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Layout and Design of Mold Plate Cleaning Machine for AAC Blocks with CAD Approach for Cleaning Of Mold Plate

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ABSTRACT: AAC blocks replace the concrete and other clay bricks by their best technical properties. These blocks are also known as Autoclaved light weight concrete. It is eco friendly and certified green building materials. AAC was 1st used in 1920 by Swedish architect. It is used more in European countries and rapidly growing in other countries. The AAC blocks are made by the mixture of fly ash, sand, cement, aluminium powder, and water and mixed proportionally by weight. Here aluminium powder reacts with calcium hydroxide and water to form Hydrogen monohydride(H_2). The hydrogen gases formed and double the volume of the raw material creating gas bubble, these hydrogen gas bubbles escape out in the atmosphere and those vacant or cavities are filled by atmospheric air. From the material when the air is removed it solidifies but still soft. It is then cut by into blocks in required size and put it into autoclave chamber for 13 hrs at 12 bar maximum and with temp of 180 degree Celsius and after that the block is ready to use

During the process of manufacturing of AAC Blocks, there is nowhere provision made for automated mold plate cleaning machine, till date these mould plates are being cleaned manually using hand scrubbers. In the present work, a Mould Plate Cleaning Machine is designed to clean the Mould Plate, providing the company for uninterrupted production process, reduced man power. This machine is designed based on the mechanical concepts that cleanse the plate in a circulatory motion by the multiple wire brushes attached to circular disc powered by means of geared motor. In the design of this machine a simple mechanisms are opted therefore to reduce the maintenance cost and easy to operate. The machine components are generated and thereafter the part modeling and assembly is done using CAD Modeling software (solid works). This machine is capable of cleaning the plates at 3 Plates/Min.

KEYWORDS: Plate cleaning, Mold plate cleaning Machine, AAC Blocks.

I. INTRODUCTION

Brick is one of the oldest materials used to make pavements, walls, houses building construction. Brick is generally made up of clay, clay units such as soil, sand, concrete lime etc. number of bricks together are joined to make a wall with use of mortar. There are verities in shape, size, classes, material of the brick which changes with region and time.

USES OF BRICKS:

- Construction of wall
- Construction of floors
- Construction of cornices
- Construction of arches
- Used as aggregate in concrete mixture
- Powder bricks used in lime plaster
- Fire bricks are used in acid plants, furnaces, kiln etc.

TYPES OF BRICKS AND THEIR USES:

Bricks can be categorized in many ways as below, for example;

1. Using location
- Bricks used for facing (exterior look of the structure).
- Bricks used for backing (use for structure not for look).
2. Fired and unfired
- Fired bricks are baked in ovens to achieve hardness.
- Unfired bricks are air cured.
3. Common and Engineering bricks
- Common bricks are used for residential construction.
- Engineering bricks are used for engineering project such as road, bridge, dam, etc.
4. Shape

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- Air brick: contain holes for air circulation.
- Paving bricks: used for underfoot paving.
- Hollow bricks: they are light in weight and mostly use for partition.
- Capping bricks: used to cap wall top which are freestanding.
- Channel bricks: molded into shape of gutter and channel, used in drains.

5. Raw material

- Burnt clay bricks: these are made by molds by pressing clay in the molds which is further fried and dried in kilns. These are common bricks used for residential construction.
- Sand lime brick:
- Concrete brick
- Fire brick
- Fly ash clay brick (AAC BLOCKS)

PREPERATION METHOD OF AAC BLOCKS

1. Raw Material Preparation:

- To stock the required material for the production and adding them according in silo by sequence in required time and exact quantity.
- Fly ash is brought in bulker or pound ash and stored in the back yard and mixed with the water in the tank to form slurry. And this are transferred in the tank called slurry storage tank.
- Cement is checked by its reports from the dealer and directly loaded in the silo,
- Lime is checked for its slaking temp before loading it to the silo from the bulker.
- And other materials are loaded manually measure and poured in the mixing chamber while casting.
- The capacity of the silo is 150MT
- Proper supply chain management is to be maintained and follow-up is to be carried to avoid interrupt in the production process.

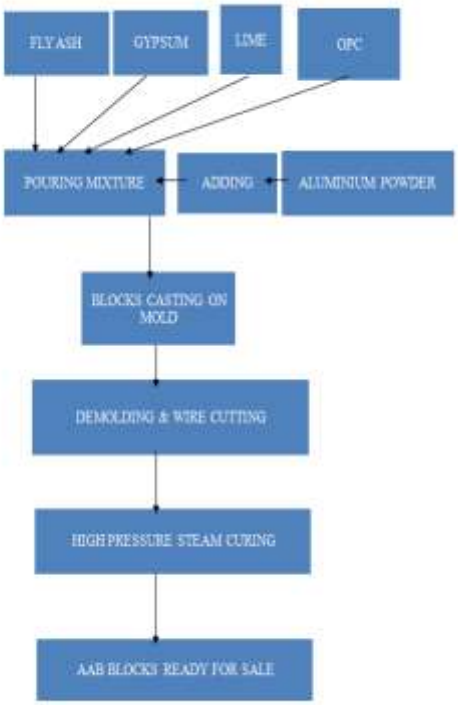

Fig 1.1: Flow chat of AAC Blocks Preparation Method

2. Measure and mixing:

- Quantity of material required is set in the software in the batching room and accordingly the material is added to the main mixer.
- The time taken for preparing a single batch is 7 minutes and adding of aluminium is done 40sec before the discharge of the mixed slurry.
- Aluminum acts as a caking agent which is to be mixed in the main mixer at the end with in 40sec, otherwise rising of slurry take place in the main mixer itself.
- Fresh slurry and waste recycled slurry is first taken into the mixing chamber in 80:20 ratios.
- Proportional weight of slurry up to 70% fly ash and 30% water is to be and make a homogeneous mixture i.e. fly ash slurry.
- After adding slurry the gypsum is added manually and after on cement and line are added simultaneously.
- 2 litres of soluble oil is add and mixed properly, if required steam is supplied to increase the temperature of the main mixer.
- Then caking agent is added i.e. Aluminium powder.

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- After 40sec the mixed slurry is ready for discharge or casting.

3. Casting:

- After the mixing or batching operation the slurry is poured in the mold for casting.
- Here rising of the green cake takes place inside the mold.
- The rising of the cake depends on the quantity of slurry or aluminium powder added to the mixed slurry.
- Empty height of the mold is measure to understand or predict the height of the cake after rising.
- The quantity of the material is measure and compared it with the previous data to ensure that the material should not overflow after the rising.
- Precautions to be taken while shifting the mold to the pre curing room because the rising process takes place in the mold should not be disturbed otherwise the cake may collapse.

