"DESIGN AND FABRICATION OF SPICES PROCESSING MACHINE"

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ABSTRACT: *Spices are very important and essential for adding and enhancing flavor, taste and scent in preparation of food. They are also useful in preparation of certain medicine. India is the largest producer, consumer and exporter of spices Andhra Pradesh, Gujarat, Orissa, Rajasthan are major states producing varieties of spices. Crushing of spices is an important activity in rural areas both for self- sustenance as well as source of subsidiary income to small farmers & agricultural labors.As of today, in the rural household, throughout the country the rural people use pounding method for crushing. Spices are essential ingredients adding taste and flavor in food preparations.There are about 30 types of fruits and seeds that are commonlyused as spices and for flavoring purposes throughout the world. To overcome this ponding process some special arrangement are made. In this spices processing machine crushing of spices taking place by using motor, gear box,chain sprocket arrangement also with some up and down arrangement so that spices will crush out.main objective of this machine is to crush the spices by using some mechanical arrangement.*

1. INTRODUCTION

A spice is a seed, fruit, root, bark or other plant substance primarily used for flavouring, colouring or preserving food. Spices are distinguish from herbs, which are leaves, flowers, or stems of plant used for flavouring or as a garnish. Many spices have antimicrobial properties. This may explain why spices are more commonly used in warmer climates, which have more infectious disease and why the use of spices is prominent in meat, which is particularly susceptible to spoiling. Spices are sometimes used in medicine, religious rituals, cosmetics or perfume production.

With changing of life style and especially with changes of food habits and increase of income level, the use of powdered spices has increased. Of late, the market for ready mix of spices has grown significantly. Export market for Indian spices is also growing- it was Rs. 2025 crore during 2000-01.Thus the market is huge with potential for quality producer. Numbers of brands have appeared in the market such as Sona, MDH, Ashok Masala, Sunrise etc. besides these, some of local brand are also there in the market.

1.1 Early history

The spice trade developed throughout South Asia and Middle East by at earliest 2000 BCE with cinnamon and black pepper, and in East Asia with herbs and pepper. The Egyptians used herbs for mummification and their demand for exotic spices and herbs helped stimulate world trade. The word spice comes from the Old French word espice, which became epice, and which came from the Latin root spec, the noun referring to "appearance, sort, kind": species has the same root. By 1000 BCE, medical systems based upon herbs could be found in China, Korea, and India. Early uses were connected with magic, medicine, religion, tradition, and preservation.

Cloves were used in Mesopotamia by 1700 BCE.The ancient Indian epic Ramayana mentions cloves. The Romans had cloves in the 1st century CE, as Pliny the Elder wrote about them.

The earliest written records of spices come from ancient Egyptian, Chinese, and Indian cultures. The Ebers Papyrus from Early Egyptians that dates from 1550 B.C.E. describes some eight hundred different medicinal remedies and numerous medicinal procedures.

Historians believe that nutmeg, which originates from the Banda Islands in Southeast Asia, was introduced to Europe in the 6th century BCE.

Indonesian merchants travelled around China, India, the Middle East, and the east coast of Africa. Arab merchants facilitated the routes through the Middle East and India. This resulted in the Egyptian port city of Alexandria being the main trading center for spices. The most important discovery prior to the European spice trade was the monsoon winds (40 CE). Sailing from Eastern spice cultivators to Western European consumers gradually replaced the land-locked spice routes once facilitated by the Middle East Arab caravans.

In the story of Genesis, Joseph was sold into slavery by his brothers to spice merchants. In the biblical poem Song of Solomon, the male speaker compares his beloved to many forms of spices.

1.2 Middle Ages

Spices were among the most demanded and expensive products available in Europe in the Middle Ages, the most

common being black pepper, cinnamon (and the cheaper alternative cassia), cumin, nutmeg, ginger and cloves. Given medieval medicine's main theory of humorism, spices and herbs were indispensable to balance "humors" in food,[6] a daily basis for good health at a time of recurrent pandemics. In addition to being desired by those using medieval medicine, the European elite also craved spices in the Middle Ages. An example of the European aristocracy's demand for spice comes from the King of Aragon, who invested substantial resources into bringing back spices to Spain in the 12th century. He was specifically looking for spices to put in wine, and was not alone among European monarchs at the time to have such a desire for spice.

