Design Practicum IC201P

Smart Grain Dryer

GROUP 22
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Introduction

Our project the Smart Grain Dryer's main function is to dry the grains upto a certain degree while protecting their viability and nutrition capability. Once cereal crop is harvested, it may have to be stored for a period of time before it can be marketed or used as seed. The length of time cereal can be safely stored will depend on the condition it was harvested and how it is dried and stored. Grain binned at lower temperatures and moisture contents can be kept in storage for longer periods of time before its quality will deteriorate. It is estimated that 20% of world's grain production is lost after harvest due to inefficient handling and poor implementation of drying techniques. This can be also seen in India since as a report 16% grain loss is due to improper storage and grain drying.Grains and seeds are normally harvested at a moisture level between 18% and 40% depending on the nature of crop. These grains must be dried to a level of 7% to 11% to be safe. So we are designing a smart grain dryer based on the principle of Equilibrium moisture content which states that a transfer of moisture takes place from higher moisture content area to lower moisture content area by means of diffusion till they reach a equilibrium moisture content. In general, higher airflow rates, higher air temperatures and lower relative humidities increase drying speed. Raising the temperature of the dry air increases the moisture-carrying capacity of the air and decreases the relative humidity. As a general thumb rule, increasing the air temperature by 20 degrees Fahrenheit (F) doubles the moisture-holding capacity of air and cuts the relative humidity in half. The rate of moisture movement from high moisture grain to low relative humidity air is rapid. However, the moisture movement from wet grain to moist air may be very small or nonexistent. At high relative humidities, dry grain will pick up moisture from the air. The airflow rate also affects drying rate. Airflow is determined by fan design and speed, fan motor size and the resistance of the grain to airflow.

Figure 1:-Smart Grain Dryer model

Literature Review

Drier Systems and Processes

We searched for different grain drying systems and following were outcomes:-

1. Natural And Solar Drying Systems
http://www.fao.org/docrep/t1838e/T1838E0v.htm
They depend on natural resource availability that is why they are quite efficient.
Disadvantage:-Too slow for drying large quantities of grains and uneven drying.

2. Artificial Drying Systems
http://www.fao.org/docrep/015/i2433e/i2433e10.pdf

They make use of different thermodynamic cycles and dehumidifying agents for fast drying of grains. They are quite huge in structure and fast enough to dry the grains but inefficient in the sense they ask for too much input and sometimes spoil grains.
Advantage:- Even drying of systems and fast drying
Disadvantage:- Inefficient on industrial scale

3. Grain Storage and Handling

http://www.fao.org/docrep/015/i2433e/i2433e10.pdf

Information:-The drying systems should not damage the grains by making them too dry.The moisture content should be between 7-11 percent and process of drying should be implemented by equilibrium moisture content. This also gives information on equilibrium moisture content of different grains.

Problem Definition

The objective of this study is to develop a automatic grain dryer in which the grains are dried simultaneously by the heated air from the hot air blower. Food scientists have found that by reducing the moisture content of food to between 10 to 20%, the bacteria, yeast, mold and enzymes are prevented from spoiling it. The flavor and most of the nutritional value is preserved and concentrated. Drying and preservation of agricultural products is a basic technique used to store for longer periods of time before its quality will deteriorate. Drying is one of the methods used to preserve food products for longer periods. It has been established as the most efficient preservation technique for most tropical crops.

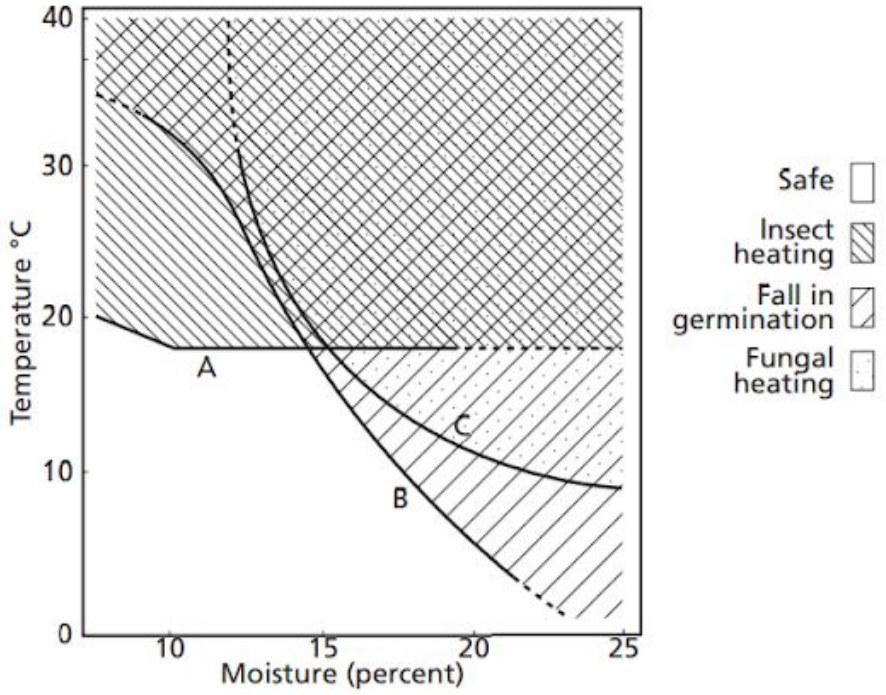


Figure 2:-Effect of moisture on Grains

Solution Methodology

Indian government faces losses due to spoiling of 8 lakh tonnes grains every year, which are spoilt mainly due to high amount of moisture in the storage houses they are kept, so in order to save the grains and retain their quality we propose our Smart grain dryer in which we will dry the grains in less than 10 minutes using basic machinery i.e no heavy, noisy and harmful equipments are there. We're mainly doing the whole process in three phases:-

1. We're taking the warm and fast moving air from the heaters and then we're allowing the air to pass through desiccant agents like Lithium chloride, silica etc. which will absorb the moisture of the warm air coming from heaters, then we will allow the air to enter the drying chamber,
2. In this phase we're using a weight measuring scale to allow only 400-500 gms of grains to enter the drying chamber, which is totally controlled using the python codes in Raspberry PI, then we have installed sloping surfaces through which the grains will pass and will come directly in contact with the warm and dry air we've processed in phase 1.
3. Now we will dry the grains using a mixer with fan to mix the grains that is placed just below the slopes, now the grains will rotate and get mixed due to the centripetal force of the

fan and the hot and dry air will constantly absorb the moisture of the grains and then we'll keep on reusing the hot air again and again 3-4 times until it's temperature drops, this will save a lot of energy, these processes will be continued until the moisture level of the grains drops to a certain level and this will be approximately be done within 15-20 minutes (estimated), at last, the grains will dry and will fall from the rotating disk into the collecting chamber, from where they can be taken away for further use. The above written idea can also be understood using the flowchart given below:

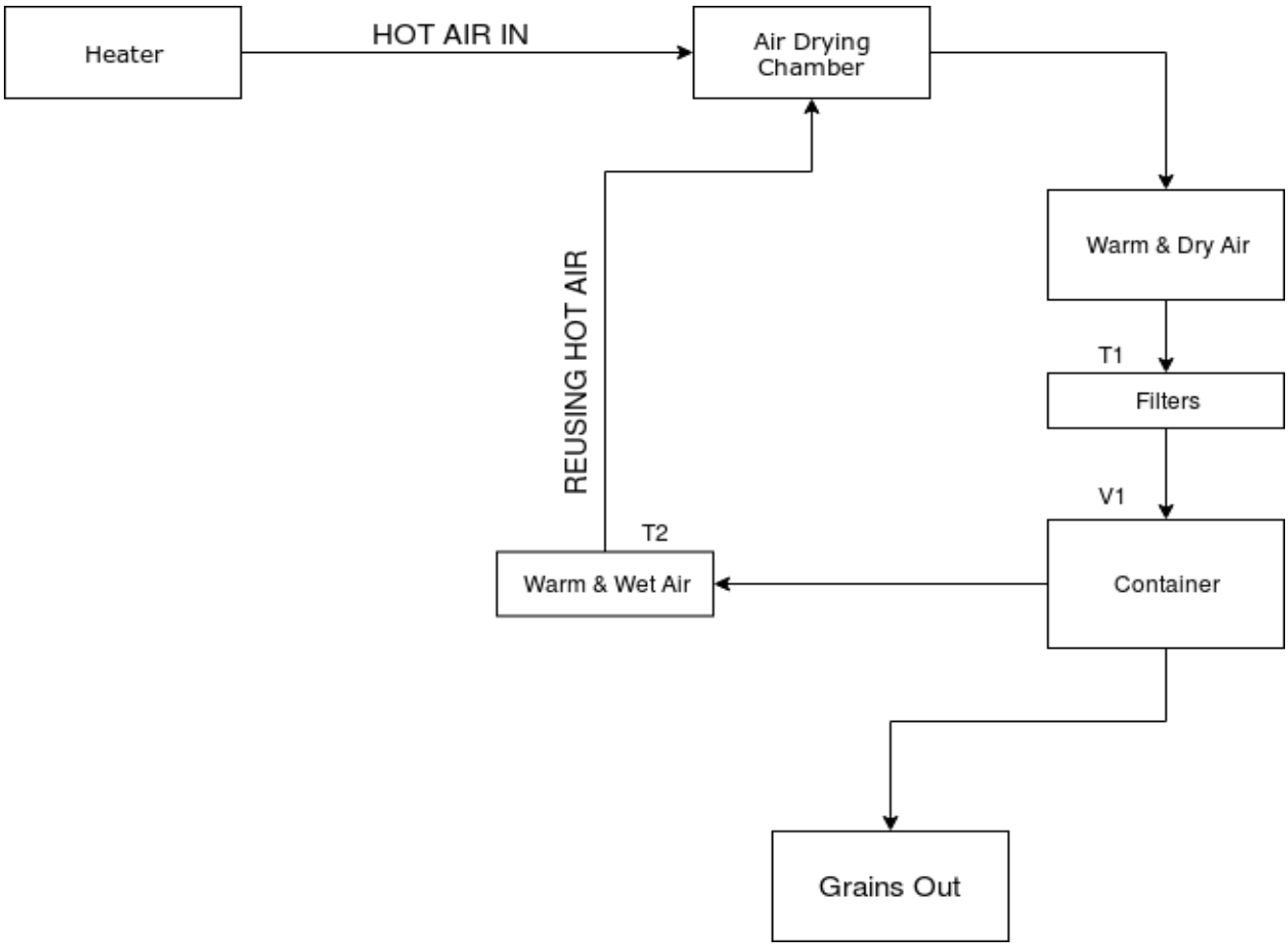


Figure 3:-Our Implementation on Grain Drying

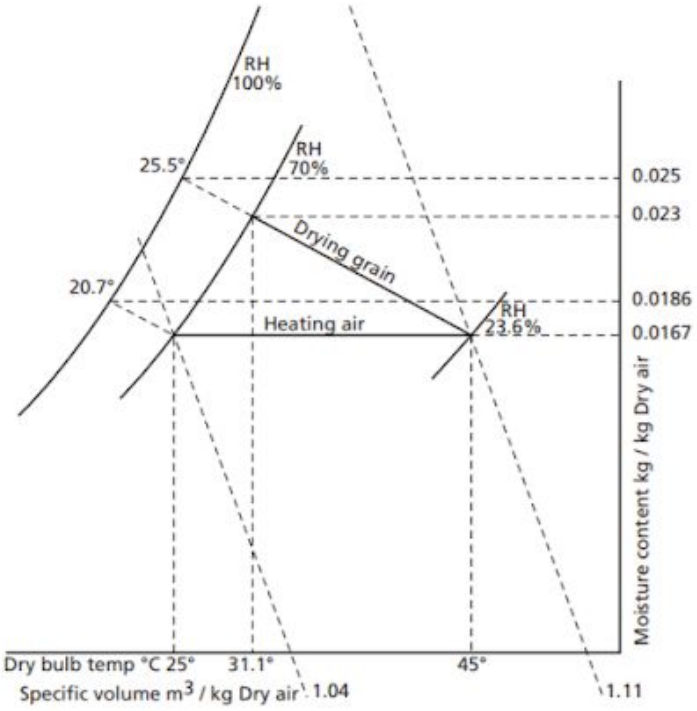


Figure 4:-Process of equilibrium moisture content

Product Design

1. **Mechanical Aspect:** The grain dryer consist majorly of two mechanical parts. First the heating/drying chamber and another is regeneration.

A) **Drying chamber :-** In drying chamber drying process happens in two stages. First is initial stage of drying that takes place in the upper heating case(as shown), in which the grains are exposed to **hot air** and second is main drying case which is a continuously rotating circular container and is exposed to **hot and dry air.**

The heating case is shown in figure , contain 3 hot air inputs, one input from top for grains to be dried and one bottom output from where heated grains fall into the main drying case.

The main focus of the air inputs is on the slope surfaces of the main case. And also the slope surfaces are a bit rough in order to produce heat due to friction between grains and surface. The slope surfaces are at 30 degrees to the horizontal so that when grain are poured over it, grains takes some time to move down and hence the grains are exposed to hot air for a little long time.

The main drying case shown in figure collects the grains falling from the heating case. It is exposed to hot and dry(dehumidified) air coming from the air drying chamber. The grains from heating case falls on the circular container that is continuously rotating that forces the grains to move more rapidly and randomly in that adiabatic(and airtight) environment of dehumidified air that removes the moisture from the grains completely. The centrifugal force is used here to move grains fastly and randomly.

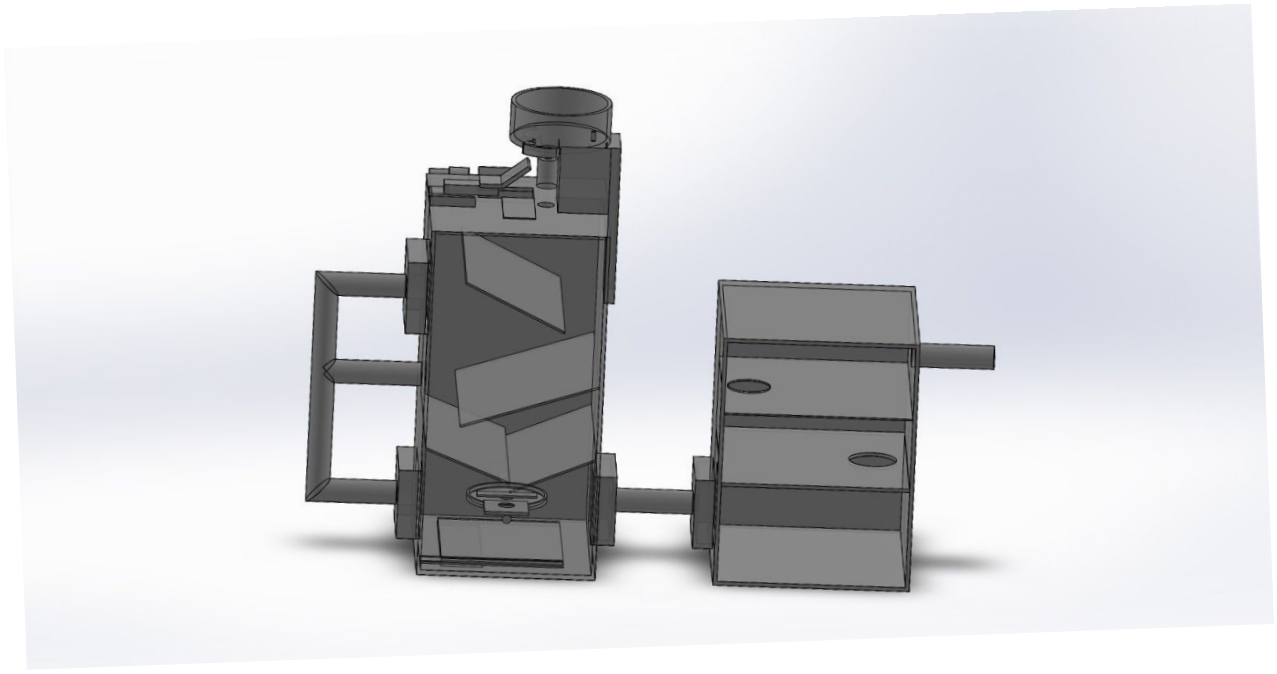


Figure 5:- Overall Mechanical Assembly of the Product

B) <u>Regeneration</u> :-

We need to use more power and desiccant agent to dry air so to improvise cost and minimise the use of desiccant we reuse the hot air. The hot air coming out of exhaust of the main case can be fed again to the heating case in order to increase efficiency of machine. Since the air will be still hot coming hot coming out of main case so it will increase the temperature of heating case in less power. The reused air will save us a lot cost.

