International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Design of Auger Type Feed Screw and its Casing for Food Extrusion Process

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Accepted 12 March 2017, Available online 16 March 2017, **Special Issue-7 (March 2017)**

Abstract

For making food products like laddu (Indian sweet), rice balls input material is to be pushed ahead as well as pressed to solidify and take a specific form or shape. For extrusion of food products in food industries a simple design of feed screw and barrels is used and is a traditional way for extruding food for further processes. The feed screw can contribute for optimum efficiency rate with proper output of extrusion. The proposed design of auger type feed screw pushes the material ahead like a screw conveyor and also applies proper pressure. The proposed design can be used for increasing the overall efficiency of a food product company by increasing the rate of production as the auger type feed screw is designed to accommodate and process larger volume as compared to the traditionally designed feed screw. The casing designed thus helps the auger type feed screw in gaining optimal output. The paper also proposes the calculations and parameters of the auger type feed screw adhering to the torque and power requirements. .

Keywords: *Auger, feed screw, casing, food extrusion.*

1. Introduction

In many food industries the arrangement of feed screw and barrel is used for extrusion of food material. These industries keep on improving their efficiency by adhering to the increasing demand and lead time reduction method. The design proposed of a auger type feed screw that pushes the material ahead like a screw conveyor and also apply proper pressure on the material as the blade height is reduced with a gradual taper and lead of screw is decreased as material moves ahead. As the screw is turned, every turn pushes the material from a higher volume region to a lower volume region, with the material getting pressed against the walls of the casing.

Material loses moisture as it gets pressed while moving ahead. The moisture content is of prime importance for smooth flow of material. If it is high, the extrude will not be sluggish enough and if it is low, the screw can get jammed. But as the material gets pushed, it releases moisture and thereby smoothing the flow. If necessary, water can be added initially to ensure the smooth flow of material. Then the amount of water must not be high to make the material fluidic but enough to make it sluggish. Milk or any other workable fluid can be used in the place of water. Initial addition of fluid would only be needed for the first turn and later the moisture released due to compression and will work naturally till the end of process.

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For input, casing is attached to a hopper of required capacity and for outlet; the casing has an extrusion hole through which the sluggish solidified material will come out from. This way is effective in the sense that material is not only pushed during the process but also is being compressed simultaneously and gradually.

An advantage of using a screw for feeding the material and simultaneously pressing it is that the outlet extruded material is continuous. A continuous flow is required for higher efficiency as compared to the discontinuous one. Also, cutting becomes easy since it is periodic due to continuous flow. Uniformity and constant rate of volume flow at outlet is ensured by the continuous flow.

In case of a traditional feed screw, material is only pushed ahead and is needed to be pressed later in most of the cases. In such cases, where there is a need, the proposed design is best suited to be utilized, as proposed design comply with the need of such applications

2. Auger type feed screw and casing design:

Electric motor is usually paired to a feed screw to compress and pushes the material for impel process. The assembly of proposed design of feed screw and motor plays an important role of carrying the material forward with correct compression and speed. Required compression and speed are important parameters here since the material should not get dry during the process. Material should flow in proper consistency at the outlet of the feeder. If the above parameters are not satisfying the conditions, then it will lead to undesirable results at the output.

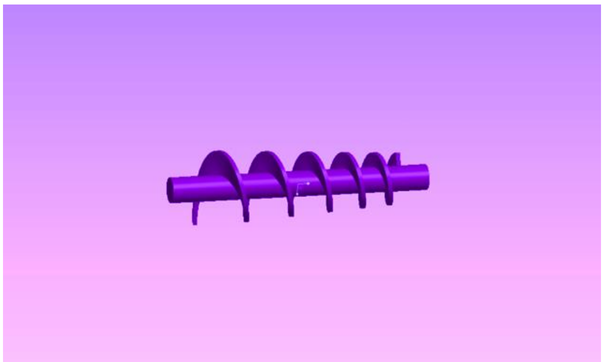

Fig.1 Auger type feed screw

Continuous smooth flow of material is necessary at the output for proper extraction of the fed material. And input material should not lose its shape and deform during the process. It should also settle quickly after shaping and should not get too dried to break into pieces by becoming brittle.

The screw designed was such that a proper compression ratio should is maintained from the inlet to outlet of the feeder. The casing design supports the feed screw functions. The screw is connected to the motor having sufficient power to apply the required forces and to provide the desired torque for pushing the material from inlet to outlet. The design used is unique in its place and is not an orthodox practice to go with. By attaining optimum speed of the motor it gives proper rate of items made per second.

