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DESIGN OF ROTARY TRAY SYSTEM OF MICROWAVE FRUIT DEHYDRATOR FOR UNIFORM DRYING

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Abstract -The expanding utilization in the dry natural products requires further consideration on quality parameters. Drying has turned out to be fundamental in light of the fact that most organic products are exceptionally transitory inferable from their high moisture content and the need to make them accessible throughout the entire year and at area where they are not created. Thus proper drying framework is basic. Tray drying is most widely utilized due to its straightforward and monetary plan. In a tray dryer more items can be stacked as the tray are orchestrated at various dimensions. The item can be spread out on tray plate at a satisfactory thickness. The real disadvantage of microwave dryer is non-consistency in the ideal moisture substance of the finished result because of poor air stream appropriation in the drying chamber. This undertaking is to anticipate and improve the drying consistency of the new structure of rotating tray dryer for agricultural item. Executing the best possible plan of tray framework may take out or lessen non consistency of drying and increment drying productivity.

Keywords – modelling, drying, uniformity, temperature distribution, convection.

I. INTRODUCTION

Drying of organic products is one of the most established strategies for protecting and handling of the leafy foods. Despite the fact that numerous analysts have arranged nourishments in various ways, by and large they are known as transient and durable. Numerous assortments of leafy foods in our day by day life needs some method for safeguarding mostly to diminish or to quit ruining, and to cause organic products as dried which to can be accessible consistently, to keep up the ideal measure of healthful properties for the longest conceivable time range and to increase the value of the items acquired from drying. Ruining of organic products is the fundamental purpose behind utilizing natural products safeguarding systems, ruining or weakening of organic products happens when taking care of natural products because of mechanical, physical, substance or microbial harm. Microbial development relies upon the capacity conditions, natural region and the dampness content in the organic products. Various microorganisms have diverse development levels relying upon the conditions. Indeed, even due to such huge numbers of compound and enzymatic changes amid the preparing and putting away of natural products.

Regular strategies utilized for products of the soil safeguarding are frosty, vacuum pressing, canning of natural products, saving organic products in syrup, light of nourishment, including a few additives are most prevalent techniques for drying. Despite the fact that it is said that drying of organic products will never supplant canning and solidifying on the grounds that these strategies can improve occupation of holding the taste, appearance and sustenance substance of the crisp natural product. However, drying is a great method to save natural products that can be changed it up of suppers and give scrumptious, nutritious bites. Dried natural products can be put away in less Space and can be canned; this is one of the greatest points of interest of dried organic products.

Drying of natural products is a standout amongst the most financially savvy procedures of safeguarding the organic products. It incorporates all assortment which includes in expulsion of water content from the foods grown from the ground lessen its moisture level by warmth application. Like this assortment of nourishments are protected utilizing drying, they are marine items, meat items just as such a significant number of sorts of products of the soil. Organic products have their dampness content 90% or more (for example the dampness content in water melon is as high as 93%) which should be diminished to an adequate incentive to maintain a strategic distance from microbial development. What's more, every natural product should be dried in various way, utilizing suitable pre and post preparing steps and legitimate organic product dryers must be utilized to show signs of improvement nature of dried organic products. The pre and post handling ventures in drying organic products are essential to diminish the drying load and to improve quality items. Different pre – handling steps, for example, osmotic lack of hydration, whitening, salting, drenching are being utilized relying on the organic product assortment to be dried. Though post-preparing, for example, covering, pressing, additionally have more significance after the fruits is dried. Customarily nourishment items and natural products were dried in open sun drying. Despite the fact that this technique is as yet regular being used at numerous spots for non-business use.

Drying is one of the mind boggling task including transient warmth exchange and mass alongside a few rate procedure such are physical or substance changes which will cause changes in item quality just as the systems if warmth and mass exchange .

Shrinkage, Puffing, crystallization, glass progress are a portion of the physical changes. In some different cases attractive or bothersome, compound or bio-substance responses may happen which will prompt change in the shading, surface, scent or different properties of the natural products. Despite the fact that conservation of foods grown from the ground of drying goes back numerous hundreds of years yet depends on sun and sun based drying strategies as it were. The low quality and item pollution in those systems, prompted advancement of many substitute drying innovations. As of now a wide range of kinds of drying techniques are utilized dependent on need. To decrease the operational cost diverse pre-treatment technique and new low temperature strategy and low vitality drying strategies are utilized.