Spices were all imported from plantations in Asia and Africa, which made them expensive. From the 8th until the 15th century, the Republic of Venice had the monopoly on spice trade with the Middle East, and along with it the neighboring Italian maritime republics and city-states. The trade made the region rich. It has been estimated that around 1,000 tons of pepper and 1,000 tons of the other common spices were imported into Western Europe each year during the Late Middle Ages. The value of these goods was the equivalent of a yearly supply of grain for 1.5 million people.[8] The most exclusive was saffron, used as much for its vivid yellow-red color as for its flavor. Spices that have now fallen into obscurity in European cuisine include grains of paradise, a relative of cardamom which mostly replaced pepper in late medieval north French cooking, long pepper, mace, spikenard, galangal and cubeb.

1.3 Early Modern Period

Spain and Portugal were interested in seeking new routes to trade in spices and other valuable products from Asia. The control of trade routes and the spice-producing regions were the main reasons that Portuguese navigator Vasco da Gama sailed to India in 1499.When Gama discovered the pepper market in India, he was able to secure peppers for a much cheaper price than the ones demanded by Venice. At around the same time, Christopher Columbus returned from the New World. He described to investors new spices available there.[citation needed]

Another source of competition in the spice trade during the 15th and 16th century was the Ragusans from the maritime republic of Dubrovnik in southern Croatia.

The military prowess of Afonso de Albuquerque (1453–1515) allowed the Portuguese to take control of the sea routes to India. In 1506, he took the island of Socotra in the mouth of the Red Sea and, in 1507, Ormuz in the Persian Gulf. Since becoming the viceroy of the Indies, he took Goa in India in 1510, and Malacca on the Malay peninsula in 1511. The Portuguese could now trade directly with Siam, China, and the Maluku Islands.

With the discovery of the New World came new spices, including allspice, chili peppers, vanilla, and chocolate. This development kept the spice trade, with America as a late comer with its new seasonings, profitable well into the 19th century.

1.4 Contemporary history

One issue with spices today is dilution, where spices are blended to make inferior quality powdered spices, by including roots, skins and other admixture in production of spice powder.

2. PRODUCTION

India contributes 75% of global spice production.

Top Spice Producing Countries (In metric tonnes)

Spice	Largest Producer	Second Largest Producer
Cardamom	Guatemala	India
Ginger	India	China
Turmeric	India	Pakistan
Chili pepper	India	China
Cumin	India	Turkey
Vanilla	Indonesia	Madagascar
Nutmeg	Indonesia	Grenada
Cinnamon	Indonesia	China
Cloves	Indonesia	Madagascar
Saffron	Iran	Spain
Pepper	Vietnam	India

Some of spices are in powder form

Front view of machine

3. PROBLEM IDENTIFICATION:

- **MARKET PROSPECT**

India is the world's biggest exporter of spices. There is good scope for domestic market for this commodity in processed form. The market for export of spices is encouraged in processed form as it will bring more value addition to the unit price of whole spices. The demand for spice powder is increasing day by day with the changing attitude as well as improvement in purchasing power of the people. The products find good market in the urban areas of the country particularly within the state itself.

Market Promotion plays a vital role for the generation of the potential customers therefore, application of marketing strategies is recommended. Marketing plan of the proposed project may include good quality maintenance, promotional campaign like offering special discounts, referrals, advertisement and tying up with buying houses.

4. PROCESS DETAILS:

(i) Washing: First of all, the spices are washed with water under high pressure to remove impurities.

(ii) Peeling & Cutting to Small Pieces: Some spices require peeling and cutting to small pieces. Such spices are peeled with hand knives.

(iii) Drying: Spices are spread on the floor to provide sun drying. At times, mechanical dryers are also used. Tray type dryer is most suitable.

