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Design and Fabrication of Automatic Flour Mill Plate Grinding Machine

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ABSTRACT:

This automated world insisting technology by which a process or procedure is performed without human assistance. Automation is the use of various control systems for operating equipment with minimal or reduced human intervention. In our daily life we come across several flour mills. Flour mills used to grind the grains or pulses and to produce flour. At present every flour mill use a pair of grinding plate inside them to grind the grains or pulses. These plates play important role in produce the fine flour in a single try. These plates contain 22sectos each contain 10 grooves which flow toward the center of plate. Nowadays the flour mill operators repeat the process s two or more times to get the desired fineness of flour. This is due to the wear of the grinding plates if the grooves on the grinding plate are in proper condition the machine can produce fine flour. After 10 cycles of grinding operation the plates has to be re-grooved. So has to produce a good final product as flour mills became the part and parcel of human life, using innovation in its structure is blindly required one. This proposed project flour mill plate grinding machine will replace the conventional machine by its cost effective way and economy of time in the process of re-grooving the plate. This new project will assure and support the flour mill owners who was facing many difficulties during festival season

Keywords: Automated, flour mill, Grinding, Re-grooving

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1. INTRODUCTION

1.1 Flour Mill

A mill is a device that breaks solid materials into smaller pieces by grinding, crushing, or cutting. There are many different types of mills and many types of materials processed in them. Historically mills were powered by hand (e.g., via a hand crank), working animal (e.g., horse mill), wind (windmill) or water (watermill). Today they are usually powered by electricity. The grinding of solid materials occurs through mechanical forces that break up the structure by overcoming the interior bonding forces. India is 2nd largest producer of wheat producing 85-90 million metric tons (MMT) every year, accounting 12.05% of the total world wheat production. 40 to 45 MMT of wheat is ground to produce whole wheat flour, locally known as Atta in stone mills known as chakkis. Indian market is largely dominated by local flour mills.

1.2 Evolution Of Flour Mill Machine

From the stone age period to till now there is a lot of innovation done by humans as below.

1.2.1 Early Milling Machine

The first ever flour milling machine was two stones one at the top and another at the bottom. We all know wear is produced when two stones against each other, by placing the grains between the two rubbing stones, the grains get grinded and crushed finally we get the flour. Addition of lever and extension of top stone (hopper) made the work easier. This has been the flour producing method for thousands of years.

1.2.2 19th Century Milling

In the 19th century, the industrial development that made possible the invention of reapers and threshing machines was also reflected in mill design and construction. Power carried by shafts, belts and gears was used to turn one or a series of stones. Water began to displace wind as a more dependable source of power and larger milling plants were built near sources of waterpower. In the United States of 100 years ago, almost every settlement where there was a source of waterpower included a small community mill. Although the trend was toward larger plants of merchant mills that produced flour for sale commercially in larger market areas, the smaller grist mill, grinding either wheat or corn and sometimes alternating as a sawmill, continued to operate. In 1870, more than 22,000 mills served the total population of about 30 million people. Most of the small grist mills were driven by waterpower.

1.2.3 Steam Engine Flour Mill

The invention of the steam engine by James Watt in 1769, the introduction of the more efficient roller mill system, and the application of the middling's purifier, combined to make possible model milling. The steam engine could be geared directly to the turning of millstones or employed to raise water into reservoirs, freeing the miller from his dependence on sources of natural power. Watt designed an English mill powered by steam

in 1780. Less than 30 years later, Oliver Evans used steam to drive a Pittsburgh flour mill. By 1870, steam was used in 5, 383 of the 22, 573 flour mills in America.

1.3 Rollers

The first mention of rollers to replace grindstones first occurred in 1558 with the publication of an engineering handbook by an Italian, Agostino Ramelli. His drawings illustrated a number of devices later adapted to modern milling. In 1662, another mechanical genius, G.A. Bockler, developed a mill using two corrugated rollers together with an agitating device for sifting the grind. Eventually the use of rollers for milling was widely adopted in western and central Europe. The second half of the 19th century was a period of immense development and change in flour milling. Hundreds of patents were issued for mechanical purifiers, sifters, cleaners, dust collectors, grain washers and other milling equipment. Together, these improvements and refinement of the basic process- separating the outer bran and germ from floury, inner endosperm- made possible the modern mill. Flour milling is perhaps not only one of the oldest industries, but also the first fully automated manufacturing process in the history of man It required a skilled labour so that the product and the worker or not affected. The fineness of the flour is reduced slightly due to some change in the pattern of the groove.

