

# **Design & Fabrication of Conveyor Mechanism for High Temperature Molten Chocolate**

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**ABSTRACT:** A study was made in a chocolate factory located in Gujarat Rajkot, find a problem were identified, the molten chocolate for to be transferred boiler to the hopper manually. This project aim is solving this problem. The object is to be designs and fabrication preparing mesh to transfer the molten chocolate from boiler to hopper which is separated by a distance of 17ft.

## **I.OVERVIEW**

The geometry of an Archimedes screw is governed by certain external parameters (its outer radius, length, and slope) and certain internal parameters (its inner radius, number of blades, and the pitch of the blades). The external parameters are usually determined by the location of the screw and how **much molten chocolate** is to be transfer. The internal parameters, however, are free to be chosen to optimize the performance of the screw. In this paper the inner radius and pitch that maximize the volume of **molten chocolate** lifted in one turn of the screw are found. The optimal parameter values found are compared with the values used in a screw described by the Roman architect and engineer Vitruvius in the first century B.C., and with values used in the design of modern Archimedes screws.

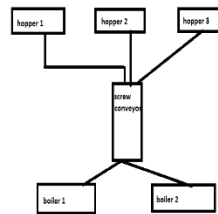
## **II.INTRODUCTION**

An Archimedes pump utilizes a threaded screw to turn the material down a cylinder. The material is pumped forward by the relative movement of the screw in the cylinder. The transporting mechanism is similar to a nut held in a wrench with the screw rotating in the nut. Normally, the screw advances in the nut, but when the screw is physically prevented from advancing, as in the case of the Archimedes screw, the nut will slide in the wrench. A motor through a gearbox turns the screw, but a circular ring on the head of the screw prevents it from being pushed out of the cylinder. The movement of the screw within the cylinder causes a pressure rise along the length of the screw. When the material reaches the nozzle, It experiences a change in area, and as a result, it undergoes pressure variation. The nozzle offers resistance to the flow of material, termed as Back-Pressure. The force with which the material dispensed is resultant of the pressure difference between the pump and the nozzle. As a result, it is extremely important to understand the screw parameters, the screw-nozzle combination and the operating conditions that maximize production.

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## 3.1 . Archimedes' screw

### 2.1. Study of problem

Archimedes' screw, also called the Archimedean screw or screw pump, is a machine historically used for transferring water from a low-lying body of water into irrigation ditches. water is pumped by turning a screw-shaped surface inside a hollow pipe.

The screw pump is commonly attributed to Archimedes on the occasion of his visit to Egypt. This tradition may reflect only that the apparatus was unknown to the Greeks before Hellenistic times and was introduced in Archimedes' lifetime by unknown Greek engineers.

On the basis of screw conveyor chocolate also can be transfer from hopper to boiler with the help of our special design. Archimedes' principle indicates that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces. Archimedes' principle is a law of physics fundamental to fluid mechanics.

### 3.2. Design

Archimedes' screw consists of a screw (a helical surface surrounding a central cylindrical shaft) inside a hollow pipe. The screw is turned usually by a windmill or by manual labour. As the shaft turns, the bottom end scoops up a volume of water. This water will slide up in the spiral tube, until it finally pours out from the top of the tube and feeds the irrigation systems. The screw was used mostly for draining water out of mines or other areas of low lying water.

The contact surface between the screw and the pipe does not need to be perfectly watertight, as long as the amount of water being scooped with each turn is large compared to the amount of water leaking out of each section of the screw per turn.

In some designs, the screw is attached to the casing and they both rotate together, instead of the screw turning within a stationary casing. A screw could be sealed with pitch resin or some other adhesive to its casing, or cast as a single piece in bronze.

Some researchers have postulated this as being the device used to irrigate the Hanging Gardens of Babylon, one of the Seven Wonders of the Ancient World. Depictions of Greek and Roman water screws show them being powered by a human treading on the outer casing to turn the entire apparatus as one piece, which would require that the casing be rigidly attached to the screw.

### 3.3. Uses

- Along with transferring water to irrigation ditches, the device was also used for draining land that was underneath the sea in the Netherlands and other places in the creation of polders.

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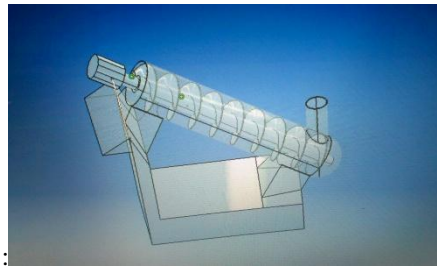
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- A part of the safely from ponds and transport them to another location. This technology is used primarily at fish hatcheries, where it is desirable to minimize the physical handling of fish.
- It is also used in chocolate fountains.

### 3.4. Variants

A screw conveyor is an Archimedes' screw contained within a tube and turned by a motor so as to deliver material from one end of the conveyor to the other. It is particularly suitable for transport of granular materials such as plastic granules used in injection molding, and cereal grains. It may also be used to transport liquids. In industrial control applications the conveyor may be used as a rotary feeder or variable rate feeder to deliver a measured rate or quantity of material into a process.