4. Rising and curing:

- The curing room is maintained at the temperature between 45^0 to 50^0 Celsius
- As the aluminium reacts with the other agents in the mold the cake starts rising.
- Within interval required measures are checked.
- Time taken for rising of the cake is 50mins and for hardening is 3hrs.
- After hardening penetration test of the cake is taken.
- When the penetration is up to limit of 100mm and temperature is above 60 degree then it is assumed that the cake is ready to achieve cutting strength.
- Then the mold is moved to the cutting zone with the help of crane.

5. De-molding:

- The mold is then moved from the curing room to the cutting zone with the help of crane as shown in the figure (1.14).
- In this process as shown in fig (1.16) the mold is tilted to 90^0 from horizontal to vertical direction and kept on the ferry cart for the cutting operation.
- The mold is kept resting the side plate downwards on the ferry cart.
- De-molding of the mold is done in which the side plate with cake is separated.
- With the help of ferry cart the cake is moved for the cutting operations.

6. Cutting:

- The mold is lift by Crain and de-molded and set on the cutting machine.
- Cutting the cake into a particular size in horizontal and vertical direction.
- Cutting of the cake is done by wire rope.
- The extra material after cutting is then reused as waist slurry in the batching for next cycle of casting.
- Sizes of the blocks are checked after every cycle.
- Then the cake is placed over the tilting table to remove excess material from the top surface by tilting the cake.
- After require size is achieved then the cut cake is transferred on wagon with the help of crane and then transfer to autoclave.

7. Autoclave:

- Autoclave is the last process in the production of the AAC here the strength of the blocks is achieved.
- It is a long pressurized vessels length up to 32meters and diameter of 2meters; it is design for operating pressure of 12bar.
- There are 4 autoclave, 7 wagon and accommodate a total of 14 cakes in each autoclave.
- Auto clave is the process of curing of cake in less time, here the water contain from the cake is removed.
- The temperature maintained in the autoclave is 180^o C.
- The autoclave process consists of 3hr of charging then constant for 6hrs again 3hrs for discharge. Total of 12hr autoclaving process.
- After 12 hr of autoclaving process the blocks are removed from the autoclave and are ready to dispatch as shown in fig 1.20.

Difficulties Faced In AAC Blocks Manufacturing:

1. Collapse of cake:

This happen during the curing stage as the proportion of recipe varies or use of low grade material in the slurry collapse of cake takes place.

2. Rising cracks:

This happens when there is sudden rise in the cake or any disturbance occurred while in rising of cake.

3. Cutting cracks:

Cracks cause during the cutting operation in vertical and horizontal direction due to the tension of cutting wire.

4. Error in the dimension of the cutting wire:

This takes place do to the negligence of the operator, wrong or uneven size of blocks is cut.

5. Thermal cracks:

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Thermal cracks occur in autoclave due to excess of steam in autoclave or sudden release of the steam from the autoclave.

6. **Shrinkage cracks:** This cracks occurs due to sudden expansion and contraction of blocks, this happens when the blocks are left to cured in the ambient temperate after the autoclave process.
7. **Adhesion of thin layer of block to wagon:**

This occurs as the lower thin layer of block gets attached to the wagon plate due to the following reasons.

- Due to self weight.
- Due to binding properties of the material.
- Due to chemical reaction & insufficient lubricant applied.

II. MPCM CONCEPT

Different Method for Cleaning:

1. **Hand scrubber:**

It is used for small cleaning operation where the cleaning process is carried out manually by hand. Here manpower is required and cleaning process takes more time and more labour.

2. **Power drill scrubber:**

This is used for small cleaning operations where it's impossible for big size scrubbers to reach the corners or edges. It consists of a disc scrubber attached to the drilling type machine to perform cleaning operations. In this skill labour is required and handling of machine is done by hand.

3. **Industrial floor cleaning machine:**

This machine are use in industries for floor cleaning, oil, grease etc. these machine have big size rotary scrubbing head to perform large area cleaning operation. This is not suitable in cleaning for small purpose and difficult to operate in edges and corners.

4. **High pressure water jet cleaning machine**.

It is use for multi industrial application, it is recognized for the capabilities for providing power and environmental safe for solving difficulties in various cleaning operation. It has the power up to 500hp and discharge flow up to 1000lpm and pressure up to 2000bar.

5. **Chemical Method:**

It is in liquid for easy cleaning, degrease if any oil contain cleaning, cleaning of various chemical present, heavy rust strain cleaning and alkaline cleaners. Eg: concrete dissolver chemical.

- This will react with the metal plate.
- The cost of the chemicals is more.
- This will affect the final product price.

Concept Generation:

- Disc type is the commonly used for all purpose. Typically it is used in industrial or commercial facilities. Mechanism use for this concept is not much complicate that makes it cost effective. Below are some advantages. In this overall down pressure is more.
- It is good in cleaning tough soils or strains.
- Variation in speed cans easily achieved.
- Low speed cleaning can easily obtain.
- It is not suitable for picking up debris.
- Different types of brushes from soft to hard can be used.
- Polypropylene to abrasive wired brush.

Fig 2.1: Disc Type

The final selection of the concept is always based upon the selection methodology, where the technical aspects are consider for the product to be developed and the highest rated concept is then selected.

III. DESIGN AND CALCULATION OF MPCM

1. **Torque required for plate:**

Data;

Plate Diameter D = 680mm = 0.68m
Radius R = 340mm = 0.34m
Thickness t = 20mm = 0.02m
Force F= 100kg

F= 100 x 9.81 = 981 N ≅ **980 N**

Co-efficient of friction between plate and brush (μ) = **0.8**

Torque = Force x Radius
T = F x R
T = (0.8 x 980) x 0.34
T = 266.56 N-m
T ≅ **270 N-m**

2. **Motor Selection:**

Considering 3 hp motor,

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Power P = 2.2 KW = 2.2 x 10^3 W
Speed N = 1440 rpm

Power, $P = \frac{2\pi N T}{60}$
Torque produced by motor @ speed of 1440 rpm

$\therefore$ $T = \frac{P\ 60}{2\pi N}$ N-m
$T = \frac{2.2 \times 10^3 \times 60}{2\pi 1440}$ N-m
T = 14.6 N-m
Torque produced by same motor @ speed of 70 rpm
$\therefore$ $T = \frac{P\ 60}{2\pi N}$ N-m
$T = \frac{2.2 \times 10^3 \times 60}{2\pi 70}$ N-m
T = 300 N-m
The torque available is less than the torque produced by the 3hp motor at 70rpm i.e. 270<300 respectively, hence this motor is suitable for this machine.

