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Design and Fabrication of Automatic Shell Core Shooter

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Abstract:
Foundry industry is one of the major industries where casting is produced. The major components of any automobile parts are produced by casting process. To produce such intricate shape hollow components core are required, which are produced in core shop. In manual core making process cores are produced manually and having ergonomics issues along with problems that are core rejection is more, man power requirement is more, less productivity, higher cost. So an automatic core making process is needed. In automatic core making process, pneumatics system is used for movements which are controlled by programmable logical (PLC). In this process shell core type is used for making cores. By using shell core there is no need for further baking process. It will possess very smooth surface and closed tolerance. High permeability is achieved in this type of core. The major components used are hopper, core box, pneumatic cylinder, heating catridges, sensors, PLC control system, etc. In which core sand is stored in the hopper, heating catridge is fixed in the core box for sand curing. Control box contains PLC systems which controls the operation. The core making machine can be operated by both manually and automatically with a help of sensors which is controlled by PLC system. For any emergency purpose, the machine can be turned OFF using emergency stop switch.

Keywords: Fabrication of shell core shooter, Automatic shell core shooter, Core shooter.

1. INTRODUCTION

1.1 Core shooter

Machine for the production of sand core which are thus produced by the respective core moulding process in appropriate core boxes suitable for the respective application. According to the latest technology, the core shooting machine can be categorized into those for flowable, dry shell mold material, for dumb and dry mold material and dry mold material. Generally, during core production, the mold material is not compacted but it is hardened or solidified chemically and physically.

1.1.1 Shell core shooter

It is a type of core shooter that the core is heated with external source with the help of that heat the core will be heated and solidified, thus the core is obtained. In the development of the automatic core shooter machine heating catridge are used for heating purpose.

1.1.2 Process in automatic shell core shooter

Sand with suitable binder ratio mixture is filled in the hopper

i. The core box is moved from its initial position to clamping position with the help of pneumatic cylinder which is controlled by PLC. All the movements are controlled by PLC.
ii. Six bar pressure is applied to the hopper to transfer the sand to the core box though a small opening
iii. Previous the core box is heated with the help of heating catridge, the maximum temperature reached is 270^0C with the help of this heat the sand is solidified.
iv. After that the core box is released and it is moved to its initial position.
v. The core is taken from the core box.

1.2 Common technologies used in core making

Following are the most common core making processes used by foundry industry, they are

i. Oil sand core
ii. CO_2 core
iii. Amine core

1.2.1 Oil sand core

Core sand is used for making cores and it is sometimes also known as oil sand. Core sand is highly rich silica sand mixed with oil binders such as core oil which composed of linseed oil, resin, light mineral oil and other bind materials. Pitch or flours and water may also be used in large cores for the sake of economy.

1.2.2 CO_2 core

Cores are responsible for providing the internal cavities and features within a casting. They are produced in a mold know as a core box. ... To produce a CO2 core, sand that is packed into a core box is given a shot of CO2 gas. To produce a shell core a core machine produces the core through a shell moulding method.

1.2.3 Amine core

The binder coated sand is packed into a *core* box and then sealed so that a curing gas can be introduced. These gases are often toxic (i.e. *amine* gas) or odorous (i.e. SO_2), so special handling systems must be used.... A third way to produce room temperature *cores* is by shell moulding.

1.3 PLC (programmable logic control)

A programmable logic controller is a industrial digital computer which has been ruggedized and adapted for the control of manufacturing process, such as assembly lines or robotic devices or any activity that requires high reliability control and ease of programming and process fault diagnosis.

A typical block diagram consists of following basic parts

i. CPU (Central Processing Units)

ii. Programming device
iii. Input and output module

The central processing unit is the part of the plc system. This is the microprocessor-based control system that replaces central relay, counter, timer and sequencers. A processor appears only once in plc either one bit or a word processor. One-bit processor are adequate for dealing with logic operations. PLCs with word processors uses only when processing text, numerical data, calculations, controlling, and the simple processing of signals in binary code.