1.1 PROPERTIES OF FRUITS:

The properties of structure of vegetables and products of the soil organic and microbiological qualities and their significance made the requirement for remarkable thought of their thermal properties, subsequently it made the need to decide the thermal properties of vegetables and natural products tentatively, look as moisture content, thermal conductivity, thermal diffusivity, thickness and explicit warmth limit at different temperatures. thermal properties of organic products are critical to store and to structure the natural product dryer.

1.1.1 Physical properties of fruits:

Fruits	MC %	Specific gravity	Total Solids%	Solid Density (kg m^{-3})
Orange	89.2	1.040	10.8	1040
Pine apple	85.0	0.983	15.0	983
Lemon	90.0	1.032	10.0	1032
Water melon	95.0	1.030	5.0	1030

Table 1.1: Physical properties of fruits

1.1.2 Thermal properties of fruits:

Fruits	Thermal conductivity	Thermal Diffusivity	Specific heat capacity	Latent heat of fusion
Orange	0.588	1.45	3.91	29882
Pine apple	0.567	1.52	3.80	28475
Lemon	0.592	1.46	3.93	30150
Water melon	0.616	1.48	4.05	31825
Lime	0.595	1.47	3.94	30385

Table 1.2: Thermal properties of fruits

The above table encourages us to think about the natural products physical and thermal properties which is fundamental for doing the examination , through which we will know its conduct that what sort of organic products can be put away and what required conditions . As the strong substance builds the moisture substance diminishes in the organic products which will decrease the development of Microbial development.

1.2 SELECTION AND CLEANING OF FRUITS:

Dried organic products are normally sweet and flavourful, we need to ensure that great quality natural products chose as a begin. By choosing natural products that is crisp, completely ready and sound a similar quality. Sort and wash those natural products altogether. Dispose of every single ready piece or any wounded. On the off chance that there is rot on one piece, it might give an awful flavours to the entire cluster. Sanitation is significant amid the taking care of and drying process.

1.2.1 Pre-treatment:

Practically a wide range of natural product need a few or the other sort of treatment before drying. Apples are stripped, cored, and cut. Natural products with pits, for example, peaches and apricots, are generally split and set. Most organic products don't should be stripped before drying. Yet, the skins of certain organic products, for example, fruits are intense and waxy, so you should "split" the skins first. Organic product ought to be cut into uniform pieces or cuts with the goal that it will dry all the more equitably. Keep in mind that the slender pieces dry quicker than the thick ones.

1.2.2 Cracking Skins:

Cherries, grapes, plumps, blueberries and different natural products are having extreme skins with coatings like wax. The skin must be "split" or "checked" nearly in numerous spots the waxy covering is expelled from the organic products skins and it lets within dampness to rise to the top to dissipate. The skin is split, they put every one of the natural products into the bubbling water for around 30 to 60 seconds. Later they are plunged in freezing water. Channel totally on permeable towelling. We propose breaking the skins in water is superior to dunking the organic products in lye arrangements since taking care of lye arrangements can be risky to the administrators.

1.2.3 Protecting of light –colored fruit:

On the off chance that the apples, peaches, pears, apricots or other light – hued organic products are sliced and presented to the air, the substance ends up dark colored quickly. It obscures as a result of the compound change called oxidation. It will harm the surface, season fragrance and presence of the natural product if oxidation isn't ceased. When we are working with light – shading natural products, we need to treat them with turning dark colored. Blend little measure of ascorbic corrosive in some water. Sprinkle the arrangement over the organic product shaper. Business cancer prevention agents contain ascorbic corrosive and different fixings, yet they are more costly than unadulterated type of ascorbic corrosive. It's anything but a smart thought to absorb the natural product salt or vinegar water. Since it will add water to the foods grown from the ground will build the drying time. Some water solute nutrients likewise breaks down when absorbing water. On the off chance that the natural products are absorbed salt and vinegar arrangement it will in general dull the shade of the organic product, covering the organic products by ascorbic corrosive is impermanent treatment. For perpetual enemy of obscuring natural products ought to be exceptionally treated before drying. *(a) Sulfuring:-*

It is a standout amongst the best cancer prevention agent treatment utilized for protecting the natural products shading. Just with perpetual cell reinforcement treatment, apples and different natural products with light hued tissue will begin turning dim amid drying and capacity. The loss of nutrient an and C in the organic products can be avoided by utilizing sulfur. Sulfur pulverizes creepy crawlies and organisms which can cause deterioration. We need not stress over sulfur being destructive in the sums utilized for treating organic products. Sulfur is vital forever and is a mineral which happens normally in sustenance's. Sulfur ends up sulfurous corrosive when it consolidates with water in the natural product however the corrosive dissipates amid drying. The build-up is an innocuous intensify that the body discharges effectively. We should open the natural products to sulfur following setting it up to shield the organic product from staining. There are two kinds of sulfuring:

- Sulfur fumes
- Sulfite solution

Sulfur fumes:

More than sulfur arrangement, sulfur exhaust are progressively successful. Be that as it may, this strategy takes greater hardware's and time. Organic products sulfured ought not to be dried inside in light of the fact that the smell of the vapour is upsetting and we should fare thee well whenever sulfured are bothering to the eyes and nose.

