Theoretical assumptions and selection of Dies and Punch for the rotary camphor tablet making machine

Rushabh Rathod[1], Rohit Pawar[2], Pratik desai[3], Muzammil Bepari[4]
[1,2,3] *Department of Mechanical Engineering, Annasaheb Dange College of Engineering, Ashta, Sangli, Maharashtra, India*
[4]*Assistant Professor, Department of Mechanical Engineering, Annasaheb Dange College of Engineering, Ashta, Sangli, Maharashtra, India*

***Abstract*- Tablet compressing is an established manufacturing process with multiple applications in pharmaceutical, dietary supplement, food, cosmetic, diagnostic, and other industries. Actual tablet compressing may be subdivided into four stages: Filling, metering, compression, and ejection. The current overall research is oriented on tablet used in the medical field, where the accuracy, weight and drug content is more important. This paper specifically deals with the camphor tablet making machine. In this study various types of tablet compressing machines and tooling methods are discussed. In this work, selection of tooling is done by referring to the TSM (Tablet Specification Manual), which specify the dimensions of punch and dies and other factors affecting the machine. By using rotary tablet making machines the production rate and quality of product is increased. In future work can be carried out in adjustable die system with many other creative and innovative applications.**

***Index terms*- Adjustable die, Production rate, Quality, TSM (Tablet Specification Manual).**

I.INTRODUCTION

In the present scenario most of the organisations are going for automation to achieve higher production rate. Automation reduces human effort and it increases the quality of the product automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices and computers, usually in combination. Complicated systems, such as modern factories, airplanes and ships typically use all these combined techniques. The benefit of automation includes labour savings, savings in electricity costs, savings in material costs, and improvements to quality, accuracy, and precision.

Camphor or Kapoor as most commonly termed in Hindi language, is an ingredient that is related to having its religion importance. It is a widely used puja samagri and a part of Indian culture. The ingredient is found in crystalline solid form, and is best preferred for its strong fragrance. It is basically extract from a special plant called as Camphor Laurel. Camphor is mainly manufactured in three types that are oil, powder and tablet. The tablet form of camphor is produced using different types of machines. In camphor tablet making machine automation is used to increase production rate and quality of the product.

Camphor Tablet Making Process

Camphor powder is converted into tablet by mainly four stages which are- Filling, Metering, Compression and Discharge. These are explained below:

A. Filling

The filling stage of the tablet compression process involves transfer of raw materials into position for tablet compression. These raw materials have undergone prior processing by wet granulation, dry granulation (roller compaction), sizing, or other processes. The final formulation is then blended to yield a homogeneous blend. The blend then flows to the compressing machine punch-die cavity. The punch-die cavity is composed of punch die and lower punch. The position of the lower punch within the die determines the volume of the punch-die cavity. This volume must be appropriately sized for the weight of granulation to be compressed into tablets. The granulation is overfilled on the die table (turret) to ensure complete filling of the punch-die cavity volume.

B. Metering

The metering stage of the tablet compressing process involves removal of excess granulation from the compressing machine. This stage enables the exact weight (volume) of granulation to be compressed into tablets. The exact weight of granulation is controlled by the height of the lower punch in the die. The height of the lower punch is controlled by the metering cam (also called the dosage cam). The lower punch is raised to the appropriate level in the die to provide the exact weight of granulation in the punch-die cavity. The excess granulation is scraped from the surface of the die table. The metering stage is similar to the method used to measure flour when baking a cake. A measuring cup is first over-filled with flour; then a knife is used to scrape off the excess. The exact amount of flour is then left in the measuring cup.

C. Compression

The compression stage of the tablet compressing process forms the tablet. This stage involves bringing together the upper and lower punches under pressure within the die to form the tablet. As the punches enter the compressing stage, the upper and lower punches move between two large wheels called pressure rolls. These pressure rolls push the punches together to form the tablet. The distance between the upper and lower punches determines the thickness and the hardness of the tablet. When the punches are close together, a thin and hard tablet is created. When the punches are farther apart, the tablet made is softer and thicker. The proper balance of thickness and hardness determines the optimum roll distance for any specific product. These adjustments are made while keeping the tablet weight constant.

D. Ejection

The ejection stage of the tablet compressing process involves removal of the tablet from the lower punch-die station. In this stage, the upper punch retracts from the die cavity and rises above the turret table. Then the lower punch rises in the die, which in turn pushes the tablet upward to the top surface of the die table and out of the die cavity. A scraper (also called take-off scraper or tablet rake-off) then pushes the tablet off the die table away from the compressing machine into the collection container. “This paper is focused more on the camphor making machine. Currently there are only machines for tablets making of medical field. So this paper gives the extra information about camphor making machines.”

