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Automatic Potato Chips Making Machine

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Abstract: ***In food production domain one of the key task is to maintain the high production rate and hygienity. Considering the production of potato chips, it is time consuming task and also labor intensive if conventional method of producing chips is followed i.e. using separate machinery for each individual task. As more time is consumed while processing chips from one machine to another, we have concentrated into this factor. In order to reduce time consumption and labor intensity, we as a team came up with an idea of a product with integrated, effective and hygienic way of production of chips. Effort is made to come with better design in addressing the above problem. The machine is divided into 3 units based on different working principles. The units are namely i) Chopping unit ii) Frying unit iii) Flavoring unit .The chopping unit has a container where the potatoes are loaded and these potatoes are pushed against the rotary cutter through the compressive force of spring attached inside the container and potato slices are obtained. Next, Frying unit consists of a heating panel and it is filled with oil .The slices are deep oil-fried with optimum temperature and it is soaked and flipped to flavoring unit using mesh pan. In the flavoring unit, the fried slices are flavored using box spray and are vibrated using oscillatory flavoring drum. All the units are controlled using PLC programming. Finally, the chips are prepared with less time consumption, human intervention and hygienic.***

Keywords: potato chip, labor intensity, hygienic, chopping unit, Frying unit, Flavoring unit, PLC programming

1. Introduction

Potato chips currently represent one of the world's most popular snack foods. From its accidental birth in 1853, the potato chips market has evolved with time and currently represents a multi-billion dollar market. Owing to their easy affordability and cheaper price even for the premium products, potato chips are popular among all age groups. Currently, the growing young population (below 15 years) represents a key segment for the potato chips market. Major factors driving the global demand of potato chips are growing urbanization, rise in disposable incomes and rapidly changing lifestyles. Chips are the most popular variety of snacks on various occasions.

Potato chips are popular processed food items resulting in substantial value-addition. They are used as snack food both in domestic as well as in fast food centers and restaurants as side dish and garnishes. So there is need of alternative which produces chips quick, hygienic with less labor intensive.

There exists a very large market for chips and they can be sold at various retail outlets, paan shops, bus-stands, railway stations, roadside eateries, etc. There also exists institutional market consisting of clubs and other institutions, school & college canteens, army establishments, bars & pubs, railway and airlines caterers, etc. Competition from organized sector is increasing but local and small units have distinct advantages in terms of less overheads and transportation costs, longer shelf life, quick access to market and cost.

1.1 Customer Survey

Our potential customers are household industries (Snacks manufacturer/s), Small hotels and restaurants, Hot chips shops, Bakeries.We concentrated for home industries as there is a need of reducing man power and increasing production rate by considering hygienic factor also. It would be one time investment for them. Hence, we under-went client survey and customer survey and obtained certain attributes which helped us to get a clear idea about the problem.

The present method of producing chips in small scale industries involves manual as well as separate machines for all the different tasks and hence more manpower and time is required. Now a days, as chips is more consumed by people and at the same time, they expect the products to be more hygienic and healthy. Thus, reducing human intervention would be one way to attain hygienic and healthy products at lower cost. Our product satisfies this need as it is an integrated solution where the complete process is attained automatically by just switching it ON.

1.2 Literature Review

To formulate an optimum, efficient, and low cost device for making potato chips, various research papers and web based information were studied & analyzed. There is requirement for a high production chips making machine for home industries with normal cutting action [8]. A machine which is very compact in size, portable and efficient to make Potato chips at household level[9]. A machine that can be adjusted to slice Potatoes of varying thickness and production capacity above 150 kg/hr. To ease the problem of slicing for small and medium application outfits [10].

1.3 Functional Analysis

In conventional way, initially the potatoes are de-stoned and then peeled then peeled potatoes are then washed with cold water. A slicer then cuts the potatoes into thin slices and is again washed in cold water. The slices are then fried and flavored. The chips are then cooled and sorted. Accordingly,

the Black box & White box was drawn for clear understanding of the whole process.

1.3.1 Black Box

Black box functional analysis for our product is as shown in figure Fig.1, where the inputs are potatoes, energy, oil and flavoring powder output is flavored chips.