Sulfite solution:

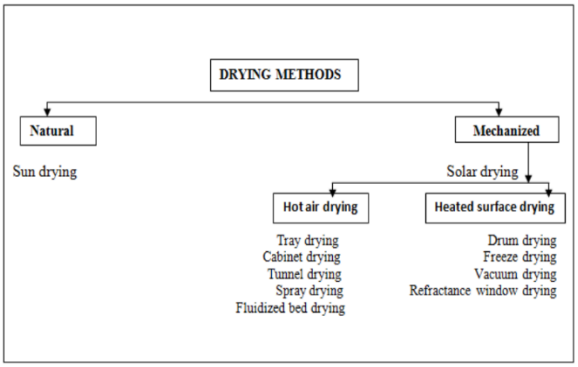
Sulfite arrangement is simple for drenching natural products. The bits of natural products are less completely sulfured than that by sulfur vapour. Since drenching is included the organic products assimilates some water, so the drying time is expanded. Natural products can be dried indoor or out by utilizing this technique.

II. LITERATURE SURVEY

The drying is a helpful procedure to protect sustenance for long time against microbial tainting. Since it is a synchronous warmth and mass exchange task it finds adaptable applications. In 2008 agriculturists from Sistema Producto Vainilla A.C.†, from Quintana Roo State in México mentioned the structure of a vanilla sun oriented dryer and in 2009 educators and understudies from the University planned and developed the principal model named TIKIN-1. This model worked appropriately in its warm conduct however there were issues with the materials it was worked, by this we intend to their low protection from enduring. The intersection between the sun powered gatherer and the bureau presented tourist leakage, because of its structure and development materials, which influenced the warm presentation of the model and the drying procedure. Likewise, item holders were structured with sisal ropes to subsequently enhancements were made to the dryer

keeping the general components of Tikin-1, yet changing the materials from wood to excited sheet metal and keeping the fireplace with PVC. This new model was called Tikin-2.

2.1 EVOLUTION OF DIFFERENT TYPES OF DRYING METHODS USED:



2.1.1 Natural Dryers:

(a) Sun drying:

It is most seasoned technique for conservation strategy for foods grown from the ground. The old Hindus and Chinese used to dry natural products and vegetables by the sun and wind around 5000 years back In Pakistan Early Bronze Age (3,300 to 2,100 B.C.E.) raisins and dried figs are distinguished in an archaeobotany contemplate (milczarek 2013).

2.1.2 Mechanized Dryers:

After sun drying, in late 1700s French individuals utilized controlled air and temperature to dry leafy foods acquaintance of air with increment drying effectiveness was watched. As per Vega Mercado et.al. 2001 motorized drying out strategies can be arranged into four ages arranged by their verifiable advancement

- 1st generation dryers**:**Cabinet and bed type dryer (such as kiln, tray, truck, rotary, conveyor and tunnel)
- 2nd generation dryers**:**Spray drying, drum drying, fluidized bed drying
- 3rd generation dryers**:**Freeze drying, high vacuum, osmodehydration drying
- 4th generation dryers**:**Flash microwave, infrared, combined method, reactance window, high electric field drying.

S. Rajasekar, et al: investigate in drying will improve the plan procedure and comprehension of warmth, mass and minute exchange .The drier geometry setup, air speed and air temperature have much impact on the rate of successful drying. In the event that we can advance these parameters, we can upgrade the mechanical drying process effectively .The advantages of CFD to the nourishment handling industry in the territory of drying are many. In the ongoing years incredible advancement has occurred in these regions

Naseer Ahmed, et al: Advances in parchedness procedures and improvement of novel drying techniques have lately empowered the arrangement of a wide scope of dried out items and accommodation nourishments from leafy foods meeting the quality, strength and useful necessities combined with economy. This has been made conceivable by the continued trial contemplates throughout the years to comprehend the hypothetical and central parts of the procedure and advancement of the methods to accomplish a good mix of expense and quality. This paper surveys and features the improvements in the drying out of foods grown from the ground and their items amid the most recent decade covering hypothetical angles and pragmatic applications with significant accentuation on procedures that have gotten the greatest consideration.