3. Shaft Design:
$\tau = \frac{0.5 \times 380}{3}$ N/mm^2
τ= 63.33 N/mm^2
Considering minimum shear stress, 60 N/mm^2.
i. Based on Shear Strength:
$\tau = \frac{16\ T}{\pi\ d^3}$
Considering minimum torque,
T = 270 N-m
$\therefore$ $d = \sqrt[3]{\frac{16\ T}{\pi\ \tau}}$
$d = \sqrt[3]{\frac{16 \times 270 \times 10^3\ T}{\pi\ 60}}$
d = 28.40 mm
d = 30 mm
ii. Based on Rigidity:
$\frac{T}{J} = \frac{G\theta}{L}$
Where;
Length of shaft L = 230mm
Rigidity Modulus = 80 x 10^3
Angle of twist = 0.5^o
= 0.008726 rad
$\frac{270 \times 10^3}{\frac{\pi}{32} d^3} = \frac{80 \times 10^3 \times 0.008726}{270}$
$d = \sqrt[4]{\frac{270 \times 10^3 \times 32 \times 230}{80 \times 10^3 \times 0.008726}}$
d = 30.85 mm
d = 35mm (Standard Size)
$\therefore$ The diameter selected at minimum torque is 35 mm.
4. Considering Maximum Torque:
T_{motor} = 300 N-m
$T_{max} = 1.5\ T_{motor}$
T_{max} = 1.5 x 300
T_{max} = 450 N-m

$d_{max} = \sqrt[4]{\frac{450 \times 10^3 \times 32 \times 230}{80 \times 10^3 \times 0.008726}}$
d_{max} = 35.08 mm
d_{max} = 40mm (Standard Size)
$\therefore$ The maximum diameter selected for maximum torque is 40 mm.
The torque produced for d = 40 mm.
$\tau = \frac{16\ T}{\pi\ d^3}$
$T = \frac{\tau\pi\ d^3}{16}$
T = 753982 N-mm
T = 754 N-m
$\therefore$ The shaft of 40 mm diameter can withstand the torque up to 754 N-m, for this diameter of shaft and this torque is best suitable even for the reduced speed of motor up to 30rpm, where motor at speed produces 700 N-m.

IV. MOLD PLATE CLEANING MACHINE LAYOUT

A mold consists of a box of 2.4 x 1.4 x .6 m dimensions in which the slurry is poured to form a cake. Mold plate in the part of the mold which is detachable and act as a base for the cake to rest when the mold is detached as the cake is formed, the cake will be on the plate till the end process of the cycle.
Need for Mold Plate Cleaning Machine
1. To clean the wagon plate
2. To reduce production cost.
3. To reduce production time.
4. To reduce labour work.
5. To provide continuous / none interrupt process.

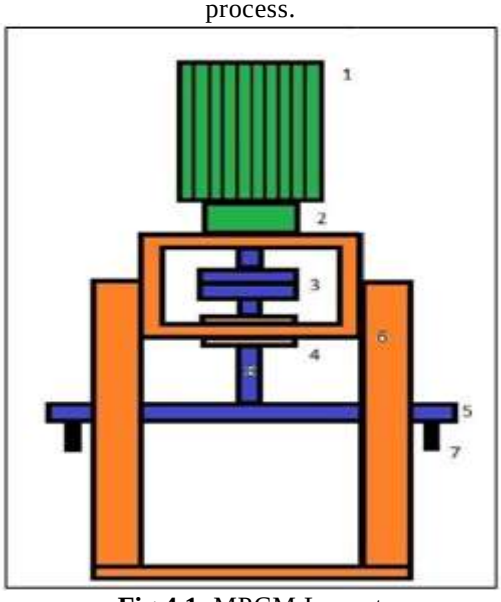

Fig 4.1: MPCM Layout

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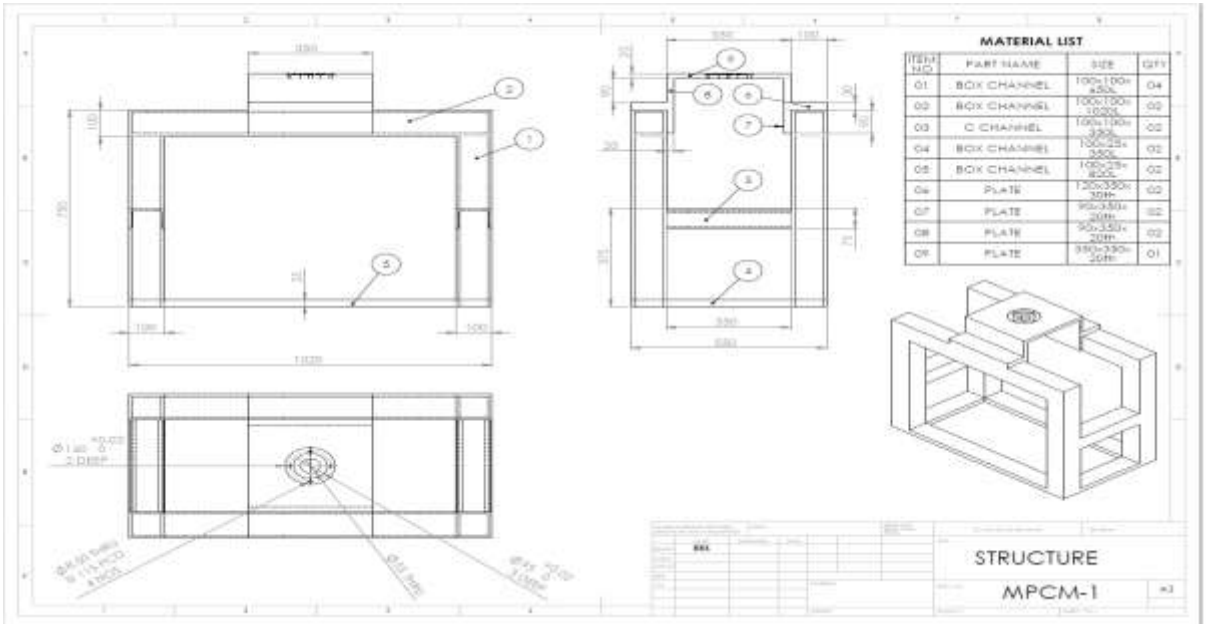
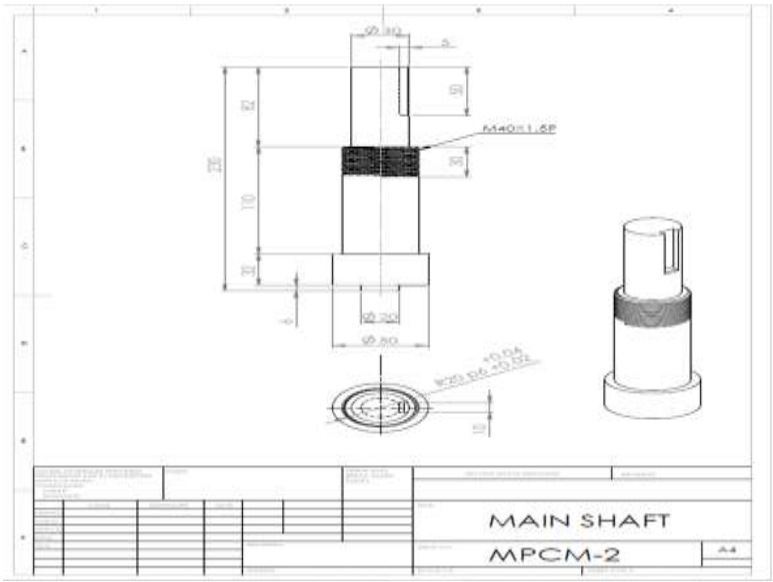
1. PARTS
2. MOTOR
3. GEARBOX
4. COUPLING
5. BEARING HOUSING WITH BEARING
6. DISC
7. STRUCTURE
8. BRUSH
9. SHAFT