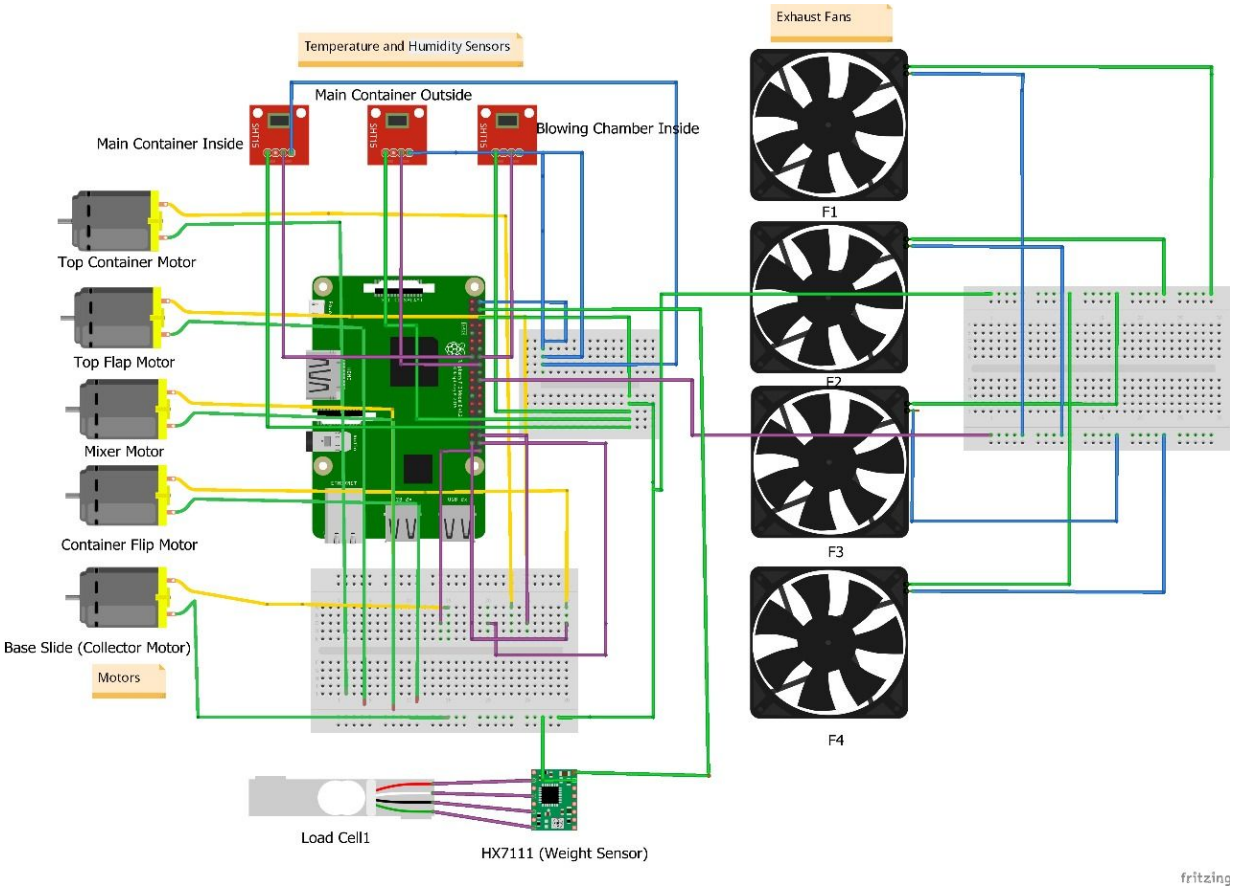
2. <u>Electrical Aspect:</u>- There are 3 major electrical circuitry in the the system machine of the grain dryer :-

A) An induction motor :- A pi and a medium power delivering motor to manage the movement of the main case rotating disk. It helps controlling rpm of the rotating disk according to the
amount of grain over it.

B) Pi and ventilators :- To alter the speed of air before, during and after, flowing through the dehumidification chamber. To minimise the speed before entering the dehumidifier and maximise its speed before entering the drying chamber. And also speed of air during sending it to reuse.

C) Feedback system :- pi and sensors are major works in this part. Using temperature sensors and moisture sensors, taking the continuous feedback of the temperature and moisture conditions of machine and grains so that we can control our heating coil and air blow and temperature of air according to the feedback sent by sensors.

All the three major circuit parts will be embedded with one raspberry pi microcontroller. And it helps controlling and governing the functioning of the system. It is shown in figure below:-



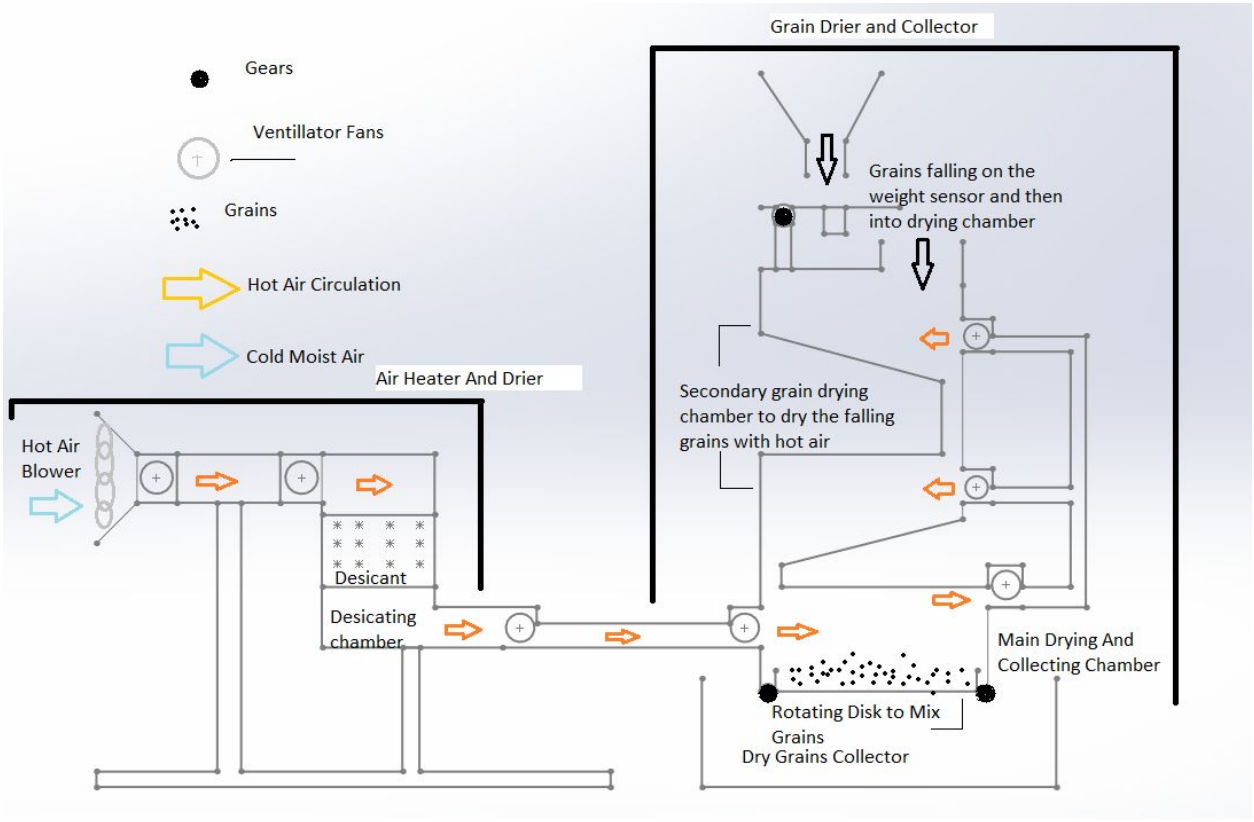
3. **Computer Science Aspect:**

The main computer science aspect of this project is automation of the machine using raspberry pi.

This includes automation and timing coordination of the following:-

(a)Ventilators/Exhausts
(b)Weight Sensor
(c)Moisture Sensor
(d)Rotating disk
(e)Blowers
(f)Temperature Sensor

Proposed Manufacturing/Assembly process:



The Manufacturing/Assembly process is made up of 2 sub-processes:-

1. **The Heating And Drying Of Air**

This consists of the blower and the drying chamber to supply hot and dry air to dry grains.

I. The Blower and the hair drier is installed at the entrance of the pipes and its function is to heat up the incoming air to a certain temperature so as to decrease the relative humidity of air so it can increase its moisture absorbing capacity. Then the air is directed into a desiccating chamber using vents.The blower and the hair drier turn off after a certain amount of time so as to

II.The Drying chamber has the desiccant(Silica Gel) to dry the air and decrease its relative humidity further so as to maximise its moisture absorbing capacity.The hot moist air enters the chamber through the top left side via ventilator fan and passes through 2 layers of desiccant and exits through the vent at bottom right side.