Suhaimi Misha, et al: Tray dryer is the most widely utilized due to its basic and financial plan. The fundamental disadvantage of plate dryer is the non-consistency of the last dampness substance of the item. Great wind stream circulation all through the drying chamber can improve the drying consistency. CFD is viewed as a fundamental piece of building plan and investigation as a result of its ability to explain conditions for the protection of mass, force, and vitality utilizing numerical strategies to foresee the temperature, speed, and weight profiles in the drying chamber. Subsequently the exhibition of new dryer structures might be anticipated by recreation work. The outcomes demonstrates that there are some item will encounter high air speed, item at plate number 1, 7, 8 and 15. The normal air speed over the plate is about 0.38 m/s. For the most part the temperatures are viewed as uniform for all plate. The new structure of dryer is appropriate for agrarian drying on the grounds that it can deliver satisfactory uniform drying at high limit of item. The drying proficiency of this framework might be expanded with high air speed bay. The uniform drying and expanding of drying rate will likewise improves the nature of dried item. The consistency of the drying might be improved by utilizing extra confuse to guide the wind stream to every plate, trade the places of the plate amid the drying procedure or directed in semi-consistent mode. Anyway it will builds the general expense of drying.

III. OBJECTIVES AND METHODOLOGY

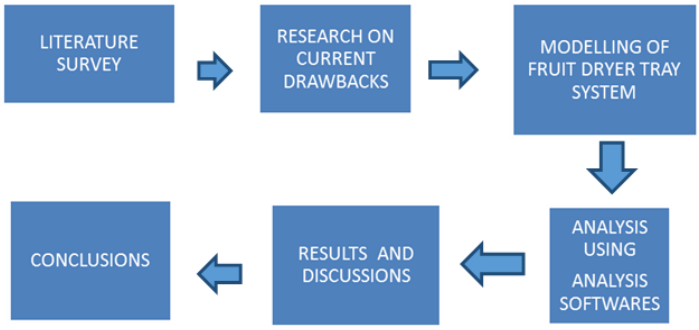
3.1 OBJECTIVES:

The main objective of this work is to study the design of a fruit dryer tray system, which will be used for uniform drying of fruits and further it will put away an extensive stretch of drying time , which will in turn reduce spoilage of fruits.

- To develop a model of a fruit dryer tray system for uniform drying.
- To reduce the time period of drying.
- To get the desire temperature distribution inside the case.
- To study the deformation of the designed model.

3.2 METHODOLOGY:

The methodology of the project work consists of following stages:



3.3 EVOLUTION OF NEW IDEA:

Task was carried out to understand the drawbacks of drying a fruit in microwave oven:

- Thin slice of papaya fruit where placed in a rotating glass tray to observe the uniformity of drying.
- Test was carried in convection mode at a temperature of 180 °C for duration of 20 minutes.
- It was observed that one side of the fruit gets roasted because of overheating.

Hence we concluded that for uniform drying proper design of tray is essential.

IV. MODELLING AND ANALYSIS OF TRAY SYSTEM

The principal phase of the undertaking is to structure the natural product dryer according to the inexact appropriate measurements. The plan of the organic product dryer is finished with the assistance of strong works programming. The capacities of the item can be part into the three principle heading of Engineering Design, Analysis and Result. The information of standard 2D creation illustration is then recorded and the 3D demonstrating of organic product dryer is finished with assistance of strong works programming and measurements are chosen from one of the microwave. Just the external components of natural product dryer has been considered From the examination it comes to realized that goal is to keep up the required temperature inside the organic product bureau by changing the structure and material of a natural product dryer. Thus by adjusting the real plan of natural product dryer from the current organic product dryer we can keep up the temperature. From the deliberate measurement created the 3D organic product dryer is additionally imported in the ansys familiar for investigation.