A variant of the Archimedes' screw can also be found in some injection molding machines, die casting machines and extrusion of plastics, which employ a screw of decreasing pitch to compress and melt the material. Finally, it is also used in a specific type of positive displacement air compressor: the rotary-screw air compressor. On a much larger scale, Archimedes' screws of decreasing pitch are used for the compaction of waste material.



Cartia model design After fabrication:



#### Component:-

1. Archimedes' Screw ( ss material)
2. Stainless Steel Pipe as casing
3. Gearbox motor
4. Flange Bearing
5. Bush
6. Stand

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## IV.SCREW DESIGN PARAMETERS

**Pitch of Threads (t)** :This is defined as the distance between two consecutive threads. A high value of pitch, i.e., small value of thread/inch, reduces the effective surface area of contact. This reduced surface area of contact causes a reduction in pressure build-up as compared to a screw with a greater number of threads/inch. A high pitch cause's excessive material to be fed between the threads than the nozzle can handle and, hence, increase the Back-Pressure. This, in turn, reduces the amount of material dispensed as it counteracts the pressure developed to dispense it.

**Depth of Cut (h)** :  $[(D_{Major} - D_{Minor}) / 2]$  : The amount of material dispensed is directly proportional to the depth of cut, up to a certain point, depending upon the nozzle ID. For a given nozzle ID there is an optimum value for the depth of cut to minimize Back-Pressure. Any increase in the depth of cut beyond this point causes the flux in the solder paste to act as a lubricant, therefore causing slippage between the screw and the solder paste. This reduces the pressure build-up in the cartridge. Hence, to maximize the amount of material dispensed through a nozzle, it is necessary to determine the optimum depth of cut of a screw.

**4.1.1 Type of Thread:** Solder paste is a mixture of solder metal spheres, flux, and additives. The density of the solder metal is about 8 times the density of flux [5]. This density difference between solder metal and flux causes them to separate at high shearing forces. Square threads have sharper edges as compared to angled threads such as the British Standard Whitworth. The square threads can possibly cause excessive shearing of solder paste and, hence, increase separation.

**4.1.2 Length of Screw:** The length of screw influences the pressure buildup and distribution. As the solder paste passes along the channels of the screw, it undergoes a pressure variation. Since the cartridge is a constant volume chamber, and as the amount of material fed increases, the pressure of the material within the cartridge rises. A very high-pressure rise within the cartridge could cause separation of flux and solder metal spheres. Hence, there is a limit to the length of the screw that causes sufficient pressure build-up and minimizes separation.

**4.1.3 Number of Starts:** The number of starts determines the number of channels through which the material can flow in the cartridge. With an increase in the number of starts, a greater quantity of material flows into the cartridge. This increases the pressure of the material in the cartridge and consequently increases the volume dispensed. A multi-start thread also provides more channels for the material to leave the screw and also increases the volume dispensed.

### 4.2 OPERATING CONDITIONS

Apart from the screw design parameters, the operating conditions also play an equally important role in the quantity and quality of the dispensed dot. The material parameters, such as viscosity, thixotropic property, metal content and solder powder size, influence the flow behavior. Viscosity is defined as the property of a fluid by virtue of which it offers resistance to the movement of one layer of fluid over an adjacent layer. There is a low and high threshold value for the viscosity of the solder paste. A high value of viscosity ( $> 400$  Kcps) will offer a high resistance to flow affecting the quality of the dispensed. Moreover, if the material has a very low viscosity, it will tend to flow freely, thus causing it to drool.

The relationship between the nozzle ID and particle size is also an important aspect for successful dispensing. Too large a particle size through a fine nozzle ID will cause it to clog. A rule of thumb suggests that the nozzle ID should be 8 times larger than the solder paste particle size to avoid clogging. With a decrease in nozzle ID the flow area for the material decreases, increasing the Back-Pressure and thus decreasing the flow rate.

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### V.HOW TO BUILD AN ARCHIMEDES SCREW

#### Step 1: Materials/ Tools Needed

##### Materials:

Stainless Steel  
Stainless Steel rod (25mm Diameter, 45mm outer Diameter)  
3mm thick Stainless Steel sheet  
600mm Stainless Steel rod  
600mm Stainless Steel pipe (50mm Inner Diameter)  
Gearbox Motor

##### Tools:

Metal , Band saw, Sander, Plasma cutter, Bench Grinder  
Angle Grinder, Handheld drill, Gas Welder, CNC Machine  
Bench Vice, G-Clamps, CATIA software.

#### Step 2: Calculations

Before we could begin to manufacture the screw, we had to do calculations for the optimum angle of the screw to sit at and for the pitch of the blades. For this we referred to 'The Turn of the Screw: Optimal Design of an Archimedes Screw' by Chris Rorres.

Our results gave us 12 blades with a pitch of 50mm and we kept our angle flexible at this stage.