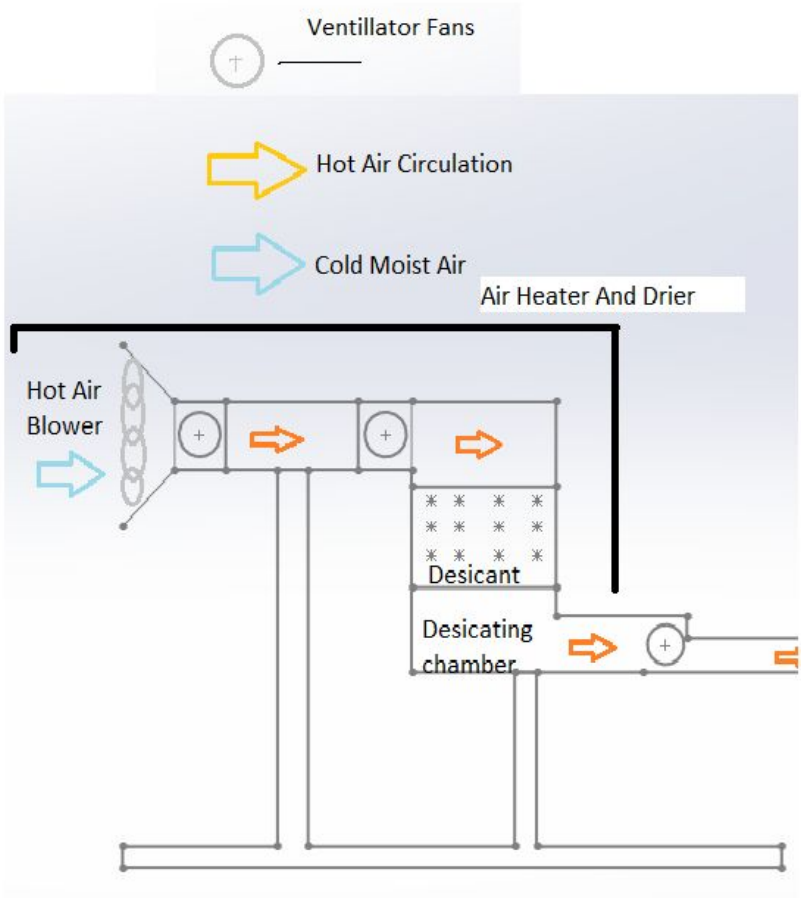


Figure 6:-The design of Air Drying Chamber

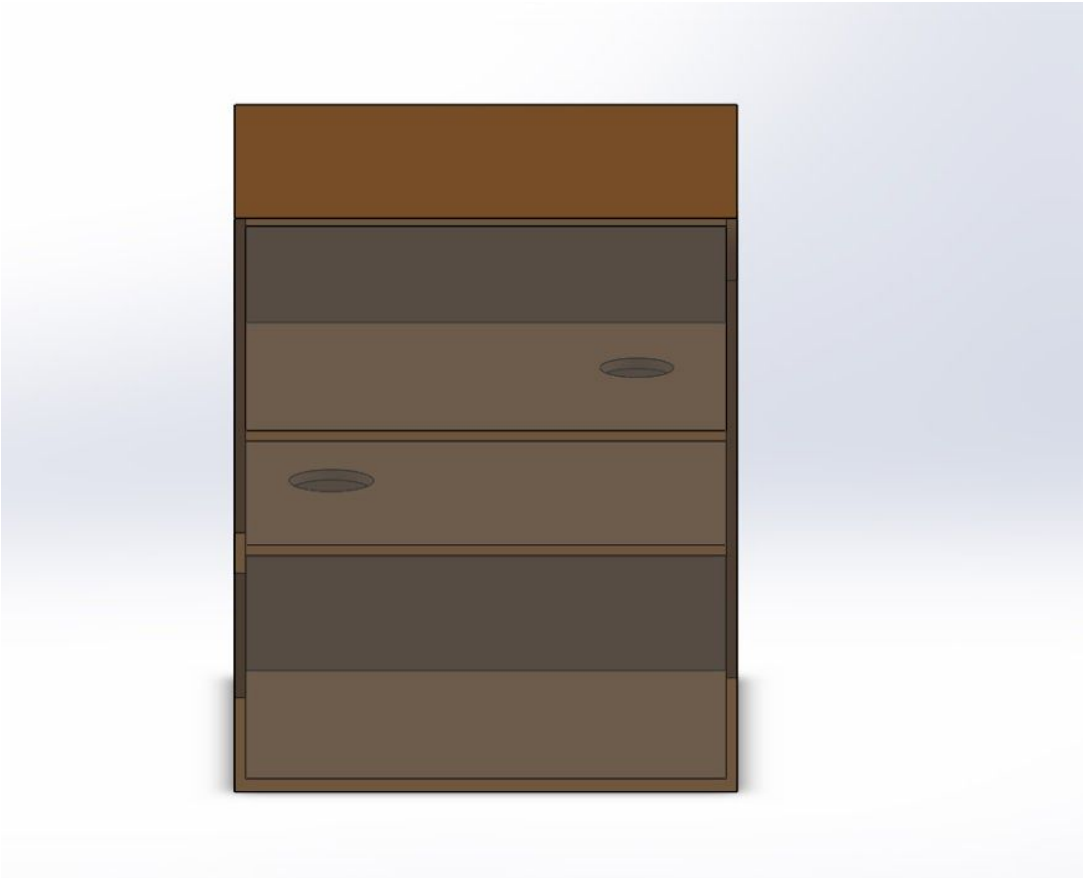


Figure 7 :-Desiccant Chamber

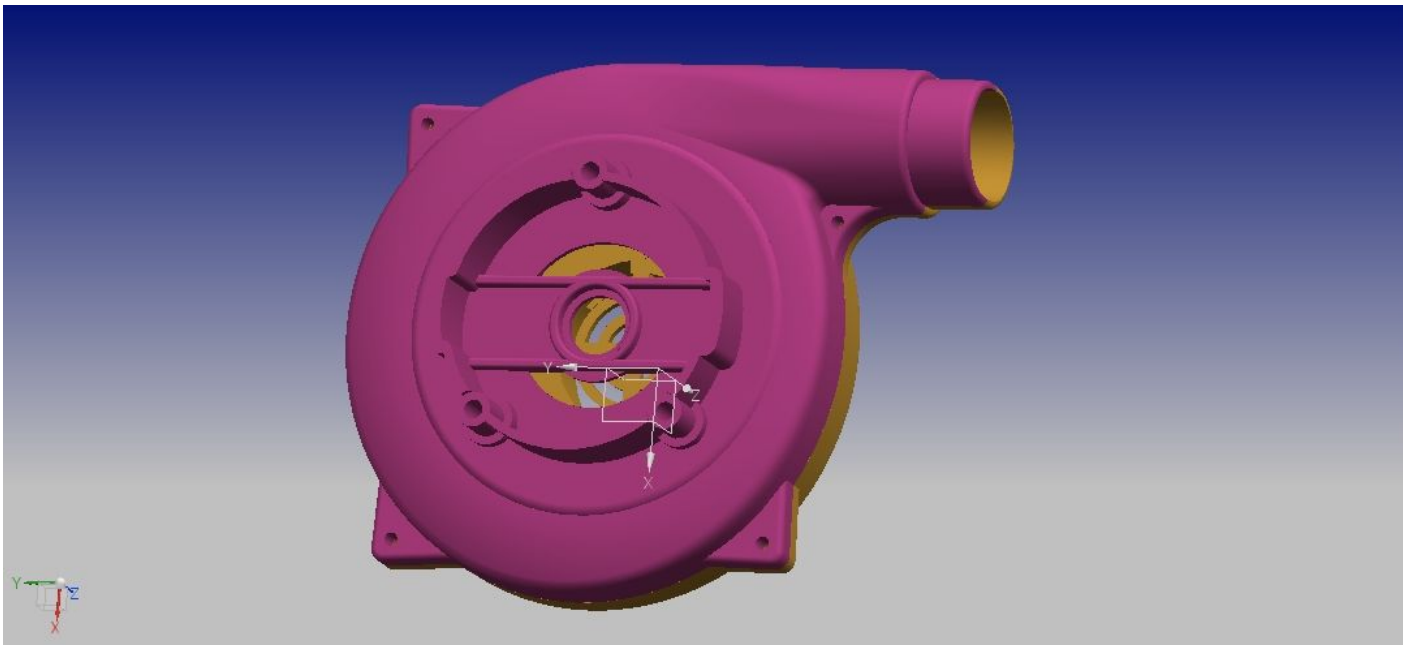


Figure 8:-Air Blower

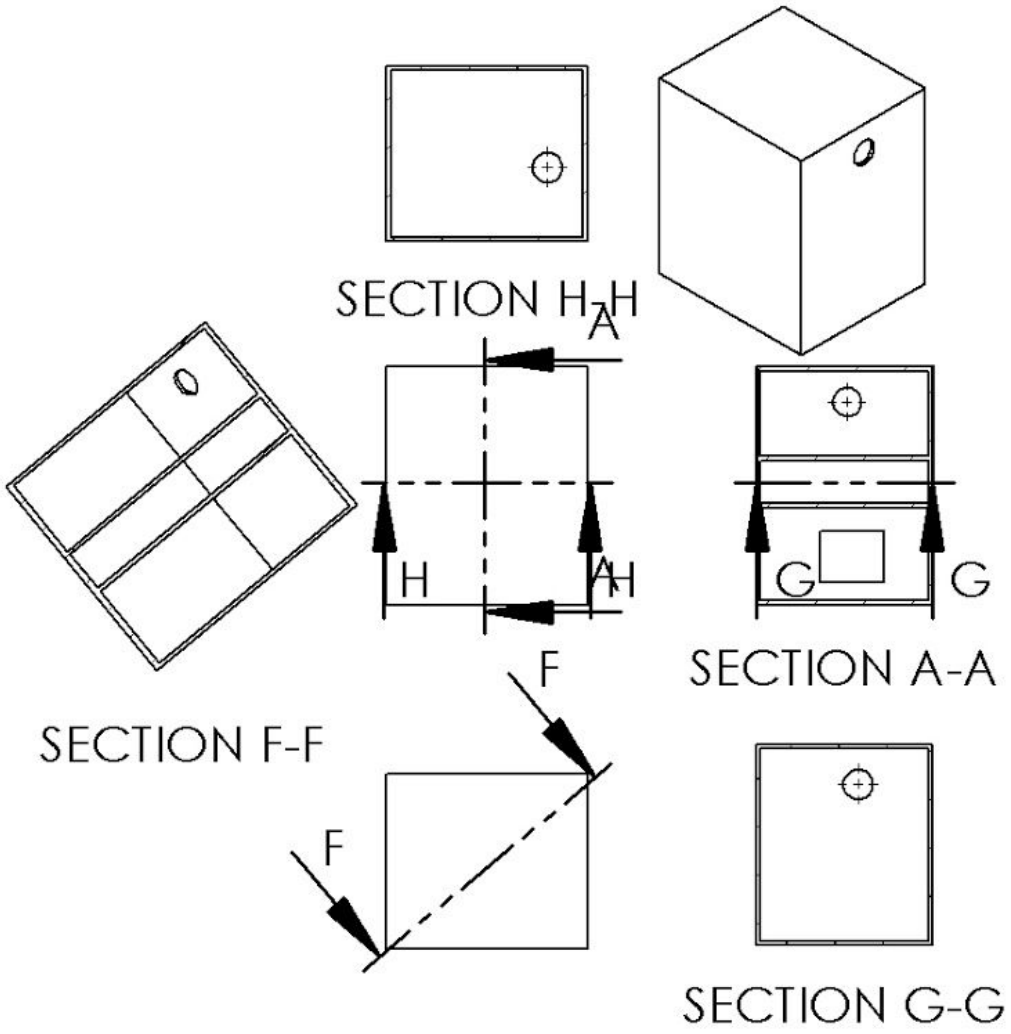


Figure 9:-Different views of desiccant chamber

Figure 10:-Silica Gel in Desiccant Chamber

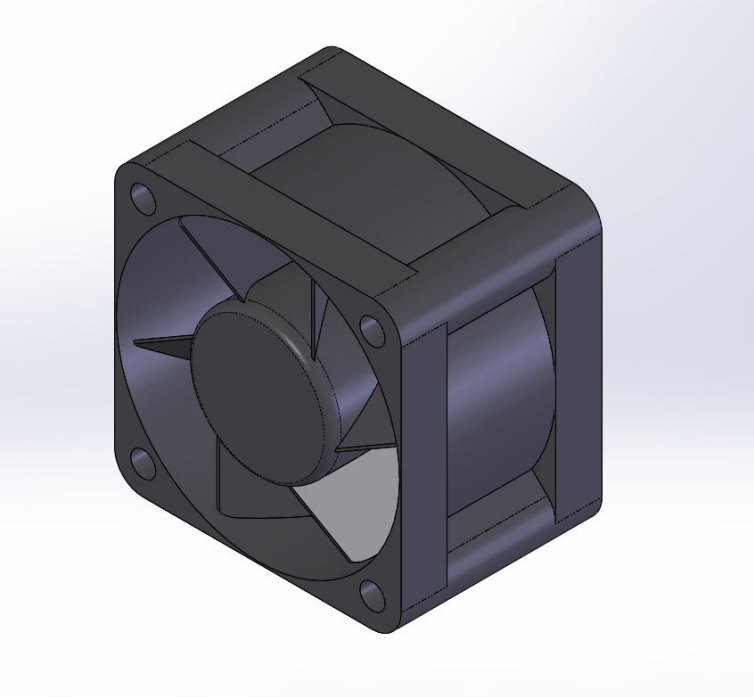


Figure 11:-Ventilator Fans

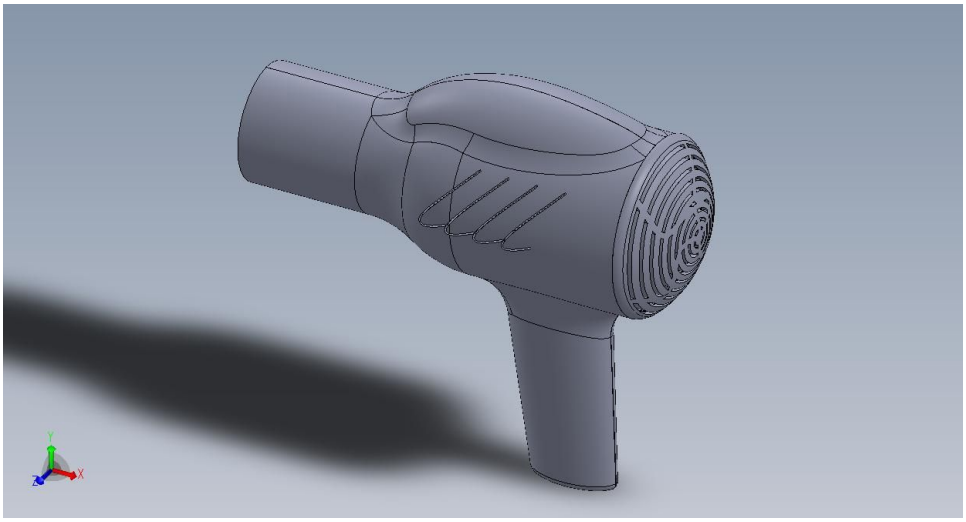


Figure 12:- Hot Air gun

2. **<u>The Grain Drying and Collecting Chamber</u>**

This consists of the grain drier and collector chamber.

I. The Grain drying chamber is installed with a weight sensor at the top to let in only a specific amount of grains (for further information please refer to the computer science and electrical aspect) so as to avoid clustering of grains at a specific spot.This is done by installing a gear

at the bottom of container and then a gate at the side of weight sensor.As the weight sensor senses 100 gms of grains the gate at the bottom of container closes and the gate at the side opens to let the grains into the container.

II. Then the grains pass through couple of sloped surfaces to slow their movement so as to expose them to the hot air coming through the opening provided at the side which are installed with ventilator fans connected to the exhaust of the main chamber so as to decrease the moisture content of grains while falling and make use of the leftover heat from the air of the main chamber. These sloped surfaces also act as the path director of the grains to the mixer.

III. After the sloped surfaces the grains enter the main drying chamber so as to fall mixer which is directly exposed to the hot dry air and mixes the grains so as to stop them from accumulating at one spot. Mixing is done by fans at the top of plate which is controlled by motor attached to it.The fan has a certain clearance between the plate so as not to crush the grains.

IV. Now the grains on the disk are exposed to the hot dry air from the desiccating chamber through another ventilator fan.After drying them for 5-6 minutes the mixer plate rotates to allow the grains to fall through the gate at the bottom of the container which is controlled by another motor and slider which slides only when the moisture sensor has sensed a certain amount of decrease in moisture content of air.

V. Now the air with residual heat is supplied to falling grains through exhaust. The process is repeated taking a certain amount of grains every time specified from the beginning.

Note:-All The containers are adiabatic containers.