(iv) Grinding/ Pulverising: Spices are grinded in dry form.

(v) Mixing: After all the above operations, various spices for different purposes are mixed together.

(vi) Packaging: At the end, spices powder are packaged in automatic form, fill and sealing machine.

(vii) Transportation and Marketing: Thereafter, the products are transported and supplied to the bulk purchasers.

5. SMALL-SCALE SPICE PROCESSING

5.1 Correct harvesting time

It is not possible to produce a high quality spice from low quality, inferior material. Harvesting spices at the correct point of maturity is the key to producing good quality products. Quite frequently spices are harvested when they are immature and before the flavour and aroma compounds have fully developed. This results in spices with an inferior taste and aroma. Early harvesting is usually through fear of the crop being stolen or because the farmer requires money urgently. Every effort should be made to wait until the spices are fully mature before harvesting.

5.2 Cleaning

Spice crops are quite often contaminated by dust, dirt, pesticides, insects, animal hair and droppings and a range of microbes. The crop must be cleaned before processing. The first stage is to remove dust and dirt using a winnowing basket. This can be made locally from bamboo, palm or other leaves. Someone used to this work can remove the dust, dirt and stones quickly and efficiently (eg they could clean 100kg of pepper in an eight-hour day). Small machines are available for cleaning but they are rarely cost effective. After winnowing the crop should be washed in clean, potable water. Washing should be quick so that the spice is not soaked in water as this reduces the quality. The washing water must be changed regularly to prevent recontamination of spices by dirty water. It is essential that clean water is used as spices are not heat treated later on during processing. Dirty water introduces more bacteria, many of which cause food poisoning.

5.3 Drying

This is by far the most important part of processing to ensure good quality spices. Inadequately dried produce will lead to mould growth. The sale value of mouldy spices can be less than 50% of the normal value. In addition, the growth of food poisoning bacteria on some spices is a real danger if proper washing and drying is not carried out. Spices contain volatile oils that are adversely affected by high temperatures. Therefore the temperature of drying must be tightly controlled to ensure a high quality dried product. Most small-scale processors dry the crop by spreading it in the sun. This is another opportunity for the crop to become contaminated. All

efforts should be made to ensure that the crop is dried in a clean place, away from animals, insects and birds.

5.4 WORKING PRINCIPLE

Spices Processing Machine is Designed to Operate on electrical 0.5 HP single phase motor for smooth operation of spice processing by using Chain and Sprocket Mechanism and the Power for the Crusher operation is taken from an 1440 rpm electrical motor. It is designed to use a single phase motor for the crusher operation as the power required for crushing the spices. The machine has been constructed in such a way that it can be operated by electric supply. The drive unit consists of an electrical motor of 0.5Hp a gear box having ratio of 30:1, this electrical motor is used to provide reciprocating motion to the hammering rod. Power supply of 230volt AC is used to drive this motor with 1440 rpm which is further reduced by gear box which is connected to another shaft with the help of sprocket and chain mechanism for smooth operation. In this machine the power of motor is transferred by using of chain drive is made to avoid slippage problem.

6. CHAIN DRIVE

Chain Drive mechanism constitutes two sprockets, one is called driver and the other is called driven, and a chain. Chain itself constitutes various links and each link is formed by joining roller, plates and pin.

The most former of all machine elements were the Chain Drives. Chains normally have lesser weight as compared to their counterparts such as gear drives or belt drives. Slip might occur on belt and rope drives, but chains are used to prevent slipping. Many stiff links are used to make chain; these links are connected through pin joints to allow required flexibility for rolling around the driven and driving wheels. Special profile teeth are protruded on these wheels. Teeth met matching recesses present in chain links. Therefore, chain and sprocket are restricted to proceed together in the absence of slip with hone velocity ratio. When power and motion are to be transferred over a short distance between the shafts, chains are used. For example, in rolling mills, motor cycles, conveyors etc.