1.3.1 Hand Cutting Machines

The most commonly used machines that are used to re-groove the plates are cutting machines that are used to cut metal plates and iron rods. These machines are not manufactured for grooving purpose. Due to lack of plate grooving machines and due to the need of grooving of plates, these cutting machines are used for grooving. These cutting machines rotate at a speed of 1000rpm – 7200rpm range. It is a easily handling machine that can be used with less effort. The plate is placed on a flat surface so that the plate won't move while grinding. This reduces the life time of the plate. The complete difference in the pattern of the groove reduces the fineness of the flour. Irregular groove pattern does not produce the desired friction is required for producing a fine powder of flour.

1.4 Types of Flour Mill

There are three main types of flour used. They are

- Roller mill.
- Stamp mill.
- Plate mill.

1.4.1 Roller Mill

Roller mills first appeared in the Indian subcontinent, where they were used as sugar mills by the 17^{th} century. The Indian roller mills used the principle of rollers as well as worm gearing. Roller mills are mills that use cylindrical rollers, either in opposing pairs or against flat plates, to crush or grind various materials, such as grain, ore, gravel, plastic, and others. Roller grain mills are an alternative to traditional millstone arrangements in gristmills. Roller mills for rock complement other types of mills, such as ball mills and hammer mills, in such industries as the mining and processing of ore and construction aggregate, cement milling and recycling.

Types

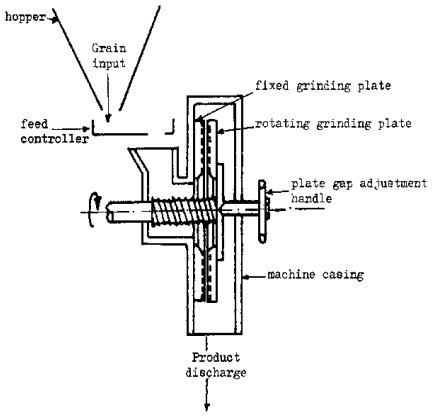
- Two roller mill
- Four roller mill
- Five six roller mill

In the 19th century roller mills were adapted to grist mills before replacing them. The mill used either steel or porcelain rollers. Between the years 1865 and 1872, the Hungarian milling industry upgraded and expanded the use of stone mills combined with roller mills in a process known as Hungarian high milling. Hungarian hard wheat so milled was claimed as integral to the "First in the world" success of the Vienna Bakery of the 1867 Paris Exposition.

1.4.2 Stamp Mill

The first stamp mill in the U.S. was built in 1829 at the Capps mine near Charlotte, North Carolina. They were common in gold, silver and copper mining regions of the US in the latter 19th and early 20th centuries, in operations where the ore was crushed as a prelude to extracting the metals.

Stamp mills are still in use in Colombia by artisanal miners, powered by electric motors. Stamp mill (or stamp battery or stamping mill) is a type of mill machine that crushes material by pounding rather than grinding, either for further processing or for extraction of metallic ores. Breaking material down is a type of unit operation. Each one frame and stamp set is sometimes called a "battery" or, confusingly, a "stamp" and mills are sometimes categorised by how many stamps they have, i.e. a "10 stamp mill" has 10 sets. They usually are



arranged linearly, but when a mill is enlarged, a new line of them may be constructed rather than extending the line. Abandoned mill sites (as documented by industrial archaeologists) will usually have linear rows of foundation sets as their most prominent visible feature as the overall apparatus can exceed 20 feet in height, requiring large foundations. Stamps are usually arranged in sets of five.

1.4.3 Plate mill

In India, grinding stones (Chakki) were used to grind grains and spices. These consist of a stationary stone cylinder upon which a smaller stone cylinder rotates. Smaller ones, for household use, were operated by two people. Larger ones, for community or commercial use, used livestock to rotate the upper cylinder. This is basic principle of plate mills. Plate mills are made of a cast iron base to which are attached two enclosed vertical grinding plates. One plate is fixed while the other is belt-driven from an electric motor (0.4 to 4 kW), or diesel engine (in the range of 11 to 19 kW). The moving plate rotates at a speed of approximately 600 rpm. The grain

is screw-fed from a conical hopper into the gap between the two plates. This gap may be adjusted to vary the fineness of the ground material. The grinding plates, approximately 25 cm in diameter, are made from hardened cast steel. They are grooved to aid the shearing (cutting and crushing) and grinding of the grain. Different plates, with a range of groove sizes, may be used for the production of meals of varying textures. The hourly output of plate mills depends upon the required fineness of the product and the variety and moisture content of the original grain. Electric plate mills have an output of approximately 67 kg per KW per hour.