4.1 MATERIALS USED:

Materials utilized in making the organic product dryer parts like case, plate and fan is stainless steel.304.and it is likewise called as A2 tempered steel, this steel contains both chromium (between 18-20%) and nickel (between 8-10.5%) metals as the fundamental non-iron constituents . it is an austenitic treated steel. It is less electrically and thermally conductive than carbon steel and is basically non-attractive. It has higher erosion opposition than normal steel and is broadly utilized in light of the simplicity in which it is framed into different shapes .it has brilliant protection from climatic situations and numerous destructive media .304 tempered steel is utilized for assortment of family and modern applications, for example, screws, hardware parts, vehicle headers and nourishment taking care of equipment's. The thermal curl of the dryer is comprised of copper, it is delicate, flexible, and pliable metal with high warm and electrical conductivity. Copper is utilized on the grounds that it is great transmitter of warmth and power, as a structure material, and as a constituent of different metal combinations, for example, sterling silver utilized in adornments, cupronickel used to make marine equipment and coins, and constantan utilized in strain checks and thermocouples for temperature estimation

4.2 CREATION OF GEOMETRIC MODEL:

The dimensions of the fruit dryer is take from a LG microwave oven mj3286bfum model. From the above mentioned oven dimensions, the model is created using solid works.

The Fruit Dryer is modelled using Solid works as per the dimensions such as,

- Outer Case
- Fan
- Heating coil
- Tray
- Tray Frame

Fig 4.1 Assembled view of tray model

➢ **Tray Frame:**It is structural rotating body used to hold trays.

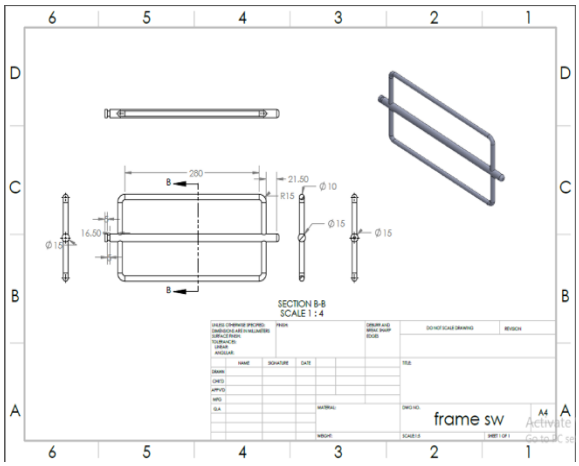


Fig 4.2 Drafting of tray frame

➢ **FAN:**

- It is attached to the backside drying chamber.
- It is used as inlet for the flow of air inside the chamber.

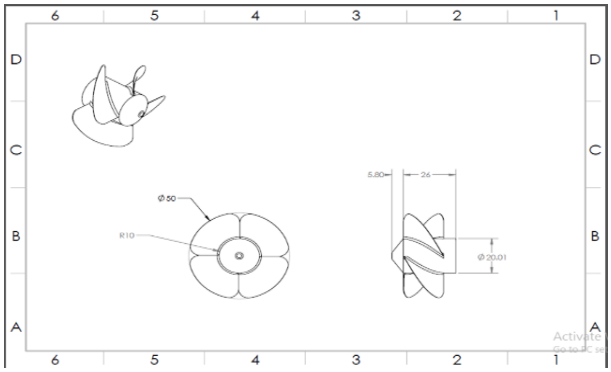


Fig 4.3 Drafting of fan

- **Tray:** It is structural body used to hold fruits for drying purpose.

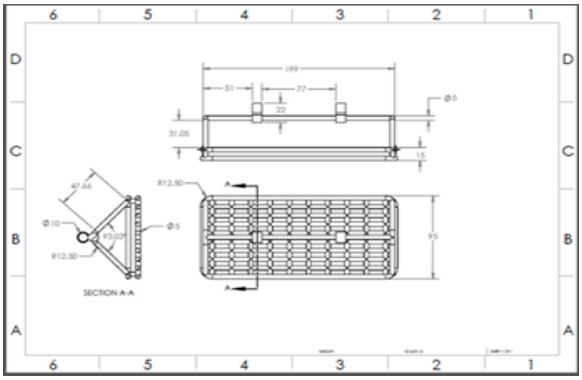


Fig 4.4 Drafting of tray

- **Outer case:**
- It is main drying chamber used to dry fruits.
- It is made up of sheet metal of around 3-6 mm thickness.
- It consists of inlet and outlet air vents for circulation of air.

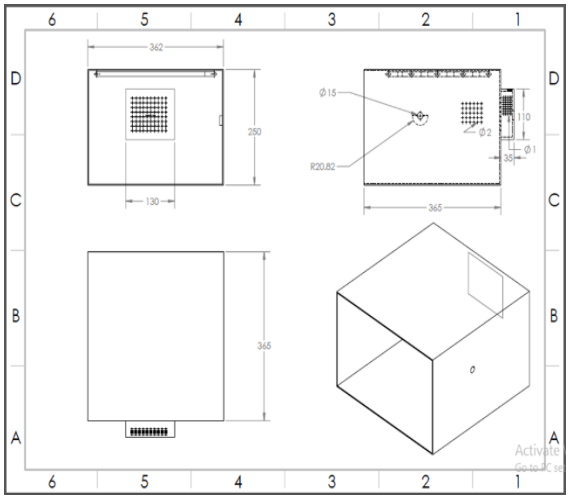


Fig 4.5 Drafting of outer case

- **Heating coil:**
- It is used to increase the temperature inside the drying chamber.
- It is made up of copper.