6.1 Advantages of Chain Drive over Belt or Rope Drive

1. In chain drive slip is zero so exact velocity ration occur.
2. chain drive is used for short as well as for long distance.
3. transmission efficiency is as high as 98 percent.
4. One chain could transfer motion to several shafts.
5. More power is transfer.
6. chain drive might be used in adverse atmospheric and temperature conditions.
7. Mostly metal chains are used, hence in width very less space is occupied as compared to rope or belt drive.
8. Chain drive is positive drive.
9. Unlike belt drives, angular velocity remains constant in chain drives
10. It allows high speed ratio of 8 to 10 in one single step
11. Highly efficient, chain drives give the advantage of more power compared to belts
12. They can operate even in wet conditions.
13. Chain drives do not deteriorate due to sunlight, oil, grease, or age
14. Lower load on shaft than belt drives.

6.2 Disadvantages

1. Production cost is high.
2. Maintenance and accurate mounting is required.
3. Excessive stretching could cause variation in velocity.

6.3 Gear box

The gear box is the second element of the power train in an automobile. It is used to change the speed and torque of vehicle according to variety of road and load condition. A gear box changes the engine speed into torque when climbing hills and when the vehicle required. Sometimes it is known as torque converter.

A gear box can either change the direction a rotary motion is being transmitted, or it can change the speed of that motion, changing speed for torque.

6.4 Why gear box is required

Most modern gearboxes are used to increase torque while reducing the speed of a prime mover output shaft (e.g. a motor crankshaft). This means that the output shaft of a gearbox rotates at a slower rate than the input shaft, and this reduction in speed produces a mechanical advantage, increasing torque.

6.5 Equations

The design proceeded from two known values, one is motor RPM i.e. driver's RPM, and second is Driven speed in RPM. From these two-values velocity ration can be calculated. The determination of number of teeth for smaller sprocket is the most important step in the design. It is due to the number of teeth on a sprocket played vital role in adjusting or determining the performance of drive system. Numbers of teeth have direct effect on efficiency of system, with lesser number of teeth the system become noisier and by increasing the number of teeth centrifugal and frictional forces can be reduced along with reduction in shocks.

$$\text{Velocity ratio} = \frac{N_1}{N_2} = \frac{T_2}{T_1}$$

N_1 = number of revolutions per minute (R.P.M) of smaller sprocket

N_2= number of revolutions per minute (R.P.M) of larger sprocket

T_1= number of teeth on the larger sprocket

T_2= number of teeth on the smaller sprocket

6.6 Calculation for shaft

Velocity ratio $=\frac{N_1}{N_2}=\frac{T_2}{T_1}$

$$\frac{40}{N_2}=\frac{15}{23}$$

$$N_2=\frac{40}{15}\times 23$$

$$N_2=61.333\ rpm$$

Power Supply = 0.5 hp

Design power $(P)_d=(P)_R\times k_1$

$= 0.5 \times 1.7$

$(P)_d = 0.85$kw

Design torque, $T_d=\frac{60\times P\times k_1}{2\Pi N}$

$=\frac{60\times O\cdot 85\times 100\times 1.7}{2\Pi\times 61.33}$

T_d= 22.499N-m
τ =175…….from data book.
Maximum stress,

T = $\frac{\pi}{16}\times\ \tau\times d^3$

$d^3=\frac{16\times T}{\pi\times\tau}$

$$d=\frac{16\times 224.99\times 1000}{\pi\times 175}$$
$$d=18.708\ mm$$

Therefore selecting the shaft of 19 mm.

Calculation for chain and sprocket

The chains were used to transmit motion and power from one shaft to another because the distance between the centers of the shafts was short. Chain drive gave high transmission efficiency as no slippage took place. The chains were made up of rigid links which were hinged together in order to provide the necessary flexibility for warping around the driving and driven wheels. The wheels had projecting teeth and fit into the corresponding recesses, in the links of the chain. The wheels and the chain were thus constrained to move together without slipping.

Design of chain and sprockets:
P = Pitch of the sprocket
d = Diameter of the pitch circle, and
T = Number of teeth on the sprocket.