II. LITERATURE

Stephen and Hunsalz (1905) invented the method of making camphor by transforming the burnole into camphor by oxidizing agents as chromic acid, permanganate, and the like. In this work they discovered some drawback in purification but they overcame it by using ozone as the oxidising agent. The process of manufacturing camphor which consists in oxidizing borneol by means of ozone and separating the resulting camphor. And in another way the process of manufacturing camphor which consists in dissolving borneol by a suitable, liquid solvent, conducting ozone into the solution, and separating the resulting camphor.

Tablet compressing is established technology, and its principles have been well documented for many years. The actual specific stages of tablet compressing on the compressing machine are very simple: filling or overfilling, metering to remove excess, compressing under pressure, and ejecting the formed tablet. The activities in a typical compressing operation are repetitive and controlled by procedures. Technological innovations have resulted in faster machines with increased productivity, new and creative applications, greater monitoring capabilities, and other improvements. These improvements, however in some cases, have come with more stringent requirements for material and process control.

A. Rotary tablet compressing machine

In a rotary tablet-compressing machine comprising a frame, a rotating head moving in a given direction, an upper punch and a lower punch, said punches being reciprocally mounted in said head for cooperating axial movement relative to each other, an upper and lower compression roller positioned at the top and bottom of the said head and contacting the upper and lower punches respectively: a cam element extending in said direction from the top of said lower roller, the end of said cam at said roller riding on said roller, said cam being pivotally mounted on said frame adjacent the end of said cam in said direction, said end of said can in said direction being at a substantially greater elevation than said end of said

cam at said roller, said cam having a curved cam track; and means to resiliently urge said end of said cam at said roller toward said roller.

In a rotary tablet-compressing machine the combination comprising a rotating head, an upper punch and a lower punch, said punches being mounted in said head for cooperating axial movement relative to each other, compression rollers located at the top and bottom of said head and contacting the upper and lower punches respectively, a cam means having a forward edge thereof in riding engagement with the bottom compression roller at the most elevated part on the peripheral surface of the bottom compression roller and having a narrow flat ridge dis posed on its upper surface said upper surface inclined gradually upwardly to a flat horizontal surface, said cam enclosed in a cam assembly which is of a curved con figuration so as to conform to the circular pattern of the tablet machine.

In a rotary tablet-compressing machine the combination comprising, a rotating head, an upper punch, and a lower punch, said punches being mounted in said head for cooperating axial movement relative to each other, compression rollers located at the top and bottom of Said head and contacting the upper and lower punches respectively, a cam means having the forward edge thereof in riding engagement with the bottom compression roller at the most elevated part on the peripheral surface of the bottom compression roller and having a narrow flat ridge disposed on its upper surface said upper surface inclined gradually upwardly to a flat horizontal surface, said cam enclosed in a cam assembly and secured therein by means of a pin which is inserted transversely through accommodating openings in the cam and the cam assembly.

In a rotary tablet-compressing machine the combination comprising a rotating head, an upper punch and a lower punch, said punches being mounted in said head for cooperating axial movement relative to each other, compression rollers located at the top and bottom of said head and contacting the upper and lower punches respectively, a cam means comprising a cam assembly with a cam element mounted therein, said cam element having the forward edge thereof in riding engagement with the bottom compression roller at the most elevated part on the peripheral surface of the lower compression roller and having a narrow flat ridge disposed on its upper surface said upper surface inclined gradually upwardly to a flat horizontal surface, said can element being pivotally secured in the cam assembly by means of a pin and held resiliently in riding engagement with the said lower roller having a spring means mounted in said cam.

B. Types of Camphor Tablet Making Machine

Single station tablet press

A single station tablet press machine is the simplest tableting equipment. At times, you may also call it a single punch or eccentric press. Depending on its design, you can operate the machine manually or incorporate an electric motor. Normally, this machine features a single tooling station with a die, pairs of lower and upper punches. Therefore, the compression force of the machine is due to the upper punch only. During this period, the lower punch remains stationary. This implies that the working process tends to be similar to that of hammering motion.

Multi-station tablet press

A Multi-station press tablet manufacturing machine, also called a rotary press is one of the most popular equipment in the pharmaceutical industry. This is due to its high production capacity and cost saving benefits. Like the single punch tableting machine, rotary presses have upper punches, dies and lower punches. The name rotary tablet press is due to the rotating tableting assembly. It is this assembly that holds dies, upper and lower punches. As one can see from the section of multi-station tablet press below, this equipment has several tooling stations. In these compression machines for tablets, it is the rotation speed of the turret and the number of stations that determine the production capacity.

