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Design of Semi-Automatic Plastering machine using Pneumatics

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Abstract - *Plastering is a process in which a layer of cement and sand mixture is set on the wall manually in most of the world. Also, there is a need for plastering in every construction site. For this process skilled workers are needed and a lot of time. To reduce the manpower along with the plastering time, automatic plastering machine is used instead. Every manual work needs to be transformed into automation, so Automatic Plastering machine was developed to lower the human efforts and concerning it reducing the overall cost. This machine consists of an AC/DC supply, pneumatic cylinder, pressure regulators, hopper, vertical aluminum sections, pressure valves, Bluetooth chip, inverted board, and compressor. This model is fabricated by considering normally plastering a 6 feet wall. This model is tested and different analysis is done accordingly. Earlier instead of pneumatic cylinders they used – gearbox, motors, ropes and pulleys which make assembly a bit more complicated. It is feasible, lightweight, inexpensive and simple structure comparing to the existing machine. Our main aim for this innovative idea is just to render the platers on the wall automatically with higher efficiency.*

Key Words: Cement mixture, aluminum section, rubber pads, Pneumatic cylinder, AC supply, hopper (inverted), vertical aluminum section, rendering, pressure regulators and control.

1. INTRODUCTION

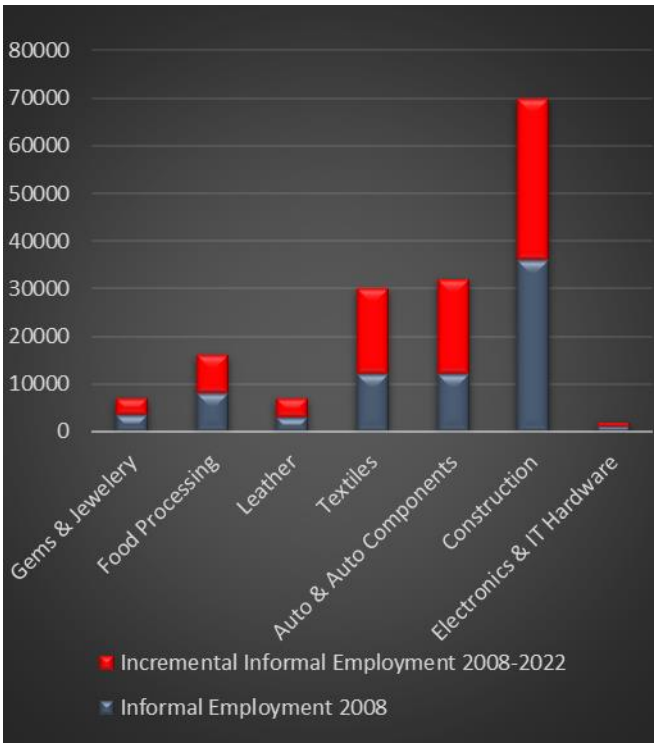
As we know that India is one of the fastest-growing countries in the world. One of the key factors of any developing country is the continuous construction of buildings in smart cities. Hence, we need to automate the process which is directly linked with the constructing sites. The plastering is still done in India manually, this can be done by introducing Automatic Plastering machine in the industry. So in this paper, there is an attempt made to rectify all the mistakes made in the currently available machines and introducing a machine that is better and can be utilized in market for plastering the wall.[1]

Let us discuss some of the basic steps of manual plastering technique –

1. Clean the wall to remove the irregularities on the surface of the wall.
2. Preparation of scaffolds to plaster the walls at a certain height.
3. Materials required to plaster are transferred to the particular site.
4. Prepare the cement mortar; a mixture of sand and cement.
5. Keep the ratio of sand to cement as 4:1, 4 units of sand and 1 unit of cement.
6. Apply plaster to the wall.
7. Forming of the plane surface by levelling the plaster.
8. Finishing the surface to meet the given tolerance.