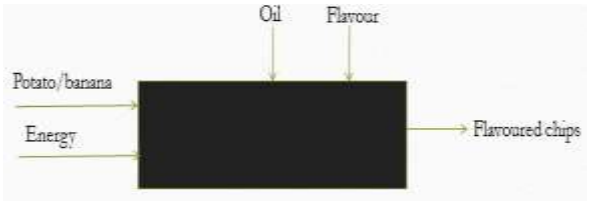


Figure 1: Black box

1.3.2 White Box

White box functional analysis for our product is as shown in figure Fig.2, where the inputs are potatoes, energy, oil and flavoring powder output is flavored chips, and in between different actions like loading, aligning, slicing, frying, de-oiling, frying and flavoring will be done with the help of input of force and heat energy.

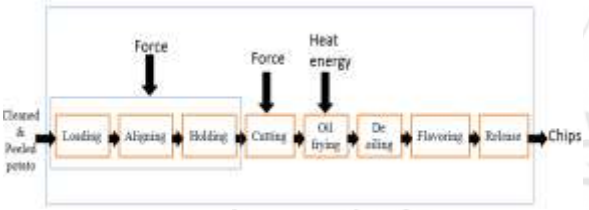


Figure 2: White box

2. Detail Design

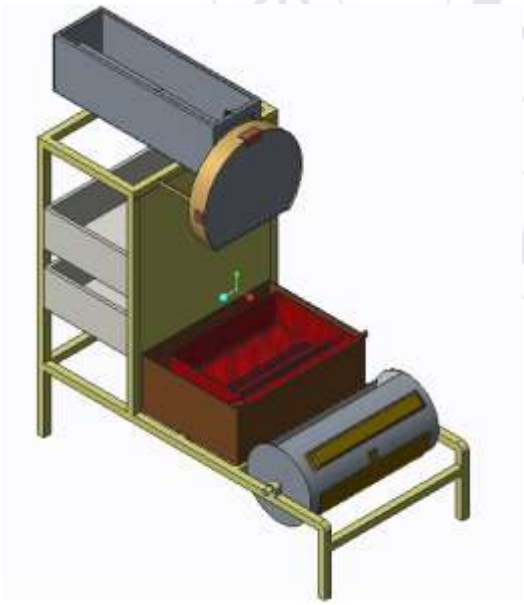


Figure 3: 3D Model of the Machine

The design consist of three major units –

1) Chopping unit
2) Frying unit
3) Flavouring unit

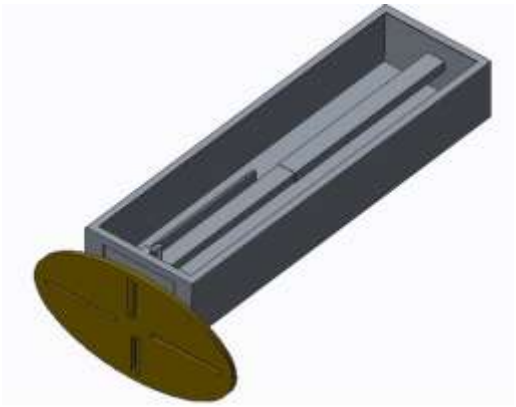


Figure 4: Chopping unit

First, Chopping unit consists of a potato holder, compressive spring with a pusher plate and a rotating blade. The holder is horizontal for enabling of systematic movement of potatoes. The potatoes are forced against the rotating blade because of the compressive spring mechanism which is engaged manually. The rotating blade controlled through the motor (40Nm-min, 12V, 60rpm, 1-2A) at the speed reduced from 60rpm to 53rpm. The total time for this cycle is set for 45sec.

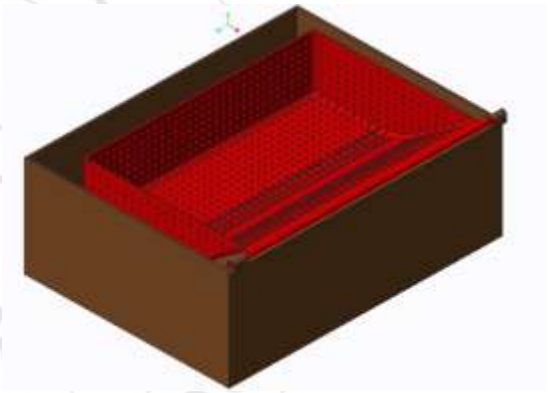


Figure 5: Frying unit

Second, Frying unit consists of two parts which are oil vessel with a heater (2kW power)& frying mesh controlled through a motor for transferring fried pieces to flavouring drum. The frying time is set to 3 min. The mesh is designed aesthetically & for easy transferring of chips to the next unit. The mesh takes 58 sec to lift which is to soak oil from chips. And the heater is controlled by microcontroller in order to maintain the optimum oil temperature.