2.1 General

A vast amount of literature has been studied about the performance of the flour mill plate inside a flour mill and some are mentioned below

2.2 Literature Review

John Everett has made an review examinations of the historical economic geography of the Prairie Provinces have tended to emphasize the significance of "raw" wheat over "manufactured" flour when studying "staple" production. However, the present cultural landscapes of this region might have been quite different if the production of milling quality wheat had not been successfully developed. In this paper the spatial and economic evolution of the flour milling industry in the Prairie Provinces of Canada is examined. It is argued that two distinct aspects of the flour milling industry should be distinguished. As the economics of flour milling have changed most of these smaller enterprises have fallen by the wayside. Bradley H.Baltensperger made a review of interplay of three factors—availability of marginal land for intensification, patterns of technological change in agriculture, and the economic viability of farms-best explain spatial and temporal patterns of farm enlargement in the central Great Plains between 1930 and 1978.

WORKING OF FLOUR MILL

3.1 Grinding Area

The most important parts of flour mill are hopper, grinding plates, then the receiving area. Hopper is where we give input for example wheat grinding area is where the grinding plates are present which is used to grind the grains finally the receiving area The grinding plates are mostly made of mild steel. First wheat is prepared for grinding and Then it is poured into the hopper, the hopper has port at the its bottom where It joins with the grinding area only when the port is open the wheat enters the grinding area. In the grinding area the wheat is caught between the two grinding plate among one is stationery and the other is rotating.

3.1.1 Specification of Grinding Plate:

Specification of Grinding Plate (Standard) is mentioned below:

- Diameter of the plate is 250 mm.
- Thickness of a new plate is 25 mm.
- Small Diameter of the disc is 85 mm.
- There are 3 fitting cavity which are used for fixing.
- The disc is divided into 22 sectors.
- It is further sub-divided into 9 divisions.
- Each 9 divisions are of different lengths.

COMPONENTS

Here use some of the Electronic Components used to automate the Re-Grinding Process

4.1 Arduino

Arduino is an open source hardware and software company, project and user community that design and manufacturing single-board microcontroller kits for building digital devices and interactive devices that can sense and control object in physical and digital world.

Arduino board design uses a variety of microprocessor and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins. That may be interfaces to various expansion board or breadboard (shields). The boards feature serial communication interface, including universal serial bus (USB) on some model.

4.1.1 Arduino Uno

The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9volt battery, though it accepts voltages between 7 and 20 volts. The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits. Arduino Uno provide 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top of the board, via female 0.1-inch (2.54 mm) headers.

4.1.1.1 Specification

- Operating Voltage: 5 Volt
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader.

- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Length: 68.6 mm
- Width: 53.4 mm
- Weight: 25 g

4.2 A4988 Motor Driver

The A4988 is a complete micro stepping motor driver with built-in translator for easy operation. It is designed to operate bipolar stepper motors in full-, half-, quarter-, eighth-, and sixteenth-step modes, with an output drive capacity of up to 35 V and ±2 A. The A4988 includes a fixed off-time current regulator which has the ability to operate in slow or mixed decay modes.

4.2.1 Specification

- Minimum operating voltage: 8V
- Maximum operating voltage: 35V
- Continuous current per phase: 1 Amp
- Maximum current per phase: 2 Amp
- Minimum logic voltage: 3V
- Maximum logic voltage: 5.5V
- Micro step resolutions: Full,1/2,1/4,1/8,
- Reverse voltage protection: No

4.3. Stepper Motor

In this we are using NEMA17 4.2Kgcm Stepper Motor for high torque applications. It is particularly well suited to the type of application where control signals appear as digital pulses rather than analog voltages. One digital pulse to a step motor drive or translator causes the motor to increment one precise angle of motion. As the digital pulses increase in frequency, the step movement changes into continuous rotation. Ideal Motor for ATM machines, 3D printers, Peristaltic pumps and job positioning and rotating applications. Standard NEMA 17 frame size. 4.2Kgcm bipolar configuration motor.