1.1 Problems with current scenario

Real estate and construction together is the second largest industry in India, next only to agriculture, according to Economic Survey 2017-18, tabled in the Parliament. The sector employed over 40 million workforces in 2013, over 52 million in 2017 and as per projections, it is stated to employ over 67 workforces by 2022. This implies that it will generate over 15 million jobs for the next five years, so around 3 million jobs annually. Over 80% of employment in real estate and construction constitutes minimally skilled workforce, while skilled workforce accounts for over 9% share, and the remaining are spread across work classes such as clerical, technicians and engineers. As per the National Skill Development Council (NSDC), the real estate and construction sector is expected to require over 66 million people by 2022. The below graph shows the incremental labor requirements for various sectors. Most of the unskilled workers come from rural areas and generally have no prior education or training and usually pick up skills on the job, informally from supervisors and peers. A small part of skilled workers also emigrates overseas in search of better wages. This worsens the current scenario even more as there already is a shortage of skilled labor. Realizing the severity of the shortage of skilled construction workers, the government of India had conducted a skills mapping study and identified carpentry, electrician, painter, welder, masonry, crane operations and plumbing as key roles which will be in demand until 2022 and the level of skills required. Together, these key roles will require 7.3 million vocationally trained workers by 2022 [2]. The Indian construction industry complained of a shortage of skilled workers which is likely to worsen if more workers are not made employable or processes are replaced with the corresponding equipment, however, the extent to which the labor is going to get shorter in future that, it is not only required to manufacture construction equipment but also there is a need to automate the equipment to avoid the labor shortage to run this equipment.



(Source: NSDC, XI the Five-Year Plan by the Planning Commission, Government of India)

Table 1.1 Classification of labor in the construction Industry

Category	Percentage of employment in the Construction Industry	Total Employment
Unskilled Labor	82.58%	25.6 million
Skilled Labor	10.64%	3.3 million
Technicians & Foreman	1.93%	0.6 million
Clerical	2.25%	0.7 million
Engineers	2.58%	0.8 million

1.2 Solution

From the above evidence, it can be easily concluded that there will be a shortage of labour in the construction industry in the foreseeable future. This will result in a steady increase in wages of labours. Hence, there is a need to start automating all the respective processes of the construction industry. Plastering is one of the significant processes in the construction of any building. This increases its priority to automate this process first before we reach a shortage of labour phase. Also, this gives us a chance to increase the efficiency of the process without compromising the quality of work. The main objective of this project helps in providing an effective solution to construction applications by using a pneumatic cylinder drive for making necessary activity.[3]

2. OVERVIEW ABOUT WALL PLASTERING MACHINE

A basic model of plastering machine consists of a gearbox, pulleys, tray mechanism mounted on two guideways, so it can slide parallel vertically upwards and downwards on the path of the guideways. The plastering machine is mounted on a fixed set of wheels and the base frame which is fixed to the ground. The working of the machine and other features will be considered below

The machine is kept against the wall to be plastered. The hopper is kept against the wall to be plastered, then the thickness of the plaster is determined. The distance between the wall and plasterboard is locked for the equal distribution of plaster on the wall. As the container is slowly raised, followed by an even layer of plater on the wall. This is how a typical wall plastering works.[4]

3. THE NEW CONCEPT

Our main aim is to develop this model is that earlier we used gear drives, conveyor belts, pulleys and motors to slide the machine against the wall, but in our case, we just use a pneumatic cylinder instead of all the mechatronics mentioned above. This would further reduce the overall weight of the machine making it more efficient. Also, the cylinder which is placed at the center of the plasterboard is regulated by the pressure valves, which also controls the speed of the piston. We also connected the movement of the plasterboard with Bluetooth chip which can be directed by our cell phones.

4. BASIC CONCEPTS ABOUT PNEUMATIC CYLINDER

The use of pneumatic cylinders presents some of the advantages when compared with other systems like hydraulic, electric systems; such as economic operation, efficiency, durability, reliability and adaptability to a hostile environment. However, some nonlinearities make difficult the position control of the pneumatic cylinder, such as compressibility of the air, and the nonlinear relation of the flow in the control holes. These pneumatic actuators are used in various fields such as; robotics, medical fields, automotive industries, and mining industries. Many studies about positioning systems using pneumatic actuators are performed through positioning control chambers. The pneumatic cylinders are normally manufactured in bore size 12, 16, 25, 32, 40, 50, 60, 80, and so on, the maximum stroke length of 100-1000 mm depending on the bore of the cylinder for standard application. Different types of mountings are also available in the market to mount the cylinder on the machine depending upon the space available and there need. The main objective was of reducing cost and some researchers adopted cheaper ON/OFF 2-way values

commanded by the pulse width modulation (PWM) technique to the control of the air mass flow directed to the cylinder chambers. This system was composed of two proportional regulators valves that were set to work in double-loop mode and each valve was equipped with one board PI controller. Here in this system, compressed air is a potent form of energy that is used to get a mechanical energy output by linear motion through a pneumatic cylinder. This linear motion, in turn, can also be used in different ways such as; pushing, lifting, clamping, feeding, pressing and forming, etc. The linear moment can also be used effectively to perform functions such as positioning, turning, bypassing, selecting segregating, index locating and ejecting in various mechanical devices. Using these we can get the smoother movement of the machine with high working speed, also these are easy to repair and maintain. Not affected by the fire as in electrical systems so can be safely used in dangerous areas like mines, compressed air from the cylinder can also be stored through pipes over long distances, although they are cleaner as compared to the hydraulic system.[5]