$P=d\ sin(360^0\ /\ 2T)$

P= 60 x $sin\ (360^0/\ 2$x15)

$P=12.4\ mm$

The exact length of the chain (L) was determined as:

$$L=\left\{\frac{P(T_1+T_2)}{2}+2\varkappa+\left[\frac{P}{2}csc\left(\frac{180^0}{T_1}\right)-\frac{P}{2}csc\left(\frac{180^0}{T_2}\right)\right]/\varkappa\right\}$$

T1 = Number of teeth on the larger sprocket,
T2 = Number of teeth on the smaller sprocket
X = Centre distance between sprockets
Motor side chain length:
L = {12.4 x (15+23)/2+ 2 x 450 + [p/2 cosec (180/23) – p/2 cosec (180/ 15)]/450}
L = 1135.63 mm

7. .CONCLUSION

Design and fabrication of spices processing machine was interesting in itself, as it required new and different approaches to solve the problem from those which were used for fabrication of machine. It was better to use existing technology to improve the performance of machine by using chain drive. Chain drives were better suited in this application as they offered zero slip and occupied less space as compared to belt drive and gear drive. Its transmission efficiency is as high as 98 percent. During design & fabrication phase it was considered that smallest possible design was designed which could be easily manufactured from local market.

According to Jack Warner who is a tech enthusiast, Energy is essential for driving the machines and equipment for various applications. Different industries use different power transmission products and sometimes a combination of all to suit their respective needs. if someone ask which is the best power transmission technology, it will be little difficult to select one over another as these drives come with their own sets of pros and cons. The only determining factor, therefore, should be the task that needs to be accomplished using the power transmission technology. And of course, the budget too.

8. REFERENCES

[1] Senthil Kannan.N1, Naveen Prasad.D2, Nirmal Kumar.R2, Premvishnu.R.S2.2016.Design of Mechanical Crushing Machine. Journal of Engineering and Technology,921-926. Vol. no. 03 issue: 01

[2] Mohd. Shahjad Aspak Sheikh.2015.Design and Fabrication of Pedal Operated Chilli Crusher Machine. International Journal on Recent and Innovation Trends in Computing and Communication.26-30. Vol.no.3 issue: 2

[3]SohailAnjum, Nabeel Kamal, Umar Shahbaz Khan, JavaidIqbal, Umar Izhar, NasirRasheed, M.A.Khan.october2012.Design of Non-Conventional Chain Drive Mechanism for a Mini-Robot.IEEE.103-107. DOI: 10.1109/ICRAI.2012.6413403.

[4]Parag Nikam1, Rahul Tanpure2. Sepember.2016. Design Optimization Of Chain Sprocket Using Finite Element Analysis. Journal of Engineering Research and Application.66-69.Vol no.6 issue: 9

[5]Akpo-Djènontin D. O. O.1, Anihouvi V. B.1*, Vissoh V. P.1, Gbaguidi F.2 and Soumanou M.3.2016.Processing, storage methods and quality attributes of spices and aromatic herbs in the local merchandising chain in Benin. African Journal of Agricultural Research.3538-3547.Vol. 11(37). DOI: 10.5897/AJAR2016.11262

[6]B.D. Shivalkar.2017.design data for machine elements.

[7] Ploj a, B. Mursec a, F. Cusb, U. Zuperl b.2000. Characterization of machines for processing of waste materials. Journal of Materials Processing Technology.338-343. doi:10.1016/j.jmatprotec.2005.04.062.

[8] Carina Ulsena, Ester Tsengb, Sérgio Cirelli Anguloc, Mirko Landmannd, Renato Contessotto a, José Tadeu Balbo b, Henrique Kahna.2018.Concrete aggregates properties crushed by jaw and impact secondary crushing .journal of material research and technology.1-9. https://doi.org/10.1016/j.jmrt.2018.04.008

[9] Marcus Johansson, Magnus Bengtsson, Magnus Evertsson, Erik Hulthén.2017.A fundamental model of an industrial-scale jaw crusher.69-78. http://dx.doi.org/10.1016/j.mineng.2017.01.012.