1.4 Heating coil

The heating coil is the actual resistance which is where the electrical load occurs. The most common type of metal alloy used for this purpose is a nickel-chromium mixture also known as nichrome. The nichrome wire is wounded around a ceramic core and the number spirals per inch varies according to the requested watt density.

1.5 Pneumatics

A pneumatic system uses compressed air to transmit and control energy. Many factories have equipped their production lines with compressed air supplies and movable compressors. There is an unlimited supply of air in our atmosphere to produce compressed air.

The major pneumatics system consists of

i. Solenoid valves
ii. Pneumatic cylinders
iii. Actuators

1.5.1 Solenoid valve

A solenoid valve is an electromechanical device in which the solenoid uses an electric current to generate a magnetic field and thereby operate a mechanism which regulates the opening of fluid flow in a valve.

1.5.2 Pneumatic cylinders

Pneumatic cylinders are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. ... Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage. In this project double acting cylinders are used. Double-acting cylinders use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for outstroke and one for instroke. It works with the help of plc controller.

1.5.3 Actuators

Its main energy source may be an electric current, hydraulic fluid pressure, or pneumatic pressure. When it receives a control signal, an actuator responds by converting the signal's energy into mechanical motion. An actuator is the mechanism by which a control system acts upon an environment.

1.6 Objectives of the project

i. To build a machine which produce small core components.
ii. To develop a system which can operate fully automatic.
iii. To increase the accuracy and consistency in operation
iv. To reduce the error occurrences.
v. To reduce the cycle time of the machine.

1.7 Scope of the project

i. The machine is used to produce small size core with high quality.

ii. The system is more flexible for shooting a core in various size of core boxes.

iii. Smaller component or by component core can be produced.

iv. Operator skills are not much needed since the operation is fully automation.

2. METHODOLOGY

The aim of this project, 'Design and Fabrication of Automatic Core Shooter' was to design a mechanical system that could reduce labour and improve productivity of small cores in SVK Industries production unit. Conceptualization, design and fabrication with their line diagrams are dealt in this chapter. Design of new machine and method of trial conduction are also discussed.

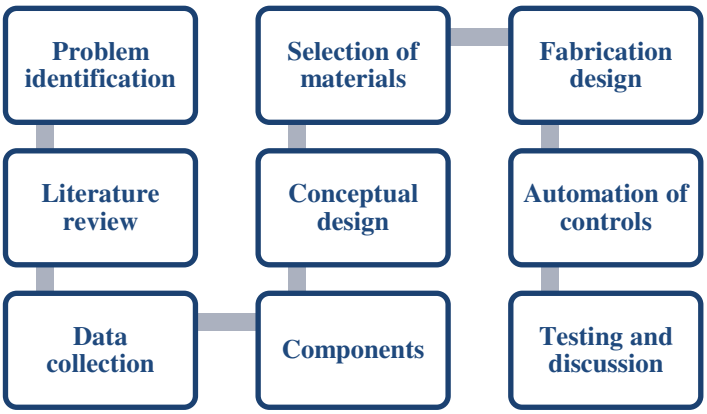

Figure.2.1. Methodology

Methodology is the way of steps followed from staring to ending, the steps which are followed are displayed on the above flow chart. The flow chart helps to do the process clearly. There is an easy way of understanding the methodology by seeing the flow chart. Thus the Fig 2.1 clearly represents about the process steps involved in methodology.