4.3.1 Specification

- Step Angle: 1.8°
- Number of Phase: 2
- Rated Voltage: 3.2V

- Rated Current: 1.4A
- Resistance per phase: 2E
- Inductance per phase: 2.8mH
- Holding Torque: 4.2 kgcm
- Weight:300 grams
- Coil A: Yellow & Red
- Coil B: Orange & Brown
- Length without shaft: 38mm
- Shaft Length: 24mm
- Width: 42.3mm

4.4 Servo Motor

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

4.5 Cutting Motor

A 775 High-speed CNC Motor which is 24V and having a rpm of 10000 having a high performance and high-precision. It is usually used to be a mini cnc spindle, making a mini bench drill, a mini table saw and so on.

4.5.1 Specification

- Weight: 290g
- JTO drill chuck clamping range: 0.3-4mm
- Rated voltage: 24V
- Speed: 10000RPM

4.6 Power supply

In this we are using a 24vDC supply with 2.5 amps which gives a 50-watt power supply as output with an input of 240-volt of AC. And this is utilized by the components of all the machine.

4.7 Construction Material

Here we are using mild steel, aluminum channel, aluminum sheets, nuts and bolts, etc.,

4.7.1 Base

It is the part of machine which holds all the parts of the machine together. It mainly consists of four circular shafts of 1mm diameter which is mainly used as support. It also has a stepper motor and a screw rod of 12mm diameter having 2mm pitch of v- thread for the linear movement of the other parts. And the movement in the circular shaft is made without friction with the help of linear bearing to avoid wear of material. This member is responsible for y-axis movement of the tool. And this base is made of aluminum.

4.7.2 Column

This part holds the moving block and responsible for the x-axis movement of the tool post. It is in a vertical position to the base which is perpendicular to each other. It has a stepper motor and a pair of circular shafts of diameter 2cm and a screw rod of diameter 2.5cm and a pair of linear bearing for frictionless movement for the movement of the moving tool post. It is made of aluminum.

4.7.3 Moving Tool Post

It is final and important part of the machine whose function is the z-axis movement and has the role of movement of tool and holding it rigidly. The movement is based on the stepper motor and pair of 10mm diameter shafts and a 12mm diameter screw rod of pitch 2mm square thread for the movement of the tool. It is made of aluminum.

4.7.4 Linear Bearing

A linear-motion bearing or linear slide is a bearing designed to provide free motion in one direction. There are many different types of linear motion bearings. A rolling-element bearing is generally composed of a sleeve-like outer ring and several rows of balls retained by cages. The cages were originally machined from solid metal and were quickly replaced by stampings. It features smooth motion, low friction, high rigidity and long life. They are economical, and easy to maintain and replace. A rolling-element bearing is generally composed of a sleeve-like outer ring and several rows of balls retained by cages. The cages were originally machined from solid metal and were quickly replaced by stampings. It features smooth motion, low friction, high rigidity and long life. They are economical, and easy to maintain and replace.

4.7.5 Brake

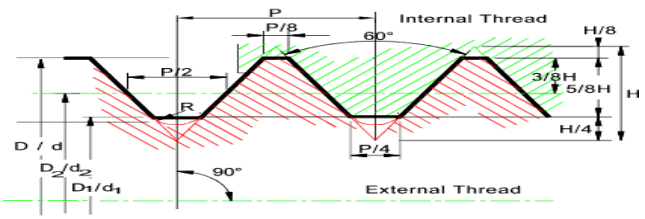
Brake may be a small part but it plays a vital role in holding the plate rigid. To avoid the shaking and the vibration of the plate while regrinding, the rotational movement of the plate has to be stopped. So we need to apply the brake. Using servo motor we made a brake mechanism. It consists of a connecting rod and a rubber bush. The servo motor helps the connecting rod to move forward to which the rubber bush is attached. Now the rubber bush press against the rotating shaft. We pasted the sand paper around the shaft so as to increase the friction to make the brake more effective.

4.8 Pitch Calculation(V-Thread)

The screw thread used in here is a V-thread. Which is in diameter of 12mm. And the pitch used in this is 2mm. Material – Stainless Steel.

