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RESEARCH ARTICLE

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DESIGN AND FABRICATION OF LOW COST MULTI-PURPOSE KITCHEN EQUIPMENT

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ABSTRACT

Increasing competition and innovation in technology sector tends to modify the existing product by new and advanced product. Our ultimate objective is to design and fabricate a machine that can perform the operations such as grinding rice flour, vegetable cutting and coconut scrapping.

The conventional machines only have the facilities of grinding rice flour and coconut scrapping. Here we combine all those three operations in a single machine that would saves time, labour & wastage effectively. We fabricated a steel frame especially for this three operations . It had undergone many analysis and finally fits for our project .The whole grinder setup is placed over the frame while the motor is fixed under it .We made a rectangular casing made out of mild steel sheet metal. Various folding and bending operations were done for that casing .The connecting rod for chopping operation is made out of aluminium to reduce the weight . There were two pulleys connected to the motor which were driven by v-belts . When the motor is energised all the three process would takes place simultaneously . Our vegetable cutting is 100% hygienic .after cutting of vegetables the size of the vegetables are uniform over the process. It requires no special skills to operate the machine . We think that our project would help the society in a better way by reducing the time and also the number of labours .

I. INTRODUCTION

Kitchen equipment is been a necessity to commercial kitchen areas now a days. Modern kitchen equipments are in a huge demand in international market because of their optimum performance, durability and reliability.

Nowadays people in this 21st century expecting more from the technological side to reduce their working time . and this is also a major reason to invent such multi - purpose kitchen equipments where multiple processes were handled simultaneously by a single person . but in the conventional method it requires more labour to involve in that work.

II KITCHEN EQUIPMENTS

Vegetable cutting machine is been a necessity to commercial kitchen areas now a days. Using this machine vegetables are sliced easily. The automatic feeding and discharge features save time. The discs have stainless steel bushings and are easily fitted with easily removable stainless steel blades and grids, which assures proper hygienic cleaning

[1]. These machine can cut vegetables in different shapes and sizes as per the requirements of the customer. The machine is manufactured with food grade stainless steel material AISI 304 material to meet the standards of catering industry[3].

III . EXISTING METHOD

In The conventional method the vegetables are cut manually whereas the grinding and other processes were done separately . In that conventional method there are many possibilities of cutting out their fingers [3]. And also these processes would take almost 1-2 hours to cut the vegetables ,if they think about time more number of labours should be employed there . This will result in the waste of money and time .Cleaning of these machines in the conventional methods were of very tedious process. And also there are machines which can do the multiple process simultaneously but not in an effective way[1]. if there is grinding with coconut scraping vegetable cutting is not there .most of the household table top grinder setup is coming with both grinding and coconut scraping facility. But these are not suitable for the kitchens situated in institutions , canteens, restaurants etc.

IV. PROBLEM STATEMENT

Vegetable cutting in a mass quantity is a tedious and time consuming process and if it is accompanied with grinding and coconut scrapping it takes more time. Large amount of human effort is needed in this. Small accidents like cutting out of fingers of the workers were seen in this conventional method .

MAJOR PROBLEMS

***MORE REQUIREMENT OF LABOURS*:** Nearly 2 to 3 workers required for cutting vegetables through ordinary method.

LACK OF SAFETY: Workers find difficulty with that conventional machine since the slicer blade rotates in the top of the machine there will be chance of accidents [3] .

MINOR PROBLEMS: It takes a long duration , since the fixing of blade in the conventional machine takes more time[2] .

- It cannot be used in large kitchens that are situated in restaurants , canteens , institutions.

V. OBJECTIVES

Our ultimate objective is to design and fabricate a machine that can perform the operations such as grinding, vegetable cutting(chopping),and coconut scrapping. The existing machines only have the facilities of grinding and coconut scrapping. Here we combine all those three operations in a single machine to save time, labour & wastage effectively.

We here provide a machine which will be more safer than the conventional machine where the blades are attached inside the rectangular casing and there is no chance for such accidents .

The vegetables are fed from the top of the casing where there is a circular vent for feeding of vegetables . A guide is provided in the grinder setup for the uniform grinding of rice flour . A separate plate is provided for the holding of coconut scraps falling from the coconut scraper [3] .

VI. VARIOUS COMPONENTS INVOLVED

CONNECTINGROD

The connecting rod consists of an eye at the small end to accommodate the piston pin, a long shank and a big end opening split into two parts to accommodate the crank pin. The basic function of the connecting rod is to transmit the push and pull forces from the piston pin to the crank pin as shown in fig 1.The connecting rod transmit the reciprocating motion of the piston to the rotory motion of the crank shaft.It also transfers lubricating oil from the crank pin to the piston pin and provides a splash or jet of oil to the piston assembly[6].