3. DESIGN AND FABRICATION

The machine is designed and fabricated. The design of each and every component are carried out and discussed. Various manufacturing process are carried out to develop the machine are also discussed

3.1 Conceptual design

The various models of the project were designed using the software solid works version 2013. The design of Automatic core shooter involves the design of various components. The conceptual design of core shooter is shown in Fig 3.1

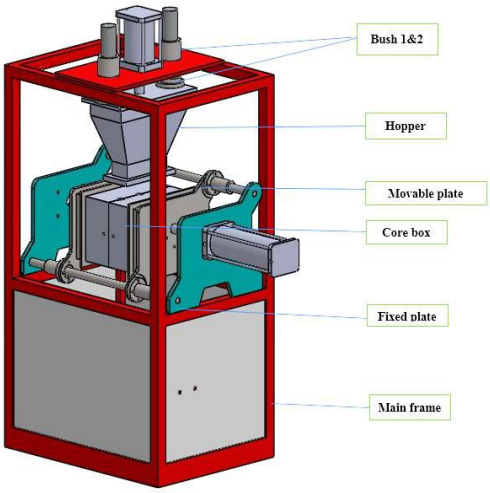

Figure.3.1 Conceptual design

3.2 Components

The conceptual design consists of the following components,

i. Main frame
ii. Hopper
iii. Fixed plate
iv. Movable plate
v. Bush
vi. Pneumatic cylinder

3.2.1 Main frame

A main frame is major part in core shooter and it the area where all components like hopper, fixed plate, movable plate, pneumatic cylinder, core box are fixed. The main frame is strong enough to withstand the capacity of the components and it define the shape of the machine. It was made by square hollow rod and these rods are joint using permanent joint (MIG WELDING). The main frame designed in solid works is shown in Fig 3.2

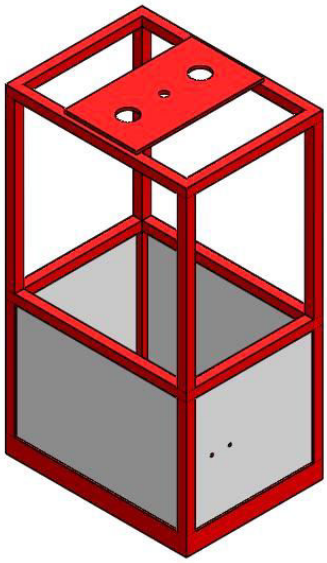

Figure.3.2 Main frame

3.2.2 Hopper

The hopper is the primary storage of core sand and it is typically one that tapers downward and is able to discharge core sand at the bottom. It is fixed on the top of the frame with supporting rod and bush and has a maximum storage capacity of 20KG.The design of hopper is shown in Fig 3.3

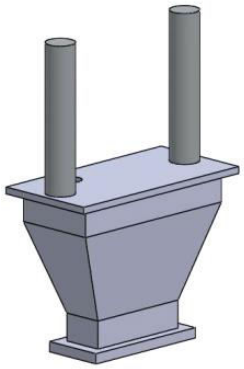

Figure.3.3 Hopper

3.2.3 Fixed plate

The fixed plate is attached with the main frame on both sides. This is used to fix the supporting rod and pneumatic cylinder. The movable plates and core box is fixed on the parallel side. The design of fixed plate is shown in Fig 3.4

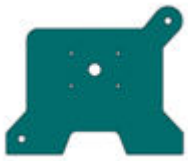

Figure.3.4 Fixed plate

3.2.4 Movable plate

The movable plate is placed on the supporting rod which is fixed in the fixed plate. In the movable plate there is square slot which helps to clamp the core box and also it reduces the heat transfer rate from the core box to body of the machine it is more flexible for clamping varies size of core boxes. The design of movable plate is shown in Fig 3.5

Figure.3.5 Movable plate

3.2.5 Bush

In the machine there are three types of bushes used they are, supporting bush for movable plate, the another one is place in the frame for supporting the hopper, and the last one is used to make a connection between supporting rod and hopper. The design of bush is shown in Fig 3.6