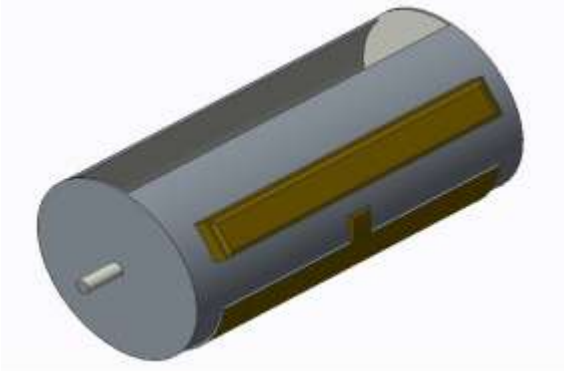


Figure 6: Flavouring unit

Third, Flavouring unit consists of an oscillating drum with 60^{o} opening at the top and sprinkler box with pores provided

at the inside part of the drum. The oscillation is controlled through a motor at the speed of 60rpm for 30sec. All the three motors mentioned above are controlled through PLC & the heating coil is controlled through the microcontroller.

Hardware Requirements:

- PLC GIC G8DDT10
- Microcontroller PIC16F874A/877A
- Oscillator Circuit
- Relay driver
- Relay
- Power Supply

Software requirements:

- MPLAB Software
- Embedded C

2.1 Block Diagram

PLC Controller

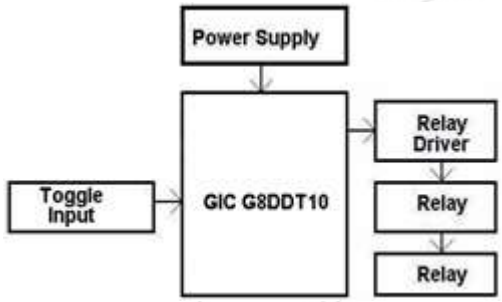


Figure 7: PLC controller

PIC Microcontroller

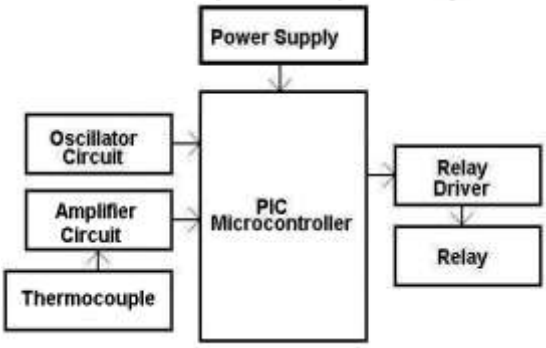


Figure 8: PIC Microcontroller

The bill of materials was listed based upon the requirement.

Table 1: Bill of materials

S. No	Item	Material	Qty
1	Container	Stainless steel	1
2	Cutter	Stainless steel	1
3	Spring	MS	1
4	Pusher	Stainless steel	1
5	Frying tray	Stainless steel	1
6	Frying mesh	Stainless steel	1
8	Flavouring drum	Stainless steel	1
9	Frame	MS	1
11	Motors	-	3
12	Sprinkler box	Stainless steel	2
13	Heating coil	-	1

3. Design Calculations

3.1 Power Supplied and Heat Released:

From the survey and study we came to know that the best temperature for frying chips is 180 ^{o} C. This temperature is achieved by the induction coil having following specifications

V=230V; P=1200-1800W; I=15A

The frying of chips is carried out by using Induction coil.
Taking, P = 1400W I = 15A

We have, $P = I^2R$

$1400 = 15^{2*}R$

$R = 6.22\ \Omega$

The induction of coil should be of 6.22Ω
The heat supplied to oil for frying the chips,
$H = I^2R*t$
$= P*t$
$= 1400*150$
(frying time considered is 5 mins)
= 210,000J
H = 210KJ

The efficiency of induction coil is 84%

Therefore the actual heat supplied
H= 0.84*420
= 176.4 KJ

The heat lost to the surroundings
H_L = 210-176.4
= 33.6KJ

3.2 Motor power & Torque calculation:

Diameter of work piece (potato) = 60mm
Revolution per min (n) = 53rpm
Cutting speed (v) = ∏Dn/1000
From MTD CMTI data handbook page no 654 for alloy steel
DOC [5-10] "v" between 10 to15
Considering cutting speed = 10
v = ∏Dn/1000 = 10
n = 10*1000/ ∏*60
n = 53 rpm