The connecting rod is subjected to the force of gas pressure and the inertia force of the reciprocating part.It is one of the most heavily stressed parts of the engine. The length of the connecting rod is an important consideration. When the connecting rod is short as compared to the crank radius, it has greater angular swing, resulting in greater side thrust on the piston.In high speed engines, the ratio of the length of the connecting rod to the crank radius (L/r) is generally 4 or less. In low speeds, the (L/r)ratio varies from 4 to 5 . In our work we used connecting rod connected in the crank shaft which is employed in the vegetable cutting operation .

Fig .1 connecting rod

CRANK SHAFT : The crankshaft that converts the reciprocating motion of the piston into rotory motion through the connecting rod.

It consists of three portions:

1.crank pin

2.crank web

3.shaft

The big end of the connecting rod is attached to the crank pin. The crank web connects the crank pin to the shaft portion. The shaft portion rotates in the main bearings and transmits power to the outside source through the belt drive, gear drive or chain drive. The crank shaft is hold by a small hollow cylindrical block where it consist of two bearings upside and down . The bottom end of the shaft is connected with the pulley[5] .

V-BELT : V-belt is mostly used in factories and workshops. It is used to transmit great amount of power from one pulley to another. The v-belts are made of fabric and cords moulded in rubber and covered with fabric and rubber. These belts are moulded to a trapezoidal shape and are made endless. It is particularly suitable for short distance. The included angle for v-belt is usually from 30*-40* [5].

In v-belt drive, the rim of the pulley is grooved in which the belt runs. The effect of the groove is to increase the frictional gap of the v-belt on the pulley and thus to reduce the tendency of slipping. The v-belt is in contact with the side faces of the groove and not at the bottom. The power is transmitted by the wedging action between the belt and the v-groove in the pulley.

PULLEYS : A pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a belt along its circumference. pulley is also called as sheaveordrum. The drive element of a pulley system can be a rope, belt, or chain that runs over the pulley inside the grooves or groove .

It describes a pulley that is secured to a single spot. While the pulley's wheel will turn with the rope or chord that passes through it, the pulley itself will remain stationary.

Because of this, the force exerted on the object on the opposite side of the pulley will be exactly the amount of force applied on the user's side of the pulley. This is described as having a mechanical advantage of one, because the amount of force you apply is precisely the amount of force the machine will exert on the object you are trying to move. In our project we used (2*A) type pulley to transmit the power to both grinder and vegetable cutter. The both driven pulleys also are same A-type.

CLAMPS: Clamps are simple mechanical device to hold the work pieces together. Here we used the clamp to hold the rectangular casing which is used for vegetable cutting. The clamp is tightened by two bolts and nuts which is other side fixed with the frame.

Fig.2. clamp

BEARINGS: A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. It is classified broadly according to the type of operation, motions allowed, or to the directions of the loads applied to the part.

We have used two bearings sized (inner diameter 25mm) .these two bearings are placed inside the cylindrical block to hold the crank shaft in

the vertical position which is operating the connecting rod .

BOLTS AND NUTS :

BOLTS: Hex bolts, or hex cap screws, are used in machineryand construction. Can be used with a nut, orina tapped hole. Fully threaded hex bolts arealso known as tap bolts.

NUTS: A nut is a fastener with a threaded hole. Nuts are almost always used opposite a mating bolt to fasten a stack of parts together. The two partners are kept together by a combination of their thread's friction, a slight stretch of the bolt, and compression of the parts.

VII. 3-D MODEL OF OUR FABRICATION WORK

The following figure is 3-D model of our fabrication work.

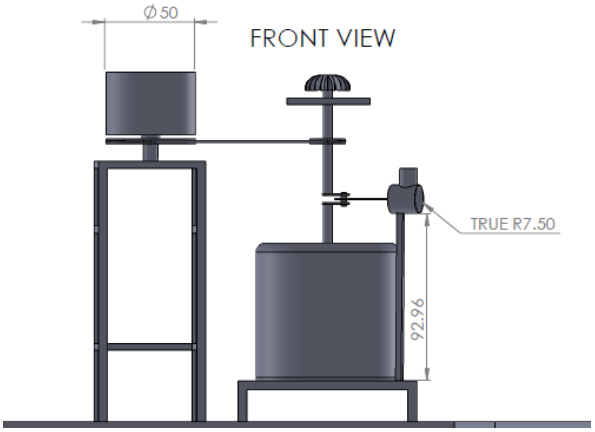

Fig. 3. 3-D model of our fabrication work

VIII. CALCULATIONS

DESIGN CALCULATIONS

DESIGN OF THE BELT DRIVE: The belt drive between electric motor and crank shaft pulley