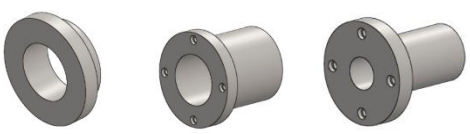

Figure.3.6 Bush 1,2&3

3.3 Exploded view

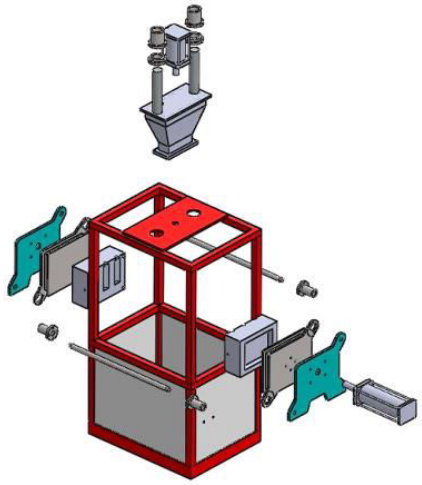

Figure.3.7 Exploded view

3.4 Fabrication process

The material selected must possess the necessary properties for the proposed application. The various requirements to be satisfied can be weight, surface finish, rigidity, ability to withstand environmental attack from chemicals, service life, reliability, etc.The various physical properties concerned are melting point, thermal conductivity, specific heat, coefficient of thermal expansion, specific gravity, electrical conductivity, etc. The various mechanical properties concerned are strength in tensile, compressive shear, bending, torsional and buckling load, fatigue resistance, impact resistance, elastic limit, endurance limit and modulus of elasticity, hardness, wear resistance and sliding properties.

4. RESULTS ND DISCUSSIONS

In this project a automatic shell core shooter was designed and fabricated as explained in sub-chapters 3.1 to 3.4. The overall specification of the project along with its economic analysis, savings are detailed in this chapter. In addition, the results of trials and the working of the automatic shell core shooter are discussed.

4.1 Automatic shell core shooter

The work study of the components for which the automatic shell core shooter are planned to be fabricated mainly involves the method study and the time study for the components

4.2 Method study

The method study of the components for the automatic shell core shooter are studied in detail. The method study mainly involves the different operations involved in the sequence of its operation.

4.3 Sequence operation

The automatic shell core shooter has to undergo steps in the below given sequential order. Each and every process is guided and controlled by PLC system and solenoid valves

i. Mandral move from the home position to the clamping position.
ii. Hopper down – Hopper moves from the home position to the shooting position.
iii. Shooting process – Shooting of core sand from the hopper to the core box with help of air pressure and solenoid valves.
iv. Hopper moves to the home position after the required core sand is shooter to the core box
v. Curing time – core sand in the core box changes from stack point to the solid state (shell core).
vi. Mandral moves to the home position.
vii. Throughout the process, heating catridge is automatically turned on/off by selac controller to maintain the required temperature.

4.4 Time study

The time taken for each operation individually is sorted in sequence and is given below in table 4.1

Table .4.1

SI.No	Operation	Cycle time (sec)
1	Clamping	2
2	Hopper down	2
3	Sand shooting	2-10
4	Curing	120-240
5	Core removing	5

The time study for the different operations involved in the core making operations are studied and noted down using the stopwatch in the time study. While in automatic cycle after every action there will be a delay time of 2sec. The time taken for each operation is studied and evaluated individually after the implementation of automatic core making machine instead of manual operating machine. The variation after usage of automatic core making machine is positive, enhancing the productivity. Hence implementing automatic core making machine is sensible and has good effectiveness. The difference between the manual operating time and automatic cycle time is clearly plotted in bar chart which is shown in Fig 4.1.

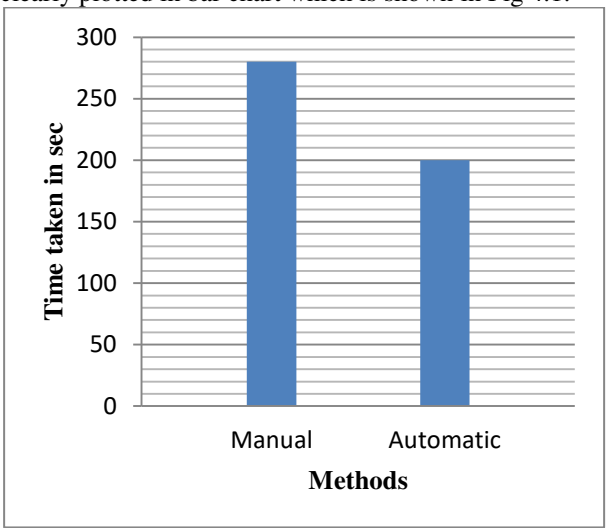

Figure.4.1

Before the process starts, initially the core box has to be heated to maximum working temperature of 270^{o}C. The time taken to reach the maximum temperature by the heating cartridges is measured using stop watch. The initial temperature setup time was shown along with atmospheric temperature in line chart shown in Fig 4.2.