Feed per revolution = s = 0.6mm (taken from page no 254)
Feed per minute = S_m = s*n = 0.6*53
S_m = 31.8 mm/min
Depth of cut for each rev = 5mm
As circular cutter has four knife edge
t = 5/4
t = 1.25 DOC

Potato removal rate = Q = stv
= 0.6*1.75*10
$Q = 7.5cm^3/min$
Side rake angle = γ= -5deg
Correction factor= k_r = 1.21
Power at the spindle = N = U k_h K_r Q
= 42*10^-3*1.08*1.21*7.5

N = 0.411164 KW

Considering efficiency of transmission as E=0.8
Power at the motor = Nel = N/E = 0.41164/0.8
Nel = 0.5145KW

From the page number 742 preferred standard motor is 0.55KW

Torque of the motor = T_s = 975*N/n
= 975*0.41164/53
= 7.571kgf-m
T_s =74.2617N-m

3.3 Performance Evaluation of the Machine

Based on the design, the whole model was first draft and drawn in the 3D Design software and fabricated. For finding out the utility of the concept the parameters are considered.

Capacity = (weight of potatoes produced by the machine)/(time taken for unit cycle)

Production Capacity:

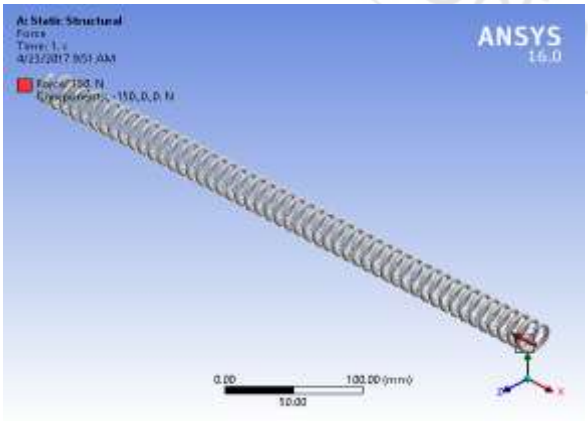
Weight of potatoes loaded per cycle = 0.5 kg
Time taken for unit cycle = 7min
Approximate weight of potatoes per hour = 4 kg
Considering 8 hours of working,
Per day production = 4x8 = 32kg/day.

The production capacity of the fabricated machine was calculated and it is found that 32kg/day which is requirement for home industries.

4. FEA Analysis

FEM analysis was carried out for critical parts such as compressive spring, rotating blade &the frame.

4.1 Compressive spring



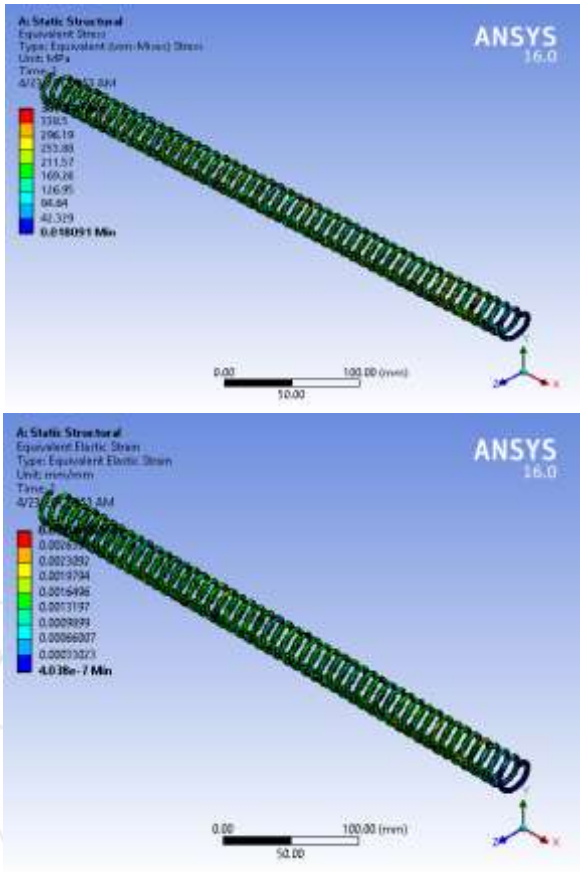
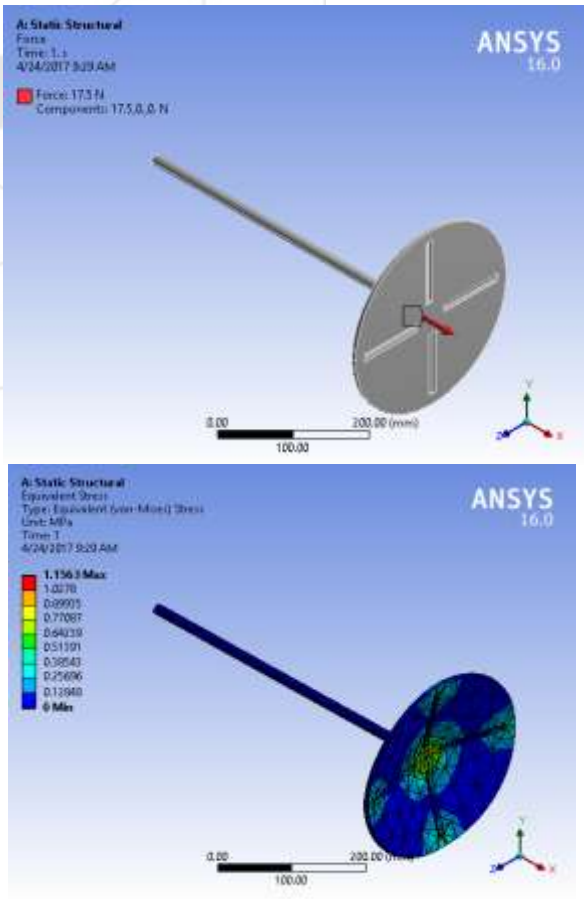