Speed of electric motor (N1) =1440 rpm

Distance between two pulleys(x) =300mm

Diameter of motor pulley (d1) =80mm

Diameter of crank shaft pulley (d2) =220

Speed ratio:

$\frac{N1}{N2}=\frac{D2}{D1}$

N2=523.636N

$\sin \propto =\frac{r2-r1}{x}$

$\sin \propto =\frac{110-40}{300}$

$\propto$ =13.49

Angle of contact:

θ =180-2$\propto$

θ =180-2*13.49

θ =153.013°

Convert degree to radθ =2.67 rad

Assume groove angle of the pulley,

2β =35°

β =17.5

Coefficient of friction, μ =0.25(leather)

2.3 log $(\frac{T1}{T2})= \mu\theta \csc \beta$

log $(\frac{T1}{T2})$ =0.965

$\frac{T1}{T2}$=9.225

To find velocity of the belt:

V =$\frac{\pi*d1*N1}{60}$

V =6.0318$\frac{m}{s}$

Mass of the length per metre length,

= area *length *density

Area =breath * thickness

Area =104 mm^2,Density =1000$\frac{kg}{m^3}$

Length =1 m

M = 104$*$ 10^{-6}*1*1000

M =0.104$\frac{kg}{m}$

Centrifugal tension in the belt,

Tc =mv^2

Tc =0.104*6.0318*6.0318

Tc =3.7837 N

Maximum tension in belt,

T =stress * area

Stress =1MPa(assume)

T =1*104

T =104 N

Tension in the tight side of the belt,

T1 =T-Tc

T1 =104-3.7837

T1 =100.216 N

Tension in the slack side of the belt,

$\frac{T1}{T2}$ =9.225

T2=$\frac{100.216}{9.225}$

T2 =10.8635 N

The power transmitted per belt,

= (T1-T2)*v

= (100.216-10.8635)*6.0318,p=538.956 w

Since overall load factor =1.5

Numberof belt required =$\frac{\text{designedpower}}{\text{powertransmittedperbelt}}$

Designed power =0.25 *746*1.5
=279.75 w (use A type belt drive)
N =$\frac{279.75}{538.956}$
N =0.51905 (say 1)
Number of belt required =1
The pitch length of the belt,
L =$\pi(r2 + r1) + 2x + \frac{(r2-r1)^2}{x}$
L =1087.568 mm
Subtracting 36 mm for 'A' type belt, we find inside length of the belt
=1087.568- 36
=1051.568 mm
According to IS:2494-1974,the nearest standard inside length of the v-belt is 1051mm
Pitch length of the belt,
L1=1087.568+36,L1=1123.568
To find out center distance between two pulleys,
L1=$\frac{\pi}{2}$(d2+d1)+2x1+$\frac{(d2-d1)^2}{4x}$
1123.568=471.23+2x1+$\frac{4900}{x1}$
$x1^2$-652.338+4900 =0
x1 =318 mm
DESIGN OF SHAFT:
D =diameter of the shaft
T =$\frac{\text{designed power} * 60}{2*\pi*N2}$
T =$\frac{279.75*60}{2*\pi*523.636}$
T =5.1016 N-m
Bending moment of the belt due to tensions,
M = (T1+T2+2Tc)
M = (100.216+10.8635+25.466)*1
M = 136.5455 N-m
Equivalent twisting moment,
Te =$\sqrt{T^2 + M^2}$
Te =136640 N-mm
Te =$\frac{\pi}{16}*\tau * D^3$
Permissible shear stress (τ) = 40MPa
Diameter of the shaft,
D =25.911
D =25 mm(approx.)
DESIGN OF PULLEY:
The dimensions for the standard V-groove pulley, are shown in PSG (data book) from which we find that for 'A' type belt
Pitch width (w) =11 mm
Pitch diameter (d) =12 mm
Minimum distance down to pitch line (b) =3.3 mm
Minimum depth below pitch line (h) =8.7 mm
Edge of pulley to first groove (f) =10 mm
Centre to Centre distance of grooves (e) =15 mm
Face width of the pulley:
B = (n-1) e +2f
B = (1-1) 15 +(2*10)
B =20 mm
The belt drive between electric motor and grinding pulley,
Diameter of grinding pulley(d2) =180 mm
Using speed ratio relation to find out (N2)
$\frac{N1}{N2}$=$\frac{D2}{D1}$
N2 =640 rpm sin $\propto$ =$\frac{r2-r1}{x}$
sin $\propto$ =$\frac{180-40}{250}$
$\propto$ =11.536
Angle of contact:
θ =180-2$\propto$
θ =180-2*11.536
θ =156.926°
Convert degree to radius
θ =2.74 rad
The coconut scraper is directly connected to electric motor pulley. So the entire rpm of motor is supplied to coconut scraper.
Rpm of electric motor (N) =1440
To finding torque of the motor:
T =$\frac{p*60}{2*\pi*N}$
T =$\frac{186.5*60}{2*\pi*1440}$
T =1.2367 N-m