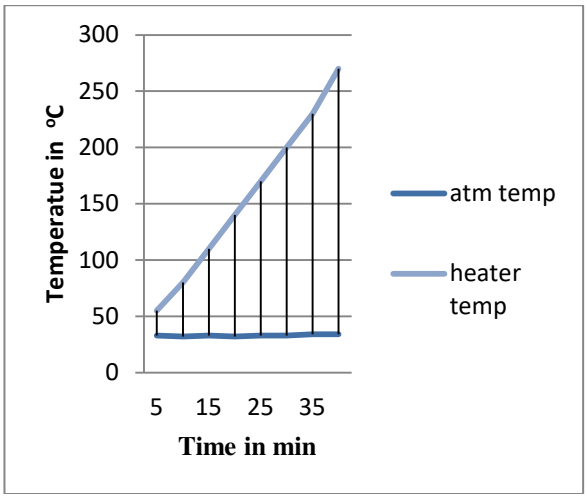

Figure.4.2

4.5 Economic analysis

Economic analysis of automatic core shooting machine was done by estimating increase in profit, total savings in labour cost, payback period and return on investment.

4.6 Savings

The major savings due to the implantation of automatic core shooter is time reduction. There is also increase in productivity which adds to profit of the company

5. SUMMARY AND CONCLUSIONS

A automatic core shooter is designed and fabricated as discussed in the previous chapter which would serve the need for the industry. The summary and conclusion of the whole project and benefits are discussed in this chapter.

5.1 Summary

Initially while starting the project work, the availability of spare parts were checked in the market and the parts which were not readily available in the market were designed separately and then manufactured. Each part was initially designed separately and then assembled into a single component. The correct material was chosen and selected once the design and analysis of the design was over. The dimensions were then marked on the raw material bought for manufacturing the machine and a number of processes were carried out which were explained in details in chapters 3.6.1 – 3.6.6. The manufacturing process was done with keeping in mind all the safety measures required. Once the machine was ready and fabricated, a trail run was conducted and then painting works were carried out once everything was finalized and completed.

5.2 Benefits of the project

The main benefits of the project is that it reduced the labour cost, and time used for producing one component to a very large extent. By doing the movement of core sand to the core box automatically with the help of pneumatic cylinder and PLC system and also heating the core box automatically with the use of heating catridge. The estimated cost of the machine is Rs.2lakh which is very cheap price since the productivity is increased with the decrease in the amount spent on labour. The key benefits of this project include decrease in,

i. Labour cost.
ii. Time consumption.
iii. Manual errors.
iv. Independent of skilled labour.

5.3 Learning from the project

i. Day to day engineering concept will solve many industrial problems.
ii. Designing and making of prototype.
iii. Knowledge enhancement of practical possibilities of making design to a component and quality.
iv. Concepts and implementation of PLC system.
v. Discipline, Punctuality, Dedication, Commitment and Time management

5.4 Achievements of the project

i. Small size cores can be produced easily.
ii. Wastes produced during casting process is reduced
iii. The machine can be operated by both manually and automatically
iv. Automatic process saves time

5.5 Conclusions

Thus a automatic core shooter is designed and fabricated for making shell core with less time and automatic process. The machine can be operated by both manually and automatically. The project was completed within the given amount of time and the project ended on the successful note. Skilled labour is not required to operate the machine. The project was completed with keeping in mind all the safety measures that are required while carrying out the pertains on the machine.

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