Figure 9: FEA analysis for spring

4.2 Rotating Blade:



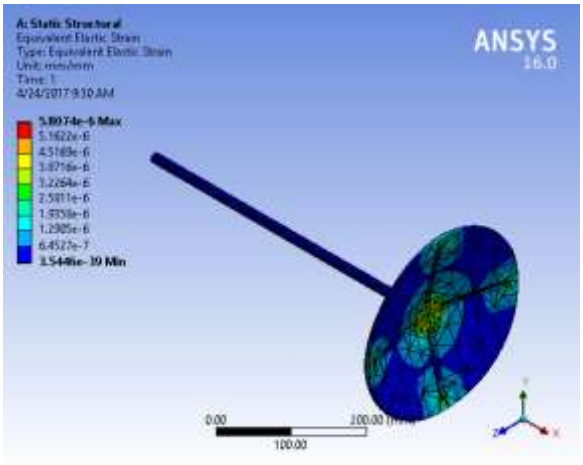
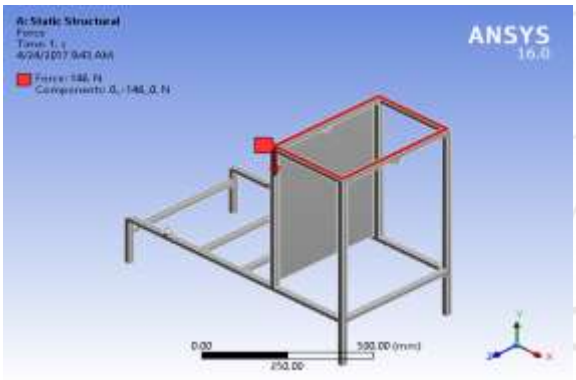
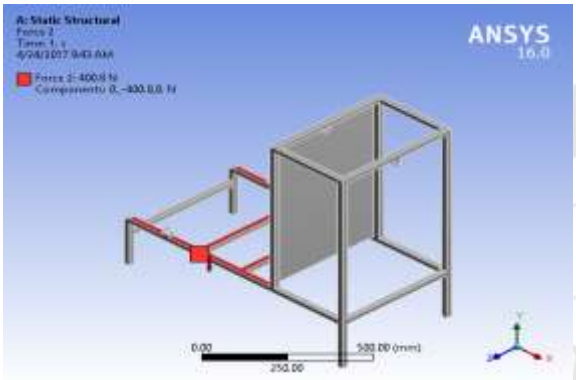
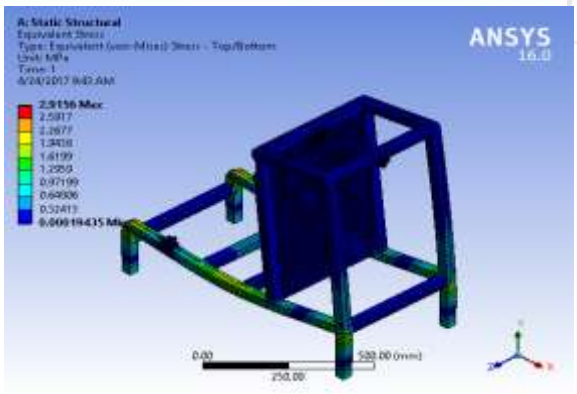