C. Rotary Tableting machine Tooling

The size, shape and the identification marks of the tablet are determined by the compression machine tooling, i.e., the punches and dies. The tooling must meet the specific requirements to satisfy the needs of dosage uniformity, production efficiency and aesthetic appearance. Internationally there are two recognized standards for tablet compression tooling: the TSM standard and the EU standard. TSM is acronym for the 'Tablet Specification Manual', widely recognized and exclusively used in the United States. The EU or 'European

Standard' is probably more widely used than the TSM standard.
Based on the TSM and EU standards, tablet tooling is mainly classified as B tooling and D tooling. The B tooling punches and dies can be further classified as BB, and D tooling can also be used on B tooling machine that is call as DB

D. Procedure for the operation of a rotary tablet press
The upper and lower punches as well as the die in should be located and fixed in the rotary pill press machine. The feed frame along with the hopper should be set up and the weight control unit adjusted for the require weight and hardness of the tablets. The hopper is next filled with the tablet powder mix or the granulated formula on starting the machine, the powder mix will be delivered by the hopper to the feed frame which feeds it into the area where the dies are located. The feed frame will confine the mix and position it over the die track. As the head revolves, the dies are located one by one under the feed frame where they are filled. Materials are then compressed by the upper and lower punches into the dies sequentially.
The overall research is oriented on tablet used in the medical field, where the accuracy, weight and drug content is more important. But in case of camphor these factors are not taken into consideration. The factors which are taken into considerations for camphor are hardness, production rate and the quality of camphor tablet. Because as the demand of camphor is increasing day by day. So there is need of designing a machine which is specifically developed for making camphor tablets. And this machine can be developed by setting some objectives in mind like more production rete, lesser the powder waste, less noise and vibrations of the rotating parts and hence ultimately resulting into better life of all parts and collectively as a machine.

III. RESEARCH METHODOLOGY

In this, the proper type of tooling is selected by referring to the TSM (Tablet Specification Manual), which specify the dimensions of punch and dies and other factors like number of stations, pressure required for the compression and the depth of die.

In between B and D type of tooling the B type is selected due to 40% higher production rate and smooth running at high speeds.
Now following are the various types of punches and dies and one of these is selected for the design of this machine.

A. Dies and Punch
Punch
Punches are classified according to their overall length, barrel diameter, and the O.D. of the punch head. These dimensions, as well as the other specifications for tablet tooling, are nominal: that is, each dimension has a specified measurement, but its actual measurement after the tool is produced may vary from its specification. The allowable variance from a nominal dimension, called its tolerance range.
The punches most commonly used in production presses are the B-type and D-type punches.

Die
Dies are classified according to their outside diameters.
The 0.945 Die: As the name indicates, has an O.D. of 0.945 inch [24.00 millimetres]. This size die can be used with B- and B2-type punches. The die is commonly referred to as a "BB die."
The 1.1875 Die: Sometimes referred to as the "1 3/16 die," has an O.D. of 1.1875 inches [30.16 millimetres] and also can be used with B- and B2-type punches. This die is commonly referred to as a "B die."
The "D" Die: Which has an O.D. of 1.500 inches [38.10 millimetres], is used with D-type punches.

B. Die system
The punch and die makes a die system and the movement of tablet press machine punches, takes place within the die bore or cavity. Therefore, the punch and die must be machined together to ensure compatibility. It is in the die cavity that the powder is compressed into desired tablets of definite thickness and size
It is the die cavity that determines both the thickness and size of a tablet. Like the punches, a die system should have the following key features:
1 Clean impression on every punch
2 Prevent chipping or damaging of tablets
3 Feature anti-corrosion protection

4 Have non-stick treatment

Other critical features should consider for machining a tablet press die system include:

1 Tapering angle: this is a critical aspect since it allows excess air to escape, while the die set is made up of Aluminium – Silicon alloy by replacing the tool steel material which enhance the high ductility and high hardness level. This material is suggested for light weight of the die and it tends to deforms while the thrust force is applied, regain its original shape. However it is good corrosion resistance. It is able to sustain up to 10 bar pressure which is applied by the hydraulic press minimizing the tablet ejection force and frictional heat.
2 Other technical specifications include die height, chamfer, die bore and die diameter.

C. Selection of Punches and Dies

Punches

For this machine 'B' type Press (TSM) tool is selected due to its high production rate over the D type press tool.