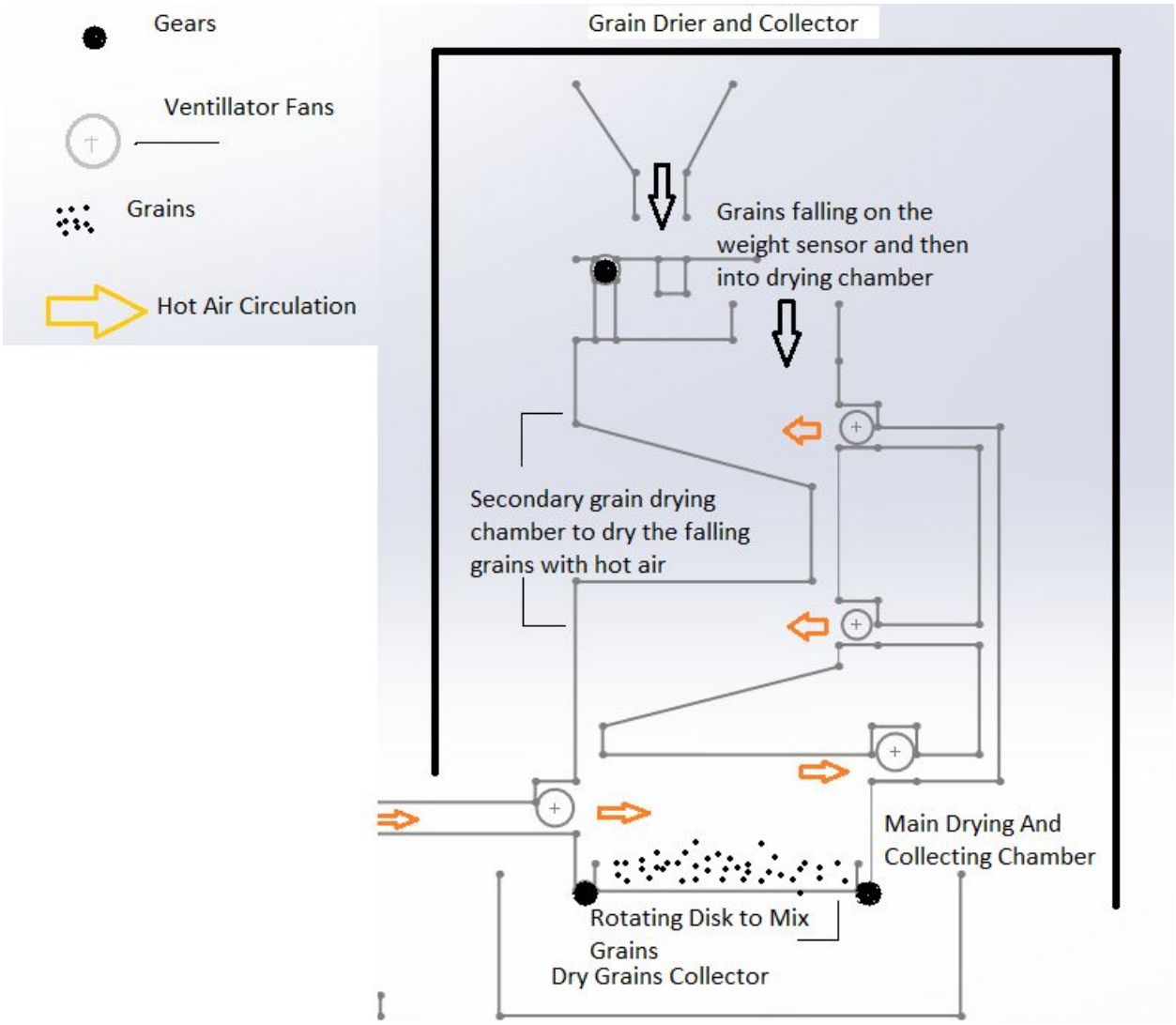


Figure 13:-Working Of Main Drying Chamber

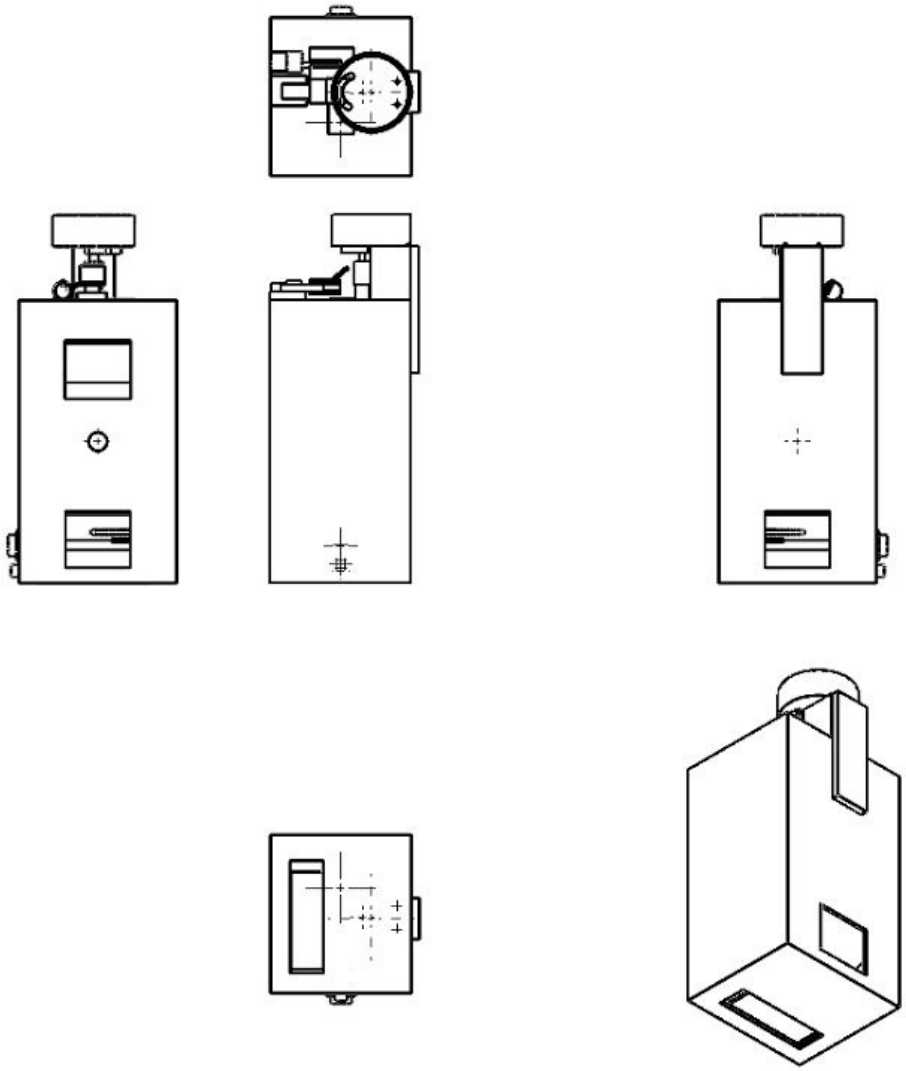


Figure 14:-Different Views of Main Chamber

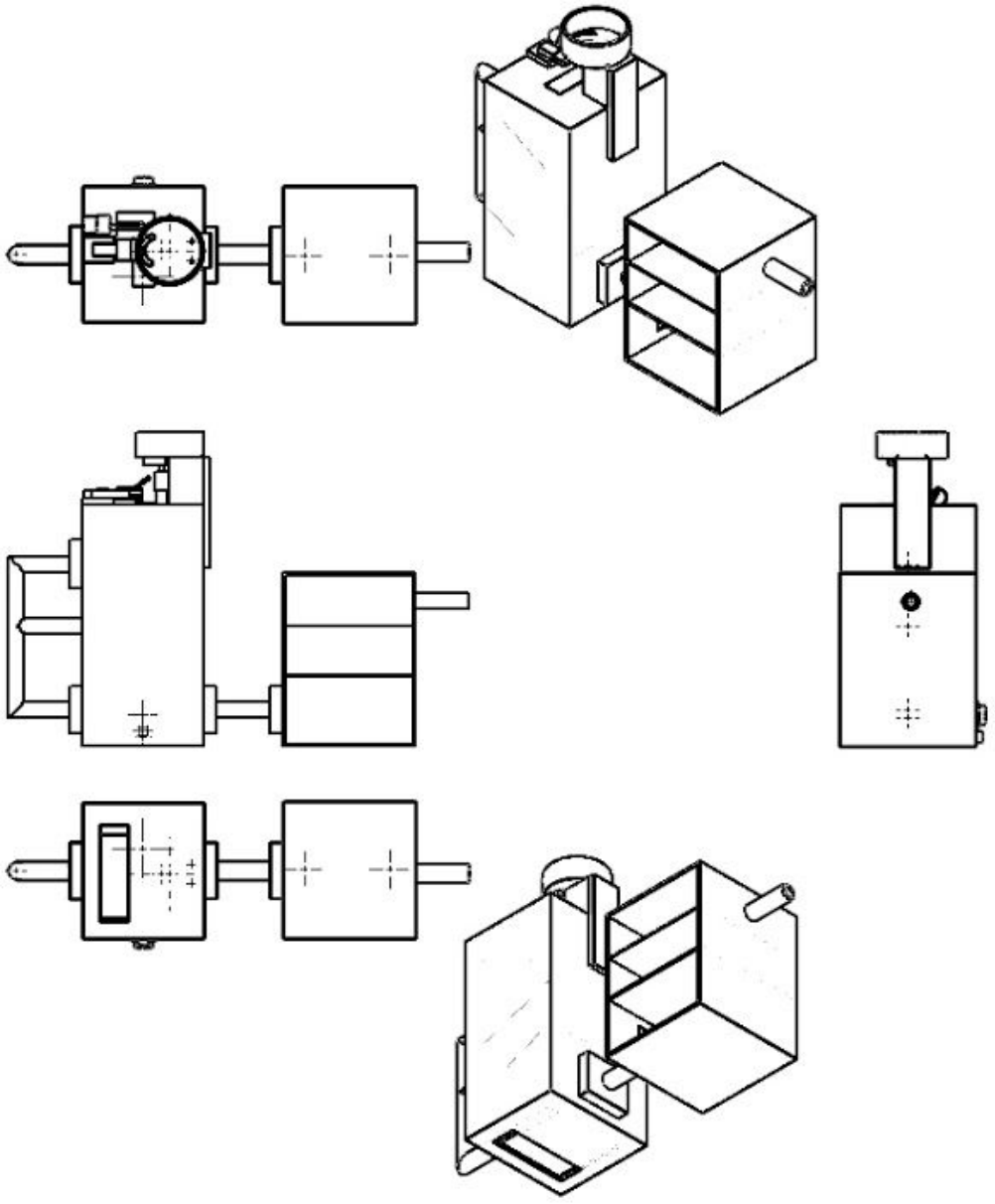


Figure 15:-Different views of overall Assembly

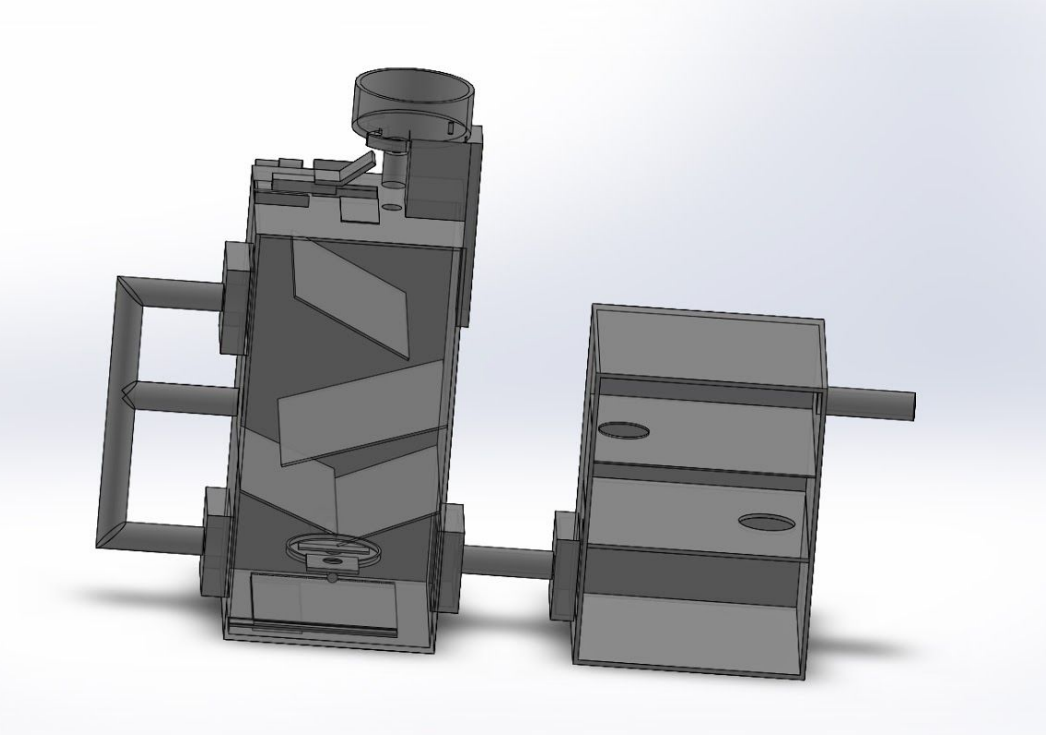


Figure 16:- Overall Assembly of the product

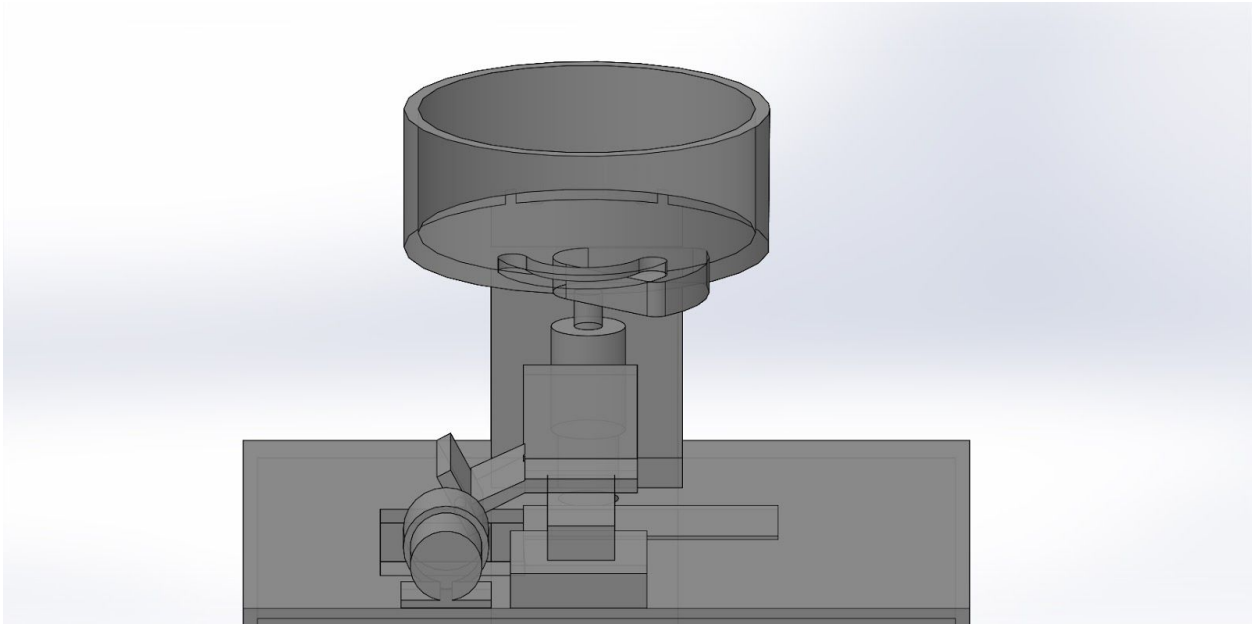


Figure 17:-Grain Dropping Mechanism

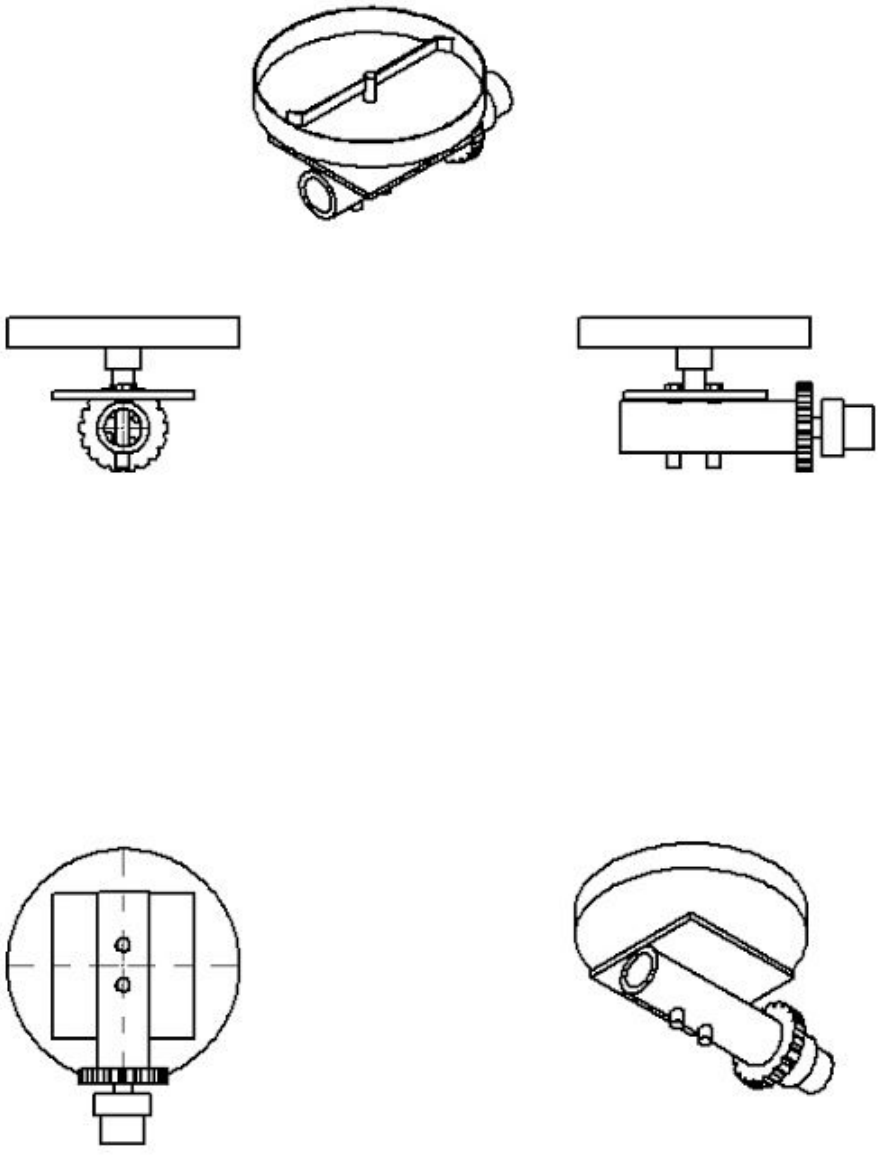


Figure 18:-Different views of the mixture

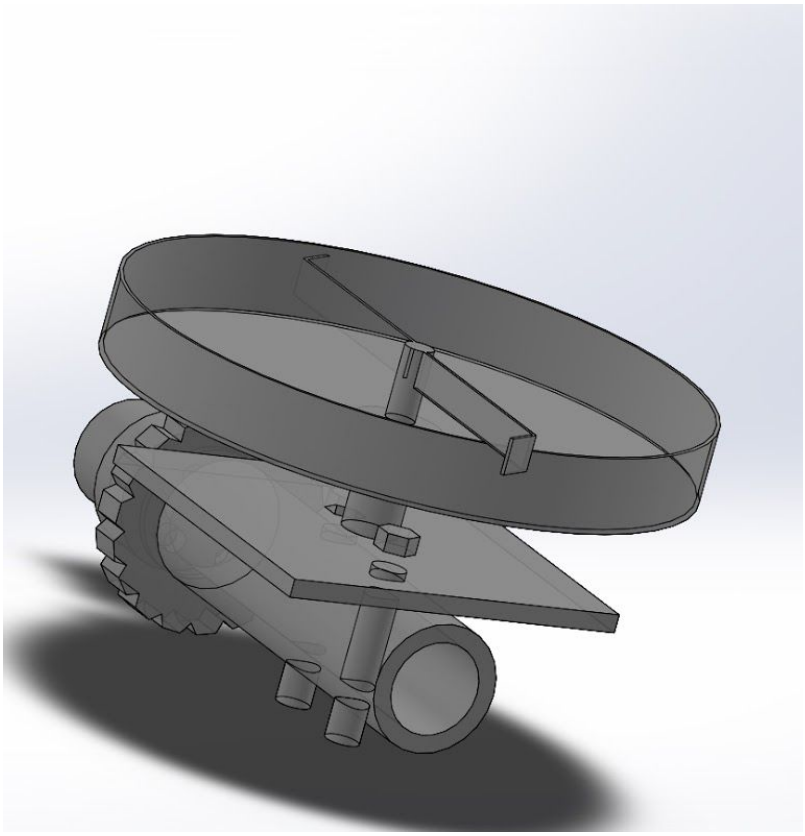


Figure 19 :-Mixer for mixing the grains

Components Required and Estimated cost:

Serial No.	Parts Name	Name of Supplier	Date	Amount(in Ruppees)
1	Exhaust Fan	SRISHTI HOME APPLIANCES	06-04-2018	1148
2	Exhaust Fan	SRISHTI HOME APPLIANCES	06-04-2018	1148
3	Exhaust Fan	SRISHTI HOME APPLIANCES	06-04-2018	1148
4	Exhaust Fan	SRISHTI HOME APPLIANCES	06-04-2018	1148
5	Temperature Sensor *3	Meltbook Convergence Pvt. Ltd.	09-04-2018	1284

6	HX711 Weight Sensor	PRATAP BROTHERS	09-04-2018	250
7	Container	PAUL CROCKERY HOUSE	19-04-2018	650
8	Raspberry Pi 3	RTECH SOLUTIONS PVT LTD	21-04-2018	3650
9	Pipes And Joints	PARAM DEV AMRIT LAL	21-04-2018	700
10	Relay Module	Shailesh Hindocha , Gujarat	28-04-2018	372.40
11	Memory Card	Appario Retail Private Ltd	28-04-2018	749
12	Load Cell + Weighing Sensor	TIF Labs Private Ltd.	28-04-2018	570
13	Pi Case Cover	GIZKART	28-04-2018	210