2D Drawings:

1. Structure:



2. Mainshaft:



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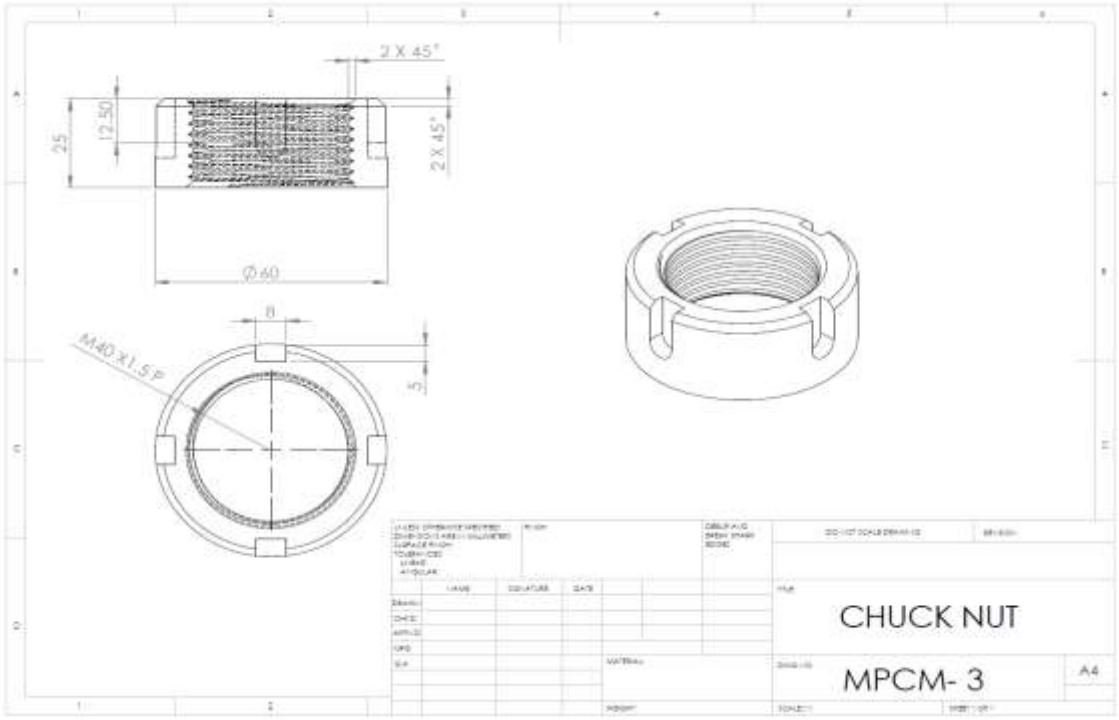
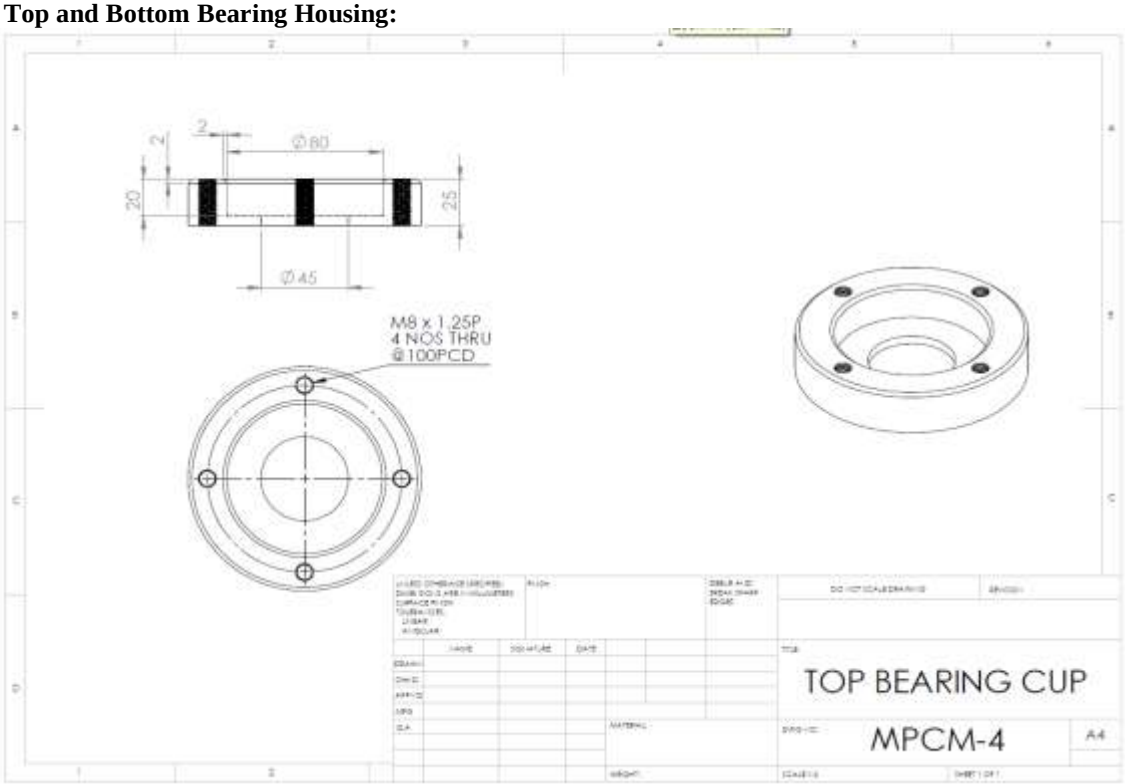
3. Chuck Nut:



4. Top and Bottom Bearing Housing:



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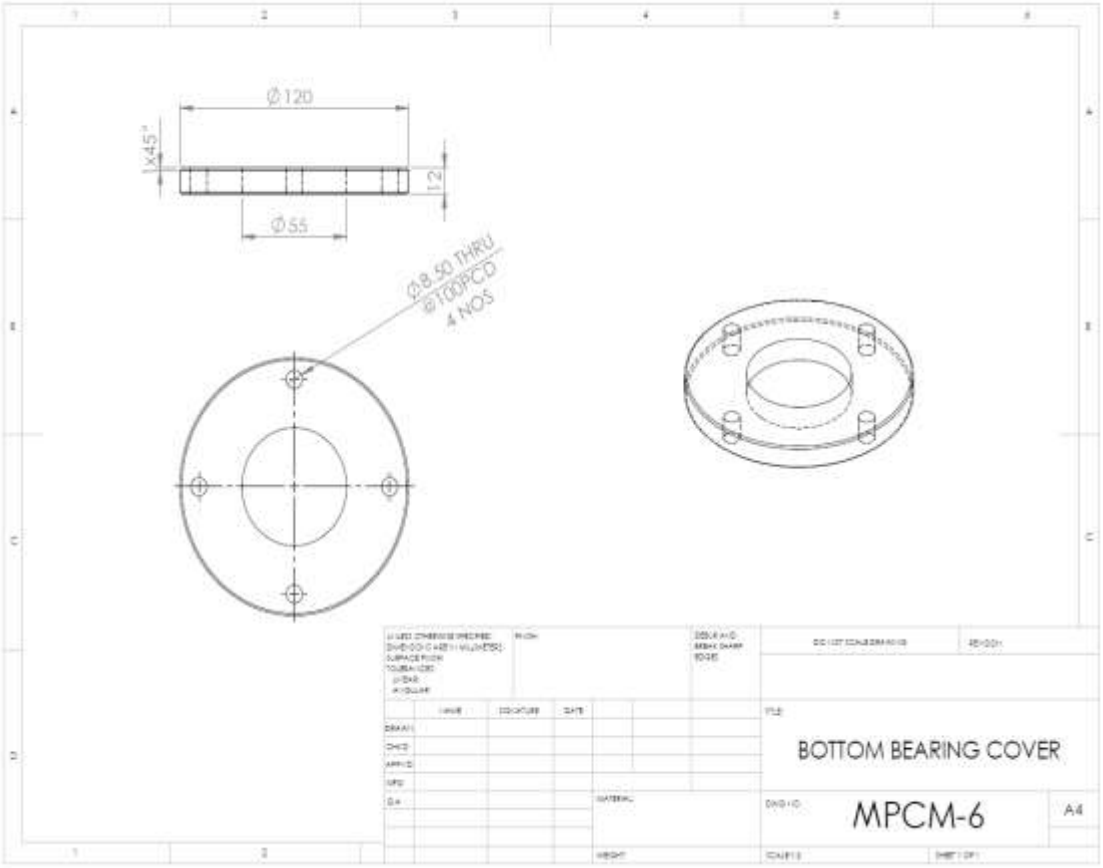
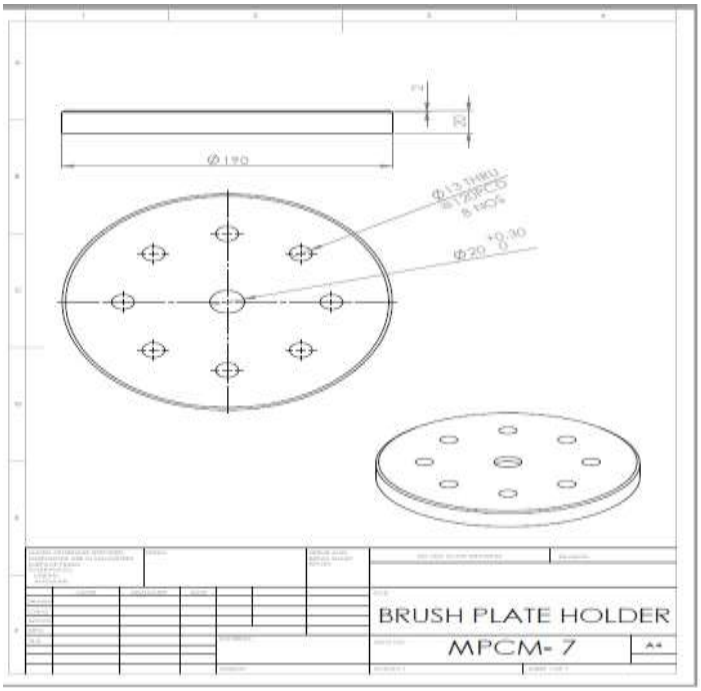
5. Bottom Bearing Cover:



6. Brush Plate Holder:



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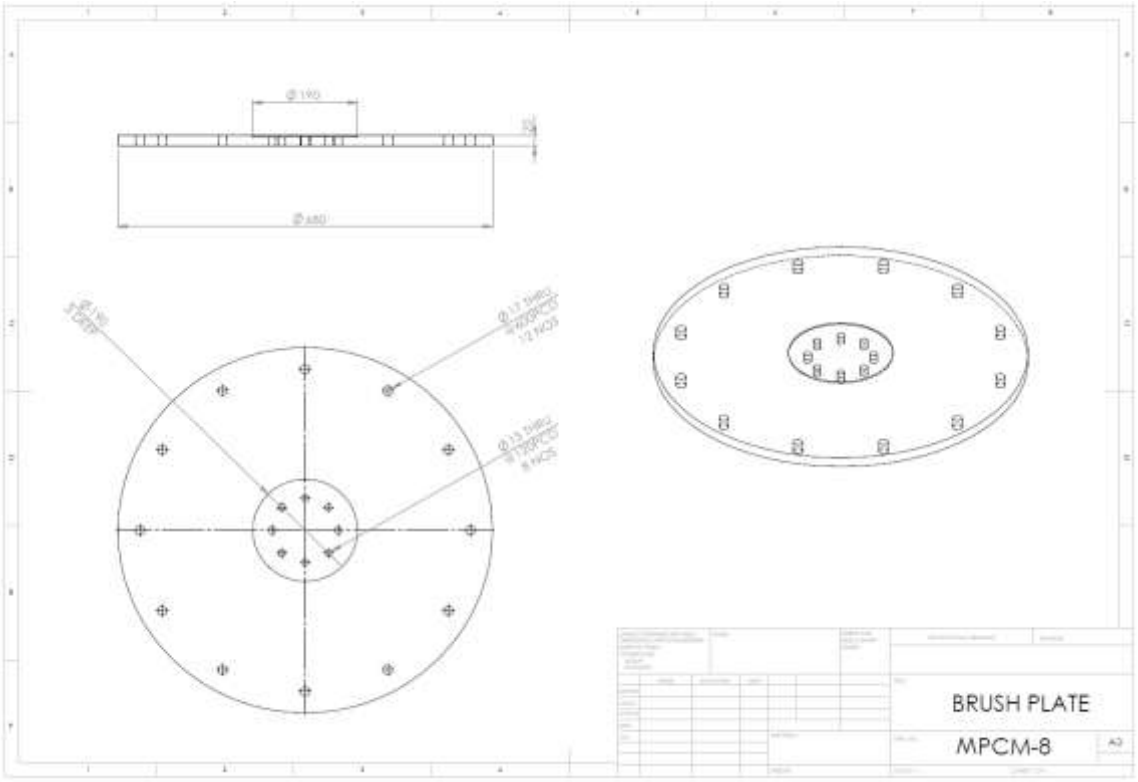
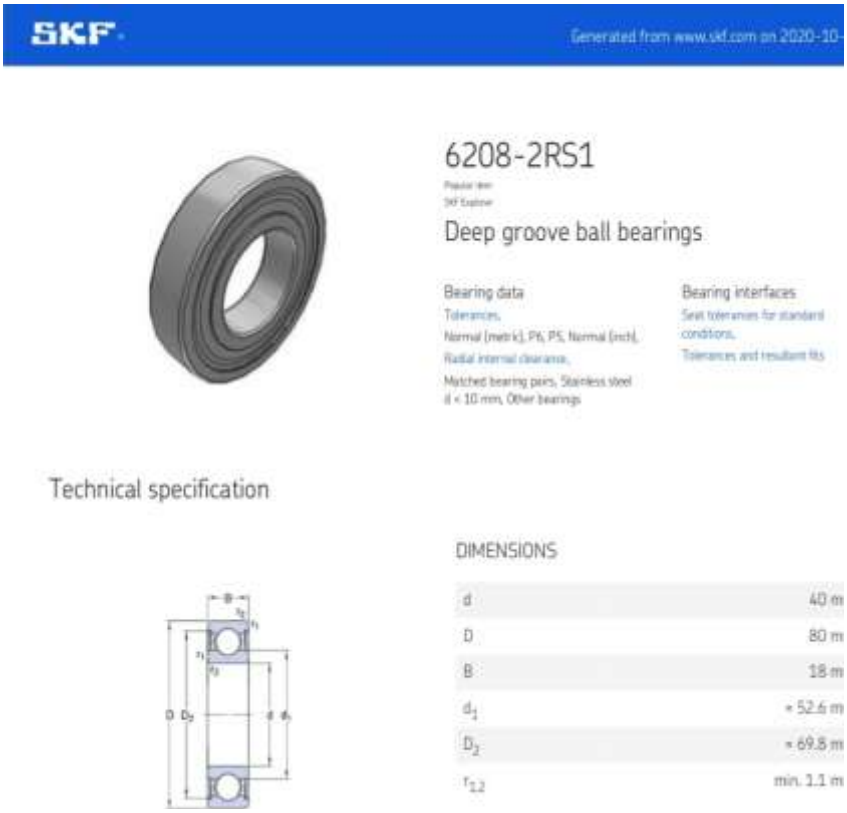
7. Brush Plate:



8. Bearing:



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CALCULATION DATA

Basic dynamic load rating	C	32.5 kN
Basic static load rating	C_0	19 kN
Fatigue load limit	P_u	0.8 kN
Limiting speed		5600 r/min
Calculation factor	k_r	0.025
Calculation factor	f_0	13.8

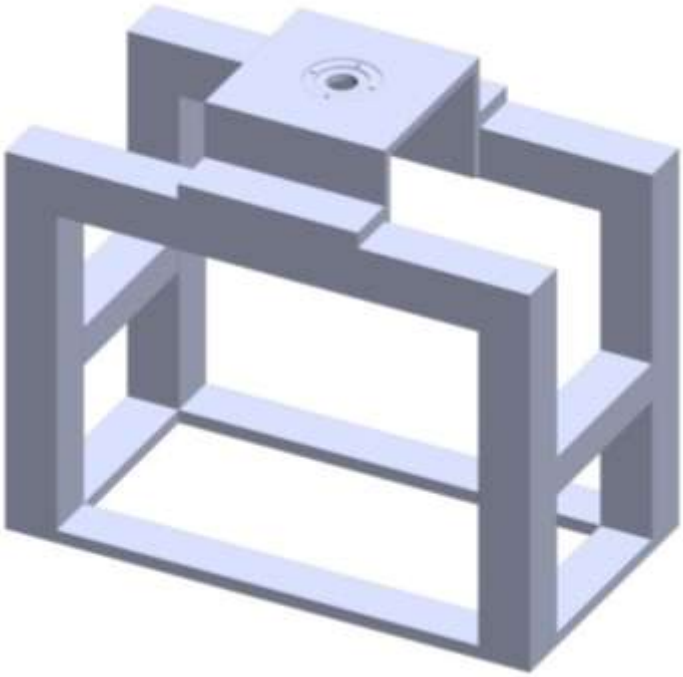
MASS

Mass bearing		0.38 kg

V. COMPUTER AIDED DESIGN Of MOLD PLATE CLEANING MACHINE

Machine Parts (3D)