Figure 10: FEA analysis for Cutter

4.3 Frame







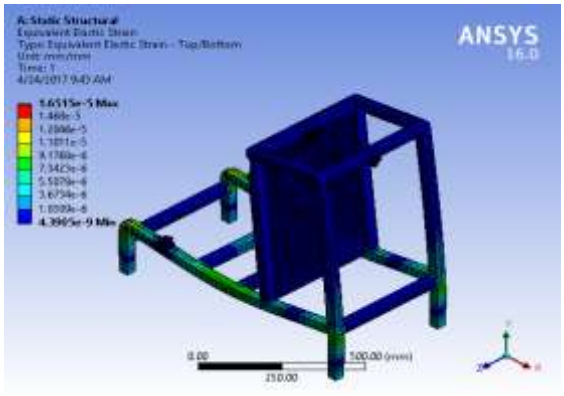


Figure 11: FEA analysis for Frame

5. Prototyping

Efforts have been made to design and fabricate this semi-automated potato chips machine. The findings have been suitably explained with logical reasons wherever possible. The requirements also have been discussed in the literature survey and with the literature support to the possible extent. Prototype of Integrated Potato chips machine is shown below.

Figure 13: Prototype of Integrated potato chips making machine

Figure 14: Potatoes loaded

Figure 15: Potatoes Slicing

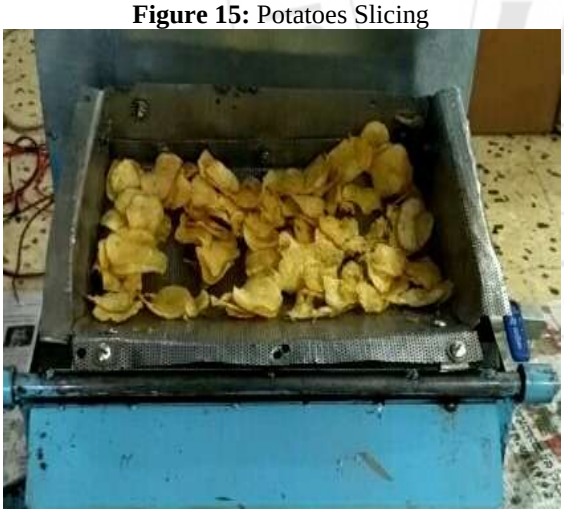


Figure 16: Potatoes slices are fried

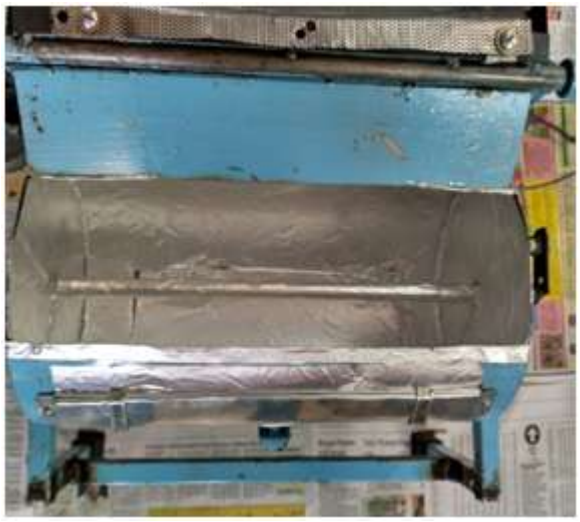


Figure 16: Fried slices are flavoured

6. Conclusion

The design of the integrated potato chips machine is based on the technical idea of the combination of all the processes in one machine using PLC which helps in reduction of man-power and satisfies the need for household industries. The essential documentation was prepared. Then, the experimental model of equipment for potato chips maker to be implemented in the technological process was developed. The machine is simple to operate. This machine allows in its simplicity of design and modest cost with the ability to producestandard taste of potato chips in comparison with packed chips.

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Author Profile

Vishal Wadagavi received Bachelor of Engineering degree in Mechanical engineering from B.V. Bhoomaraddi College of Engineering and Technology in 2017. During 2016-17 the above described Potato chips making machine is been designed and fabricated.