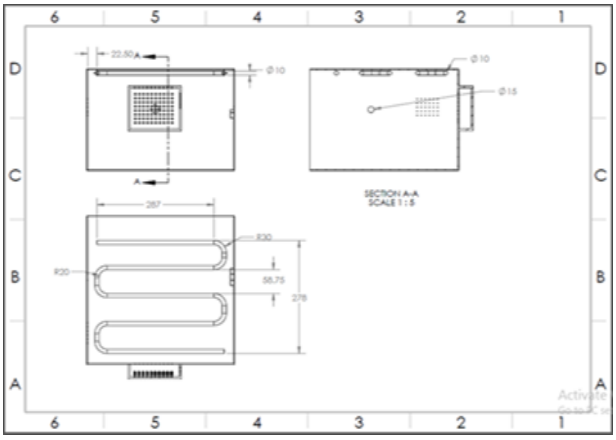


Fig 4.6 Drafting of heating coil

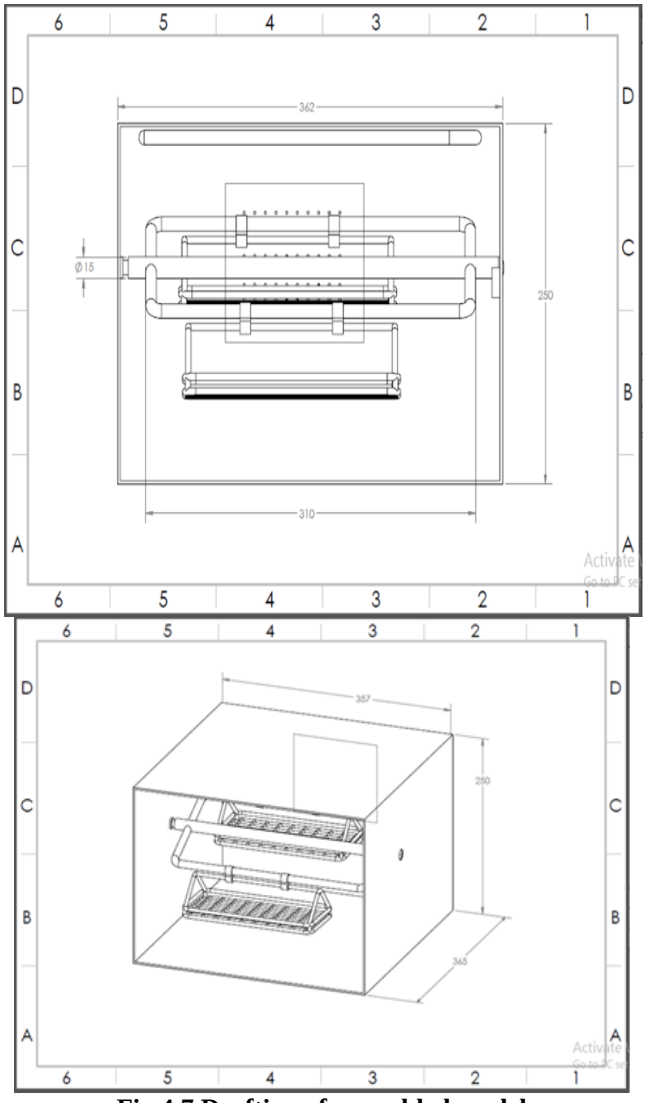


Fig 4.7 Drafting of assembled model

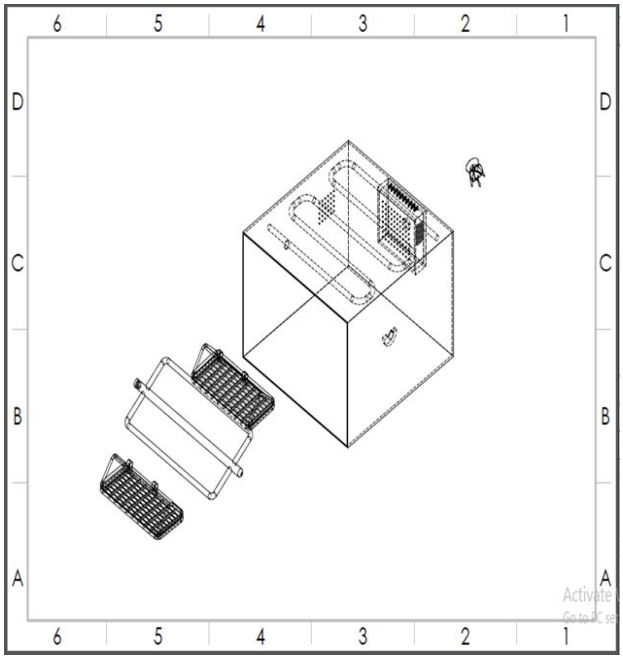


Fig 4.8 Exploded view of assembled model

4.3 THEORETICAL CALCULATION FOR ANALYSIS:

✓ **Angular velocity to linear velocity:**

v = r * w
v – Linear velocity (m/s).
r – Radius (m)
w – Angular velocity (rad/s)

✓ **RPM to linear velocity:**

v = r * RPM * 0.10472
(Or)
v = πDN / 60
As per the design model:
r = 0.025 m
RPM = 1200
Therefore,
v = 0.025 * 1200 * 0.10472
v = 3.1416 m/s

✓ **Convection coefficient:**

For the room temperature of 30 °C and wall temperature 80 °C
Tm = 80 + 30 = 110/2 = 60 °C
So at 60 °C, γ = 20 * 10e-6, pr = 0.696, k = 0.02896
Dh = A/P
Dh = (4 * 0.250 * 0.357) /
(0.357 + 0.357 + 0.250 + 0.250)
Dh = 0.294 m
Reynolds number, Re = v * Dh / γ
Re = (3.1416 * 0.294) / (20 * 10e-6)
Re = 46181.52
Since the Reynolds number is above 4000, the flow is turbulent
$Nu = 0.023 * Re^{0.8} * Pr^{0.4}$
$Nu = 0.023 * 53407.2^{0.8} * 0.696^{0.4}$
Nu = 107.23

Nu = h Dh/ K
h = 107.23* 0.02896 / 0.294
h = 10.56 W/m2-K

✓ **Rotational Speed of tray:**

As per the design model:
r = 0.03 m
RPM = 10
Therefore,
v = 0.03 * 10 * 0.10472
v = 0.031416 m/s

4.4 ANALYSIS:

4.4.1 MESHING RESULTS:

In the task of completing the geometry creation, and division of the volumes, and make it simpler to characterize limit conditions the mesh was made. When the geometry is prepared, we began with mesh. Meshing is a standout amongst the most basic parts of designing simulation. An excessive number of mesh elements may result in long solver computation. With too few work components are chance for not having careful outcomes contrast with test results. Strong cross section was accomplished for natural product tray framework. In the intrigued region fine work is done, around 1492435 elements and 2763851 nodes are produced, which will help us in getting better outcomes.

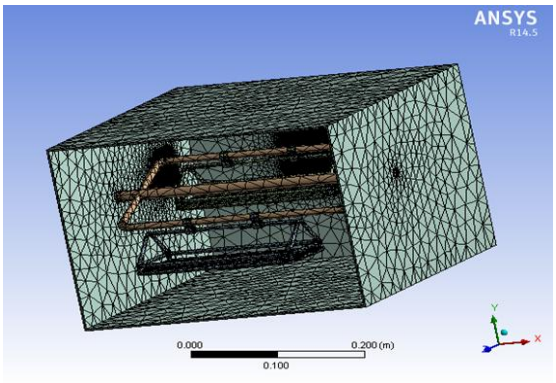


Fig 5.1 Meshing of assembled model

4.4.2 TEMPERATURE DISTRIBUTION RESULTS:

Despite the fact that the simulation was done in three measurement yet investigation was done on whole assembly. A few places of tray framework have been contemplated however base position was considered as poor zone in term of temperature dispersion. The temperature air from the inlet is 30℃. The coil temperature and the temperature of the wall was kept consistent at 80℃ in convection mode. It is discovered that the temperature at the top position of the plate was in the scope of 80 – 75.5˚c and at base position of plate the temperature was low around 35-45℃. the distinction of the temperature among the situation of tray was around 25-30℃ which was more. In any case, because of the rotational development the plan could effectively accomplish the sensible uniform air temperature at all the situation of the plate in the drying chamber.

