/2}$

A=12.3mm^2

A=(12.3/4) x d_c^2 d_c^2 =12.3x4/3.14 d_c= 3.958mm

d_c=0.8xd

d =d_c/0.8

d=3.958/0.8d=4.9 (ReferPSGDBPageno.5')

The next standard bolt diameter M5 & height of the bolt=14mm

4. ASSEMBELY DIAGRAM AND FABRICATION OF MACHINE

Component drawings and assembled drawing (Fig 9, Fig 10) are created with CAD package. Then the components are manufactured and fabricated (Fig 11).

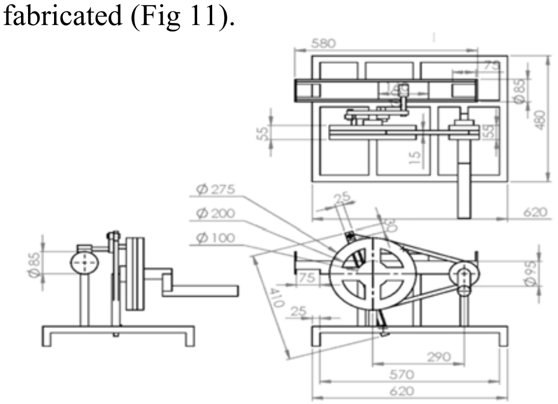

Fig.8.Assembly 2D view

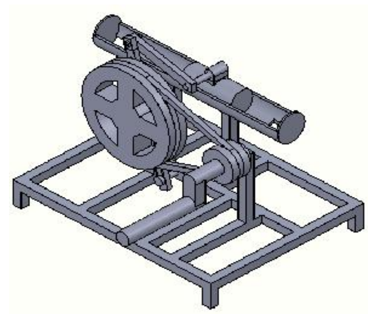

Fig .9.Assembly 3D view

Fig .10. Fabricated product

5. RESULT AND CONCLUSION

The Quick return mechanism has been fabricated and is checked for the stroke length obtained after machining the mechanism, the required calculations are done. The required stroke length that needs to be obtained is 550mm. A cam profile of 240 degree forward stroke is also obtained there for the required mechanism. After doing the required calculations and stroke length of 500mm is obtained. The obtained value is approximately equal to the required stroke length.

The forward and return stroke time is noted Time obtained for forward stroke is 3.33 sec and the time obtained for return stroke is 1.66 sec. Thus the values obtained are satisfactory.

Thus Quick Return Mechanism is fabricated to obtain the required stroke length. The required calculations are done to find out the position of the screw to get the required stroke length.

6. REFERENCE

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