DESIGN OF CONNECTING ROD:

Length of connecting rod =21cm
Crank length =5.5cm
Crank rpm = 523.636N
Stroke length =11cm

IX. CONSTRUCTION

The construction of the equipment is simple as it requires only small and large components. The framework made of angle steel bars are the principle and primary material of the equipment. The framework is heart of our project. The shape of frame is L section. This section is divided in to three parts each parts contain different

operations like grinding, coconut scraper and vegetable chopper. The single phase induction motor clamped with the mid of the section. At the end of the motor two way pulley is fixed. MIG welding is used to weld a coconut scraper on the upper portion of the pulley with the help of key slot arrangement. And then A-type belt is mounted on two sides of pulley. one pulley is connected with bearing holder for chopping operation. These action is made of slider crank mechanism using circular plate as crank and Aluminium connecting rod.

The chasing of vegetable cutting is made of sheet metal clamped with bottom portion of the frame. At the end of connecting rod piston head is used for pushing operation. Dicer blade is fixed on the end of chasing. Another one pulley is placed over the angle frame it is plastic pulley attached with some mild steel square rod for placing a grinder drum.Thus, all the components are attached to the framework with clamping means, thus by this way our fabrication is carried out.

X. WORKING: Our working is also a simple process for finishing three operations in one power supply. Here initially the motor is rotating at high speed. This speed can be divided by requirement of load to the grinding and vegetable chopping operations. The vegetables are fed into the hole of the chasing. Thesliced vegetables collected from end of slider crank motion. Coconut scraper rotating above the motor pulley. The speed of scraper is very high. Compare to grinding and vegetable cutting process. Because the scraper is directly connected to the motor pulley. The scraped coconuts are fed on the sheet metal plate. Finally collect all the sliced vegetables and scraped coconuts.

XI. OURFABRICATED ASSEMBLY:

Fig.4. final fabricated assembly

XII. COST ANALYSIS:

Sl. No	Purchase of Material	Qty	Amount {Rs.}
1	Single phase ac induction motor(0.25hp)	1	800
2	Steel angle bars(5*2m)	4	500
3	Grinder pulley setup	1	200
4	Shaft	1	140
5	Bearing	2	80
6	Bearing block	1	130
7	Bolt and nut	4set	50
8	Dicer blade	1	110
9	Dicer push rod(plastic)	1	20
10	v-belts(A type)	2	180
11	“A” type pulleys	2	150
12	Coconut scraper	1	30
13	Circular Crank plate	1	100
14	Aluminium connecting rod	1	80
15	Aluminium compressor piston head	1	100
16	Sheet metal (3*4ft)	-	140
17	Welding	-	1200
18	Mild steel clamps	2	50
Total Amount			**4060**

ADVANTAGES:

- 100% hygienic machine.
- Uniform size of vegetables.
- Requires no special skills to operate.
- Easy for cleaning.
- Simple and robust design.
- Reduced time consumption

DISADVANTAGES:

- Not suitable for household operations.
- Care should be taken while working with coconut scraper since the full speed of motor is directly transferred to it.

APPLICATION:

- Can be used in restaurants and hotels where time is a major factor.
- Can be used in hostels where large amount of food supply is required.

XIII. CONCLUSION

The main fabrication of this machine was to reduce the work of the labour involved in each process, power source level and to bring a revolution to the food preparation domain. We have faced many difficulties while fabrication of this machine, we changed the design initially due to the improper dimensions. We also worked heavily on the welding part, connecting rod fixed to the crank plate and clamping of the vegetable chopper chasing to the frame. We also inculcated the knowledge of basic mechanical components and we understood the teamwork effort. We are very proud to show off that we have successfully completed our project with full commitment and enthusiastic energy. We are also happy to show our invention to and for the goodwill of our country.

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