"B" Type Multi-station Press

The diameter of the punch barrel is 0.75 inches or 19mm.In most cases, you can use with two types of dies:

1 "B" dies that have 1.1875 inches (30.16mm) diameter
2 "BB" dies with a diameter of 0.945 inches (24mm)

Table: Specification of B Type Dies (Source: TSM-Tablet Specification Manual)

Tool	'B'
Number of stations	16
Maximum output (tab/hr)	28800
Maximum pressure (tom)	6
Maximum tablet die	13
Length of punch	133.65
Maximum depth of fill	17.5

Dies

For this machine Progressive dies are used.

Progressive Dies

In progressive dies, the work pieces move from the first station to successive which carries variable operations, to be performed in individual station. Each stations works in series manner and the work piece is placed in stock till at the end of station which cuts off finished piece. End of the each stroke, the stock is moving towards by one station and the complete work piece is constructed in a single stroke of ram.

It can be designed for complicated operations of bending, forming etc. In these dies, indexing at every station is very important and therefore accuracy is not much. However, it is simple in design.

Clearance in dies and punches

Clearance = (D - d)

Where,

D = diameter of the die

d = diameter of the punch

Hopper

The tablet compression process starts from here. It is at this point that you'll put all powder you intend to compress into tablets. Tablet press hoppers come in wide range of shapes and designs. Whatever the shape, it should be such that the material can flow seamlessly into the tablet compression chamber. Again, since it is one section that is in direct contact with the material, it is made of stainless steel.

Depending on the design of a tablet press machine, you can fill the powder manually or using other automated systems. As tablet press machine manufacturer, we put every measure in place to ensure there is a consistent flow of powder from the hopper to compression systems.

Here are major concerns that we have addressed so far:

1. Hoppers may feature optimal flow angles to facilitate flow, especially where it is nearly impossible to adjust formulation.
2. Some hoppers may feature vibratory rods. This is done carefully to enhance product flow and to prevent possible product separation.

At any given point, the design of these tablet compression machine parts aims to eliminate possible feeder starvation.

Calculation of volume of Hopper:

$$\text{volume} = \frac{\pi h}{3}(R^2 + Rr + r^2)$$

Where;

R= Upper radius

R= Bottom radius
H= Height of Hopper

Rotary Plate

1. From the standard table we have to design a rotary plate having 16 work punches.
2. Rotary plate is used to carry punches and rotates the punches
3. Rotary plate is rotating

Base plate

4. Base plate consists of 16 dies
5. Base plate is used to carry dies
6. Base plate is stationary

By using these standard formulae's the dimensions of these parts are calculated.

IV. CONCLUSION

This discussion has addressed the basics of tablet compressing with emphasis on considerations for the compliance professional. Tablet compressing is established technology, and its principles have been well documented for many years. The actual specific stages of tablet compressing on the compressing machine are very simple: filling or overfilling, metering to remove excess, compressing under pressure, and ejecting the formed tablet. The activities in a typical compressing operation are repetitive and controlled by procedures. Technological innovations have resulted in faster machines with increased productivity, new and creative applications, greater monitoring capabilities, and other improvements.

REFERENCES

[1] Stephan and Hunsalz,-process of making camphor, U S patent 801483, Oct.10, 1905.
[2] Armin H. Gerhardt, Fundamentals of Tablet Compression, Journal of GXP Compliance, volume 14, 2010.
[3] Leo Manley, Jon Hilden, Tablet Compression force as a process analytical technology (PAT), Journal of pharmaceutical sciences, 2018.
[4] Hui Ping Goah and Paul Wan Heng, Understanding die fill variation during mini-tablet production, International Journal Of pharmaceutics, 2017.
[5] SandellD and Vukovinsky k, Development of content uniformity test suitable for large sample sizes, 2006.
[6] Swaminathan S. and Ramey B, Characterising the powder punch-face adhesive interaction during unloading phase of powder compaction, 2017.
[7] Gohel M, Patel M, Amin A, Agrawal R, Dave R and Bariya N., Formulation design and optimization of mouth dissolve tablets of nimesulide using vacuum drying technique, 2004.
[8] Sugimoto M, Narisawa S, Matsubara K. and Yoshino H, Effect of Formulated Ingredients on Rapidly Disintegrating Oral Tablets Prepared by the Crystalline Transition Method, Chem. Pharm. Bull, 2006.
[9] P.C.SHARMA, A Textbook of Production Engineering, S. Chand & Company, 2000.
[10] A.K. Kumaresh et.al, Design and Analysis of Punching Die, IJRET: International Journal of Research in Engineering and Technology, 2006.
[11] TSM-Tablet Specification Manual, American Pharmacists Association (APhA), 2006.