1. Structure



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2. Main Shaft

3. Chuck Nut

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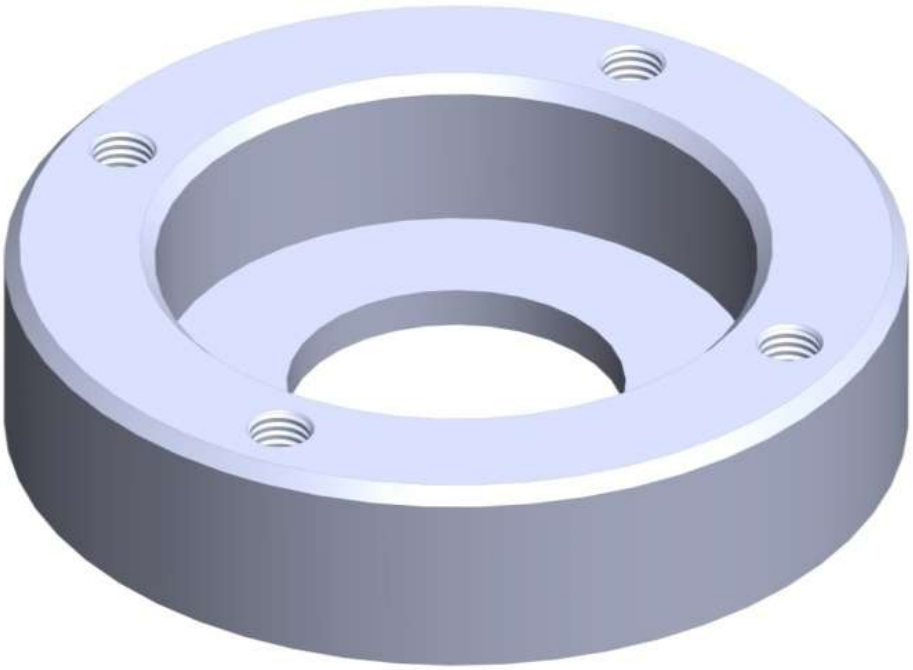
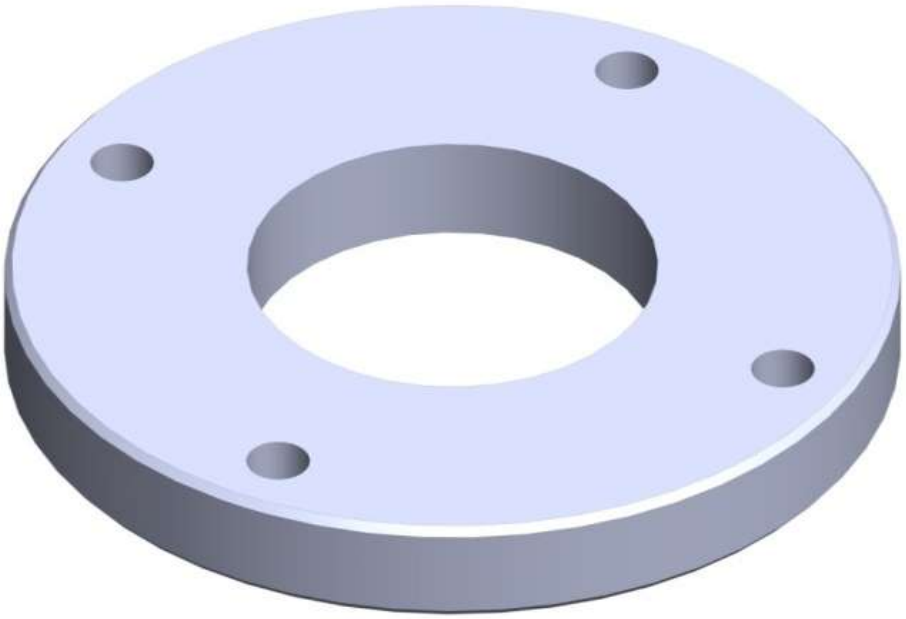
4. Top and Bottom Bearing Housing



5. Bottom Bearing Cover



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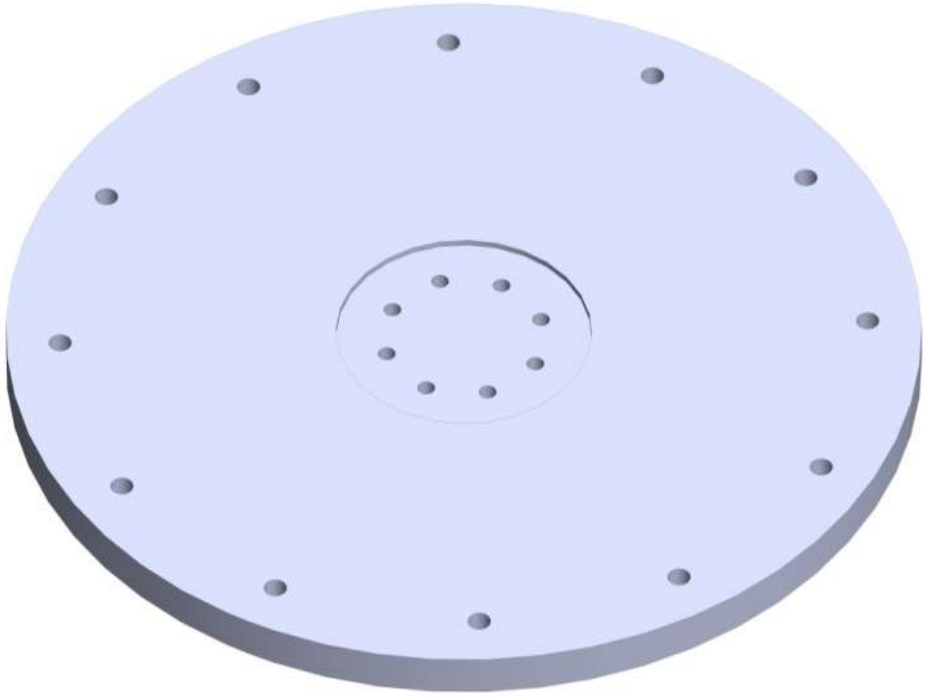
6. Brush Plate Holder



7. Stud

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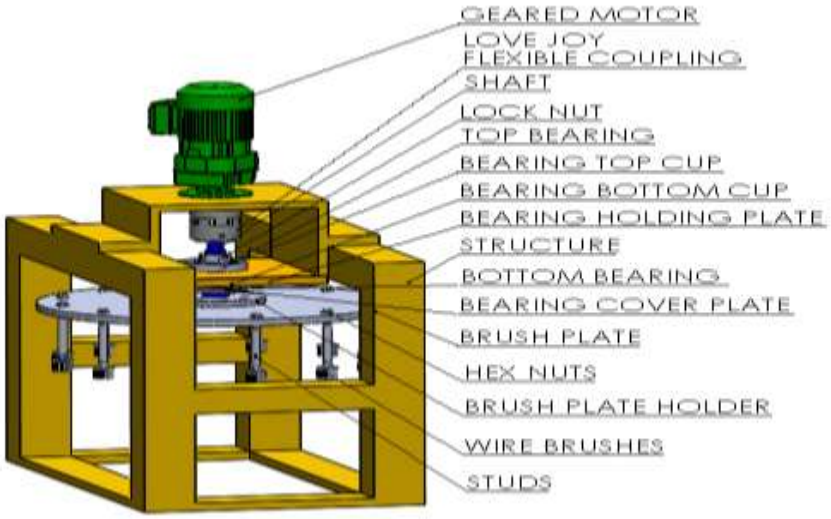
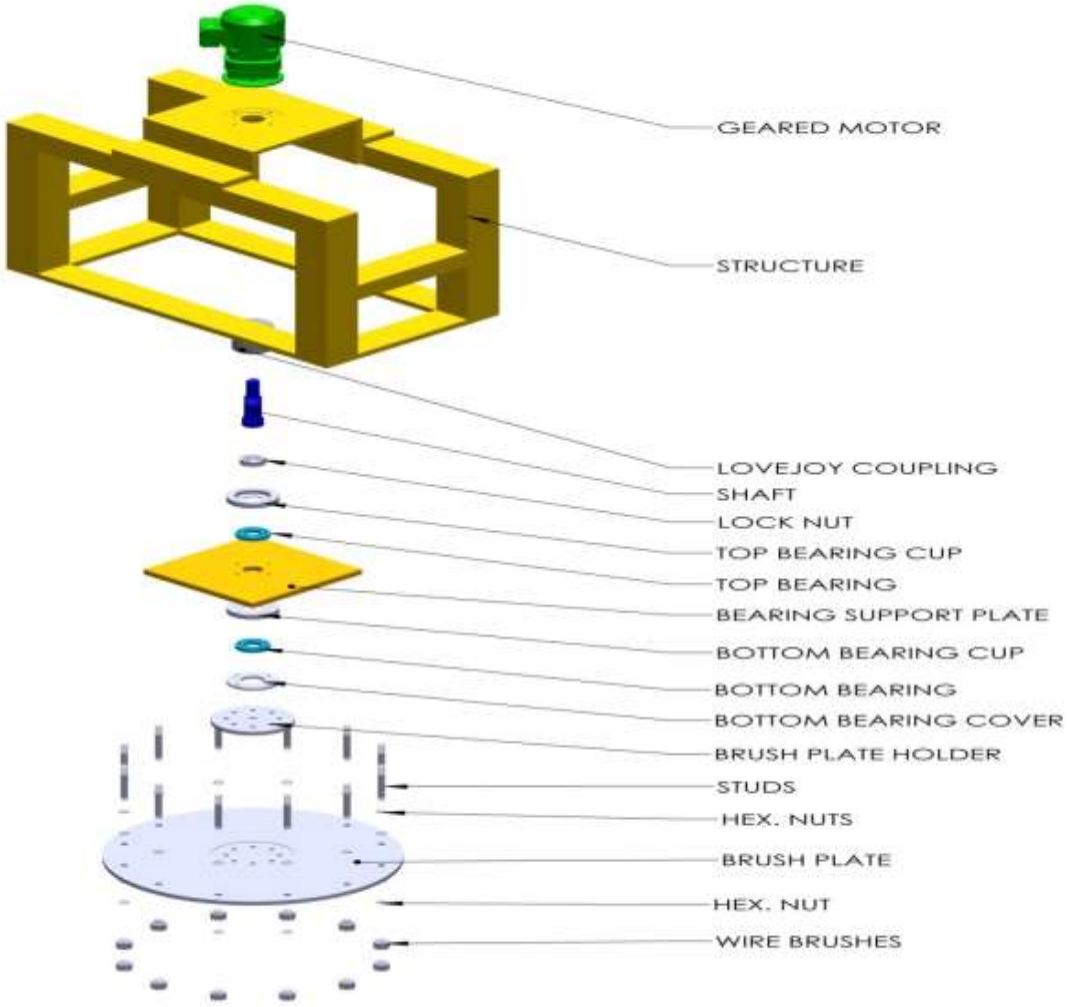
8. MPCM Assembly