14	Blower, Glue Sticks, 25 A SSR	RAJINDRA ELECTRONICS	12-05-2018	3603
15	Polycarbonate Sheet	PREM & COMPANY	12-05-2018	5782
16	Desiccating Agent(Silica Gel)	LABORATORY SUPPLIERS	14-05-2018	337
17	T Joint	M/s PK CEMENT SALES CO.	14-05-2018	130
18	Gear and Rack	Audio Video Service Centre	14-05-2018	560
19	Screws	Param Dev Amrit Lal	16-05-2018	60
20	Glue Stick, Tape	M/s Thakur Stationers	18-05-2018	235
21	M- Seel	Gurpreet Traders	18-05-2018	200
22	Hair Dryer	CloudTail India pvt. Ltd	19-05-2018	1610
23	Connecting Wire	PRAGATI ENTERPRISES	19-05-2018	281
24	Poster	DEVBHUMI PRINTING PRESS	19-05-2018	320
25	Extension Board	SATENT Storefront	19-05-2018	813
Total Bill				27341

Advantages And Features

- Our Product has a modular design that is it can be modified according to individual needs of crops and farmers.
- We are using electricity as the power source so this is viable in cold places such as Himachal Pradesh.
- The hair drier can be replaced with solar heater to suit the places which have a high temperature weather such as Rajasthan.
- The use of desiccant in conjunction with hot air makes our product theoretically 10% more efficient than industrial products.
- The use of regenerative cycle in main drying chamber saves power as we don't have to keep the drier on for prolonged periods.
- The automation in our design saves the cost of manual labor.
- Due to modular design the maintenance cost is also low.

Future Improvements

- The project can be scaled up to a industrial design without much decrease in efficiency.
- The grains can be dried as well as treated for bacterial growth by passing the air through disinfectant such as ozone.
- Due to modular design it can be developed into grain processing device by changing certain aspects.
- We could dry only one grain at a time but it can be developed to dry multigrains simultaneously and also used to separate dust particles from grains.
- The regenerative cycle used can be developed more to make the drying process more efficient by adding a dessicant chamber in the regenerative cycle.

Conclusion

- Our machine design can dry the grains more efficiently than the industrial designs present bringing the moisture content below 11% without affecting the nutritional value .
- At present it can dry 1 kg of grains in 45 to 50 minutes without any manual labour.
- If scaled up to industrial design it consumes up to 10% less power than the industrial design.
- The power source present can be controlled by a microcontroller hence it can be modified to consume less power for grains with less moisture content.
- The grains dried did not show any change in germination capabilities.

References

http://www.fao.org/docrep/t1838e/T1838E0v.htm

Figure 2, Figure 4:- http://www.fao.org/docrep/015/i2433e/i2433e10.pdf

Figure 8:- https://grabcad.com/library/blower-body-1

Figure 12:- https://grabcad.com/library/hair-drier--4

Figure 11:- https://grabcad.com/library/40-and-60mm-axial-fans-1