4.8.1 Formula Used

V-thread



Major diameter - largest diameter of the thread=D/d

Minor diameter - smallest diameter of the thread=D_1/d_1

Nominal diameter - internal diameter of the thread

Since Nominal diameter of the thread is 12mm**.**

WORKING

5.1 Working Principle

The plate which is to be re-grinded is place on the table and held rigidly by a pair of clamps. The base which has all the components also holds the plate in position. The initial position of the moving parts has to be set manually. The circuit connection was made by us in a breadboard and later we converted them in a printed circuit board with soldering. The circuit diagram for stepper motor and servo motor connection with Arduino are shown below. The vertical column is moved with the help of the stepper motor and screw rod provided for the y-axis movement. The moving tool post moves along x-axis which is provided by stepper motor and a screw rod. The depth of the cut is given by the z-axis movement of the tool post. The movement of all the parts is guided by the arduino. The arduino gives the command to the stepper motor by the A4988 motor driver which converts the commands into mechanical movement of the motor. The instructions were provides to the Arduino through a simple C program. The Arduino then send these instructions to the stepper motor driver which then is used to run the stepper motor. The coding is done so that the process are done sequentially in the desired manner. For example regrinding a single sector the parts are to be moved in the following way. Tool post→ column→break (release)→table rotate→brake(apply). This process is repeated 22 times to completely regrind the plate. Once the design is entirely engraved the process stops.

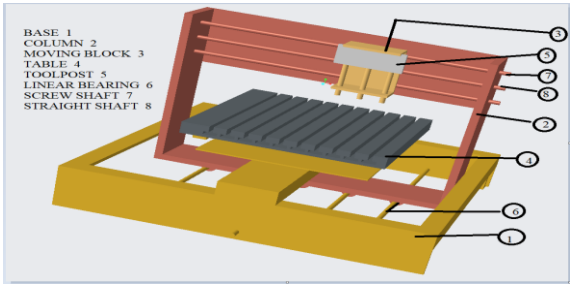
DESIGN MODEL

6.1 Introduction To The Software

The 2D design and 3D design were made in CREO Parametric 4.0 software.

6.2 3D Model

The 2D design and 3D design were made in CREO Parametric 4.0 software. First we made 3D-design then we drafted into them to a 2D-design. With the help of the 2D- design we started to work on our model to fabricate it and control them with Arduino

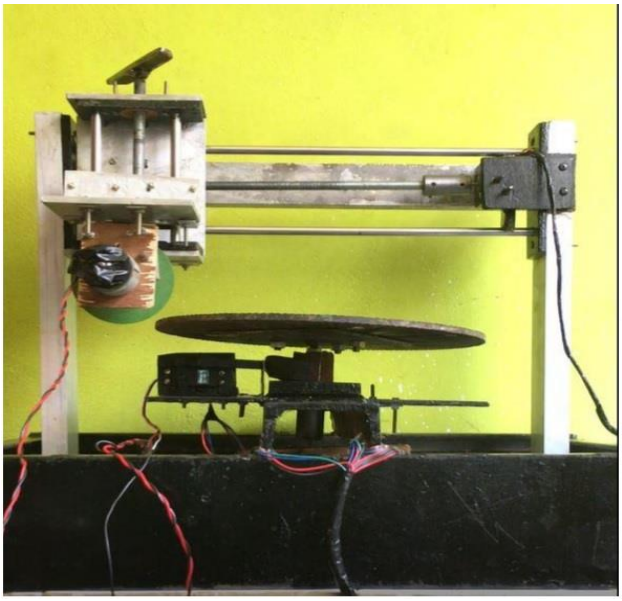


6.3 Fabrication Process

We fabricated our idea into a working model by making use of available material such as mild steel, aluminum, linear shafts, screw shafts, linear bearing, roller bearing, aluminum channel. We made use of Arc welding and temporary joint such as bolt and nuts, screws in our model, so that we can alter if problem arises in mere future.

6.4 Final Product

This is the final product which was assembled with all the motors, coupling, screw rods, cutting motor, linear bearing, etc.,



6.5 Benefits

Because of this machine we can achieve:

- Efficiency of mill can be increased
- The life time of the plate can be increased
- Time for regrinding the plate can be decreased
- Human error and human labour can be avoided
- Cost of grinding the plate for the owner can be reduced
- Hygienic food grain flour can be obtained as output

6.8 Comparison Of Human And Machine Work

	Human	**Machine**
Time	**2hour 15min**	**1 Hour 10min**
Accuracy	**75%**	**96%**
Safety	**50%**	**98%**

6.9 Result&Conclusion

We fabricated a machine to re-groove the flour mill plate. We eliminated the manual work in regrinding the plate so as to reduce the time a do regrinds the plate greater efficiency. The most important feature of this machine is it is compact and does not require large space and it is not difficult to transport. This automated

machine will be more efficient than the manual method since it can regrind the complete plate in 1hour with greater accuracy. This three axis machine will be more helpful to the mill owners during festival season

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