9. MPCM Exploded View



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VI. RESULT & DISCUSSION

Considering the problem approached by the AAC Blocks Company regarding the adhesiveness of the block material to the mold metal side plate of the mold and the problems caused during the production.

We approached to the problem step by step to solve it, 1st we studied the process of the total plant to find the problem from the basic of the production process.

1. Preparation of blocks consists of various binders such as cement, gypsum, lime etc as shown in fig (6.1). The main properties of the binder are to adhere to each other to provide good strength in the blocks. As to alter the recipe by increasing or decreasing the binding material is impossible, the recipe set for the preparation of the blocks could not be changed, so this couldn't be the solution of the problem.

Fig 6.1: Binder Material Used In AAC Manufacturing

2. The variation in the finesse of the raw material used in manufacturing may also cause the sticking problems.

Suggestion-This can be solve by maintaining the density of raw material up to (1.6g/cc). Sieve test is carried to check the finesse and passing should be from 90, 75 &45 micron sieve as shown in fig (6.2).

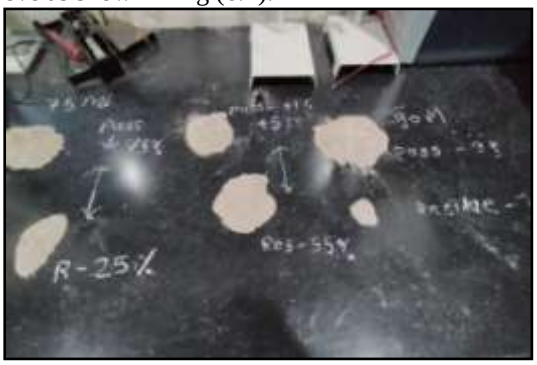

Fig 6.2: Sieve Test Result of Fly Ash

3. We observed that in the pouring process in which the mixed material from the main mixture is poured in to the empty mold to achieve shape and rising of the cake in the mold. In this the mold is to be oiled to avoid sticking of the poured liquid material and to achieve easy rising of the cake in the mold. We found that the oil applied to the mold is more than required, here when the oil is applied more than required the sticking between the cake and mold side plate take place during the autoclave process.

Fig 6.3**: Mold without Oil Coating**

Fig 6.4: Mold with Oil Coating

Suggestion-By this we cannot completely avoid use of oil but by reducing the quantity of oil applied to the mold, sticking of material is reduced. We also suggested them to use roller brush as replacement to paint brush, as paint brush takes more oil as compare to the roller brush as shown in fig(6.5)

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Fig 6.5: Use of the Roller Brush for Applying Oil

When the mold is tilted from horizontal to vertical direction at an angle of 90^{o} for the cutting process, the mold is discarded and the cake is rest on side plate of the mold and together is kept over the ferry cart by crane to perform the cutting operation. When the mold is tilted to one side over the side plate, due to the self weight of the cake adhere of lower layer of the cake to the plate takes place. There is no solution for this, thus this also cause the sticking of the cake.

By observing the above factors decision were taken to design a machine which clean the wagon plate by achieving following advantages

- More time consumption to minimum time consumption.
- High cost of the process to low cost.
- Interrupt process to continuous process.

The main problem face was when the plate wasn't cleaned there was difficulties in casting the next cake as the plate are used again for the casting. This unclean plate affect in the rising process of the cake and cause cracks in the cake due to improper rising and hence cause for huge loss or fail in production. By considering the above factors mold side plate cleaning machine is designed and developer successfully to overcome the problem of sticking.

Fig 6.6: Mold Plate Cleaning Process (Close Up)

Fig 6.7: Mould Plate Cleaning Before implementing MPCM Process

Fig 6.8: Mold plate After MPCM Process

VII. CONCLUSION & FUTURE SCOPE

Conclusion:

The wagon plate cleaning machine is successfully designed and implemented at AAC plant .This project work can be implemented for the cleaning of mold plate at all the AAC manufacturing units, thereby reducing the cost, human effort and time. It is found that the designed cleaning machine works with minimum human effort. It works efficiently by covering complete plate surface and maintenance of the machine is less and easy.

Future Scope:

In this present work the machine is operated manually soon after the mold plate approaches. Hence this machine can be atomized to detect the approach and depart of the mold plate and can automatically clean the plates. In addition, after cleaning the mold water sprayer and dryer can be implemented therefore to ensure no dust left on the surface of the mold plate.

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