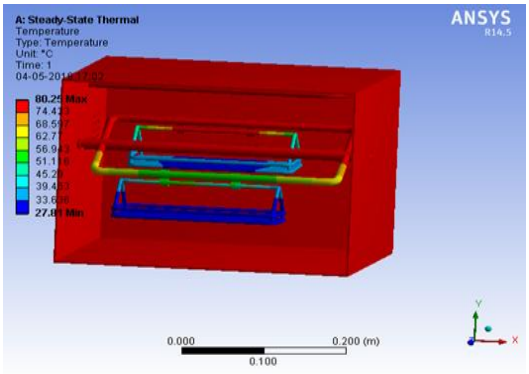


Fig 5.2 temperature distribution of assembled model

In drying application, the temperature, velocity and humidity of drying cool gives huge impact to the drying procedure. In this simulationonly temperature and velocity of the drying air can be analysed. Moisture examination will be done later on test work. From the hypothetical investigation it demonstrates that the velocity accomplished the maximum value at 3m/s determined in the inlet boundary condition. Butgenerally the velocity around the tray is low and is in the scope of 0-1.621m/s. The air velocity over the tray are essential to convey the moisture from the item. The variety of conclusive moisture substance of the item may happen dependent on the velocity profile. The high air velocity at above item (plate) will make the item dry quicker contrasted with the item with low air speed. The temperature profiles in the drying chamber can be considered as uniform in light of the fact that the tray is presented to all the temperature position because of rotational development

4.4.3 DEFORMATION RESULTS:

A deformation analysis was carried out for the modelled tray system and max load of 0.5 kg was applied on both the trays. And from this study we observed that the deformation is negligible which is acceptable and hence we consider that the design is safe.

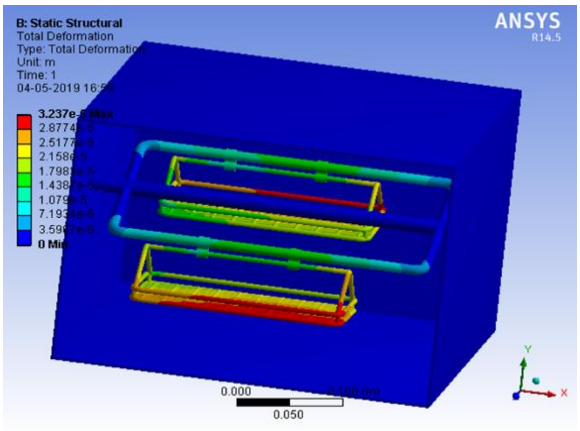


Fig 5.3 Deformation result of assembled tray model

4.5 PURPOSE OF ROTARY TRAY SYSTEM IN MICROWAVE FRUIT DEHYDRATOR:

- To increase the uniform drying efficiency
- To reduce the time period for drying
- In order to expose the fruits at all the temperature stages inside the drying chamber for uniform drying
- As the drying period (E.g. sun drying) increases the loss of vitamins and nutrients in the fruit also increases, hence in order to reduce the losses microwave drying is efficient

4.2 ADVANTAGES:

- Uniform drying
- Reduction in overall drying time
- Reduction in the losses of vitamins and nutrients

4.3 DISADVANTAGES:

- Cost of drying increases when compared to other drying processes
- Proper setting of temperature and time is very important in order to avoid overheating or drying of fruits

V. CONCLUSION AND SCOPE OF WORK

Tray dryer is the most broadly utilized as a result of its straightforward and financial structure. The principle disadvantage of tray dryer is the non-consistency of the last moisture substance of the item. Appropriate planning of tray for the drying chamber can improve the drying consistency. CFD is viewed as a vital piece of building plan and investigation on account of its ability to illuminate vitality utilizing numerical techniques to foresee the temperature, speed, and weight profiles in the drying chamber. In this way the exhibition of new dryer structures might be anticipated by simulation work. For the most part the temperatures are viewed as uniform for all tray. The new plan of dryer is reasonable for rural drying in light of the fact that it can create worthy uniform drying at high limit of item. The drying productivity of this framework might be expanded with high air velocity channel. The uniform drying and expanding of drying rate will likewise improves the nature of dried item. The consistency of the drying is improved by rotational development of tray, trading the places of the tray amid the

drying procedure. Anyway it will expands the general expense of drying. The real dryer will be created later on and the trial work will be directed to approve the simulation.
Moisture examination should be possible later on exploratory work .a few positions in the drying chamber must be introduced with temperature, speed and mugginess sensors to approve the simulation information. On the off chance that we utilize permeable item the general velocity in drying chamber may give all the more great velocity appropriation.

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