Fig.2 Auger type feed screw proto-type.

The screw is made by cutting the SS sheets having optimum thickness in varying diameters (inner and outer) and then curling it around the shaft. The cutting of discs for one turn should be such that diameter at the end of preceding circular disc should match with the start of the succeeding circular disc. These cut disc shapes are welded and then mounted on the bar. In next step they are stretched to get the desired pitch and then the unit is welded on the bar. As this proposed design is unique, this type of screw is not available in the market. So we constructed it ourselves.

The hopper is attached to the feeder casing i.e. the casing of the feed screw. The capacity of the casing is kept optimum to maintain the moisture level of the feeding material during the flow. If it is too large then the feeding material is suspected to get dried affecting the consistency of the material. If it is too small, then it will be a tiresome job to feed the material again and again. The hopper is detachable to make it handy for cleaning purpose.

As all parts are in contact with the food material, the metal used for the parts in contact with the food is also of food grade for proper hygiene. Material used is SS304.

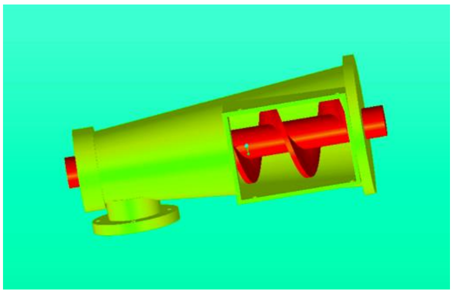

Fig.3 Auger type feed screw + casing

Fig.4 Auger type feed screw in casing proto-type

3. Design calculations of feed screw

Following calculation for lead, blade height, torque etc. concludes the actual design parameters.

3.1 Lead distances of screw

We take diameter of product = 4cm (standard convention)

Shape of product is geometrically equivalent to a sphere.

Hence, volume of 1 unit of product = $\frac{4}{3}\pi r^3$

$= \frac{4}{3}\pi(2)^3$

= 33.5103 cc

= 34 cc approx

We desire 1 unit of product per 2 seconds = 34 cc / 2s

= 17 cc/s

Volume flow rate at outlet = 17 cc/s

We take length between the end leads to be 2 cm.

And scale up the pre-tested prototype dimensions accordingly for 5 turns:

Table 1 Length between the lead.

Prototype dimensions	Scaling factor	Actual dimensions
4	2	8
3	2	6
2.5	2	5
2	2	4
1	2	2

3.2 Blade height calculation

The last turn must yield 17 cc, considering the speed to be 1 turn per second or 1 rev per second or 60 rpm.
For volume calculation of the last turn:
We take, Volume = (Area on shaft)*(Height of blade)
We know, Volume = 34 cc
Area = ½ * (end lead = 2)*(rod circumference = 3π)
= 3π cm^2
Height of blade = Volume / (Area on shaft)
= 1.8 cm
But it is just avg. blade height needed.
Now for required flow conditions, taking blade taper to be $\tan^{-1}(1/10)$
So we find, for 5 turns:

Table 2 Blade heights

Turn	Blade height
1	4.2 – 3.4
2	3.4 – 2.8
3	2.8 – 2.3
4	2.3 – 1.9
5	1.9 - 1.7

3.3 Torque calculation

Torque = Force * radius
Force = m*g
Where m = hopper capacity = 10 kg
And g = 9.81 m/s^2
Hence, Force = 98.1 N
For all radii:

Table 3 Torque acting on the blades and bar

Radius (cm)	Torque (N.m)
1.5	1.4715
1.7	1.6677
1.9	1.8639
2.3	2.2563
2.8	2.7468
3.4	3.3354
4.2	4.1202

3.3 H.P. calculation

H.P. = (Torque * (2 * pi * N/60))/746
Here we calculate maximum H.P., we will take maximum torque required instead of average torque.
= (4.1202 * (2 * pi * N/60))/746
= .05783731 H.P.

Conclusions

The auger type feed screw designed is unique with respect to its functions. It is easy to construct and its strength can be improved by increasing the thickness of material. It can be used for deign consisting unequal length between the leads. It auger type design increases the volume carrying capacity of the screw which is useful when material to be carried is sluggish or demands maintenance of moisture in its contents. The casing or barrel designed helps the auger type feed screw to compress the material and make it consistent for making moulds. This action is important for most of the food products. The pressing ratio will depend on the slant angle created by the auger type feed screw. Maintaining a small angle is important for proper pressing and indirectly reducing the torque because as the angle increases, it will increase the amount of material to be compressed with increase in compression ratio. By designing the auger type feed screw and casing it can be used for many food extrusion applications.

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