Inclination angle =  $30^{\circ}$                        $\tan = 1/\sqrt{3} = 0.577$   
 $R_o = 45\text{mm}$   
 $R_i = 12.5\text{mm}$   
 Height of the blade (h) = 32.5 mm  
 Length of the shaft = 600 mm  
 $N = \text{no. of blade} = 12$   
 Pitch = 50mm  
 Radius ratio ( $\rho$ ) =  $R_i / R_o = 12.5 / 50 = 0.25$   
 Pitch ratio ( $\lambda$ ) =  $K\lambda / 2\pi R_o = (0.577 \times 50) / (2\pi \times 45) = 0.102$   
 Power (P) = 120 watts  
 R.P.M = 900  
 Torque (T) =  $P / \omega$   
                   =  $120 \times 60 / (2 \pi \times 900) = 1.27 \text{ Nm}$   
 Volume of one cycle of screw =  $\pi R_o^2 \lambda = \pi \times 45^2 \times 50 = 318086.26 \text{ mm}^3$

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Volume of one chute =  $\Pi(R_o^2 - R_i^2) \times (L/N) = \Pi (45^2 - 12.5^2) \times (600 / 12) = 293542.56 \text{ mm}^3$

Volume ratio (v) =  $V_T / \Pi R_o^2 \Lambda$

$V_T = (2 \Pi^2 R_o^3 / K) \times \lambda \times v (N, P, \lambda)$  , where, the value of  $(\lambda \times v (N, P, \lambda))$  for 12 blade = 0.0824

$V_T = (2 \times \Pi^2 \times 45^3 \times 0.0824) / 0.577$

= 266096.58  $\text{mm}^3$  , where  $V_T$  is volume of chocolate in one cycle of screw.

Volume ratio (v) =  $V_T / \Pi R_o^2 \Lambda$

= 266096.58 / 318086.26

= 0.008

Discharge (Q) =  $V / T = 318086.26 \text{ mm}^3 / \text{min}$

### Putting it all together

Sadly we couldn't get the final screw to run off of our motor but it would work fine with a more powerful motor or off of a drill like the one we've used for testing throughout the whole project. Here's the final screw working off of the drill.



### VI. WHAT IS STAINLESS STEEL?

'Stainless' is a term coined early in the development of these steels for cutlery applications. It was adopted as a generic name for these steels and now covers a wide range of steel types and grades for corrosion or oxidation resistant applications.

Stainless steels are iron alloys with a minimum of 10.5% chromium. Other alloying elements are added to enhance their structure and properties such as formability, strength and cryogenic toughness. These include metals such as:

- Nickel
- Molybdenum



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- Titanium
- Copper

• **What is gear?**

A gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque, in most cases with teeth on the one gear being of identical shape, and often also with that shape on the other gear. Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, torque, and direction of a power source. The most common situation is for a gear to mesh with another gear; however, a gear can also mesh with a non-rotating toothed part, called a rack, thereby producing translation instead of rotation.

• **spur gear:**

• Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radially, and although they are not straight-sided in form (they are usually of special form to achieve constant drive ratio, mainly involute), the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears can be meshed together correctly only if they are fitted to parallel shaft.

**Flange bearing:**

A flange bearing frog, often abbreviated FBF, is a type of frog in which the flange of the wheel on a railway vehicle supports the weight of the vehicle. In conventional practice, the tread of the wheel rests on the head of the rail and bears the weight of the vehicle, while the flange is used to keep the vehicle in the gauge of the track. Flange bearing frogs are a relatively recent development, as a means to reduce maintenance costs associated with turnouts and diamonds, where rails must cross one another.



## VII. COST ESTIMATION

SL NO.	COMPONENT	COST
1	Archimedes screw material and labor cost	8000
2	Stainless steel pipe	300
3	Flange Bearing	300
4	Gear motor	2000
5	Nut and bolts	200
6	Stand and welding charge	2000
		<b>Total = 12,800/-</b>

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## VIII. APPLICATIONS

- It is used in chocolate fountains.
- Along with transferring water to irrigation ditches, the device was also used for draining land that was underneath the sea in the Netherlands and other places in the creation of polders.
- A part of the safely from ponds and transport them to another location. This technology is used primarily at fish hatcheries, where it is desirable to minimize the physical handling of fish.

## IX. CONCLUSION

- This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, Archimedes screw principle, purchasing, assembling and handling while doing this project work. We feel that the project work is a good option in chocolate company and also it can maintain the temperature.
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- We are proud that we have completed the work with the limited time successfully. The “**conveyor mechanism for high temperature molten chocolate**” is working with satisfactory conditions. We are able to understand the difficulties in maintaining the flow of chocolate through our special design and pressure development. We have done to our ability and skill making maximum use of available facilities. In conclusion remarks of our project work, let us add a few more lines about our impression project work.
- Thus we have developed a “**conveyor mechanism for high temperature molten chocolate**” which helps to know how to transfer semi liquid or chocolate from boiler to hopper and also by maintaining the temperature of the chocolate. The operating procedure of this system is very simple, so any person can operate. This screw conveyor is flexible. By using more techniques, they can be modified and developed according to the applications. But get some noise issue is there because the simulation is not perfect.

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