5. OBJECTIVES

Our main aim is to render the plater on the fucking walls mechanically and automating the process. Automation can be considered as one of the numerous and evolving disciplines among all technologies. This concept aims at reducing the work of trained workers. From the above discussion about old plastering techniques, problems in old plastering techniques, their downsides, the background of the plastering method and the decided aim to be achieved following are some objective has been decided [6]

1. To improve existing methods.
2. Design of machine.
3. It reduces human work.
4. The machine should be easy to operate.
5. Due to the use of pneumatics the overall weight of the model is reduced.
6. This machine can be used for constructing sites, commercial buildings, malls, etc.
7. It brings a smooth, flat finish with adjustable thickness.
8. Amount of wastage of materials can be reduced.
9. It can be remote controlled and either can be controlled by our cell phones using a Bluetooth chip.

6. LITERATURE REVIEW

Numerous attempts have been in the past by noteworthy people to bring a change in conventional plastering techniques. A lot of those failed and not all the machines are in working conditions and as a result, many of those techniques have not been adopted in the process of plastering. So to acknowledge the contributions made by various people in the field of plastering, literature review and survey is stated. After review those ideas and experiments thoroughly, the new semi-automatic plastering machine is designed keeping in mind the past experiences.

In his paper, **Forsberg et al.** have discussed the hurdles faced during the plastering of walls and ceilings at the time of construction of houses and commercial buildings. His robotic plastering machine has successfully passed the practical test at an actual construction site. The results obtained by Forsberg and his teammates were quite promising. They found out that their machine plasters any given area in almost 50% of the total time taken by a human when they plaster the same area. Also, the quantity of plaster used by the robotic machine is significantly less due to spraying as compared to manual work. However, Forsberg and his team stated that the driving force behind developing this robotic plastering machine was mainly ergonomic and not financial. In their paper, they also briefly discussed various errors they faced, namely Mechanical, Navigation & Control errors [7].

Bock et al. are his paper discussed using a robot for carrying out plastering work. Thomas Bock and his team detailed into atomization of the robot using mathematical modelling and described the synthesis of control laws and planning of the motion. In any case of errors, they developed a software module which entitles the robot to undergo a trajectorial path. The trajectory is set in such a manner that it remains optimal, i.e. when a robot moves along the defined path, the energy used will be optimized to a minimum. Additionally, the highest level of accuracy will be maintained while carrying out the processing of the area [8].

Mahesha P.K et al. conducted experiments of novel plastering method. They named this as 'trowel operation procedure'. The technique revolves around how to use a trowel for carrying out plastering of the wall. The trowel is used in such a manner that it delivers the right amount of force with a perfect angle to obtain better finishing. It includes the setting of the trowel at the perfect angle, with the outermost edge at around 10-15mm away from the wall. Mahesha et al. further discussed that structure of brick should be made properly keeping in mind the manufacturer's views and beforehand described installation method. They strongly advised that all the pre-requisites should be completed without any mistake or it might lead to an increase in cracking and contraction on the pointing lines after the plaster is done [9].

Long et al. proposed a new type of machine for plastering to increase efficiency. Their technology uses a laser sensor to calculate the flaws in the bracing pieces perpendicularity and the deflection angle of the plasterboard. If the sensors detect any potential threat then they use trajectory planning to try to nullify the error. However, there have been a few major setbacks of this technology. The first one is that this method is unable to reach the corners of the wall or ceilings and thus the work remains incomplete. Another one is that the high power of vibration generated can neither be deviated nor compensated [10].

Pritschow et al. presented an idea of using mobile plastering machine for various purposes. This robot will be used practically at the plastering sites and it will require a competent handler to control its functions. Economic aspects of the German plastering industry, requirements for semi-automated plastering, alternative robotic end-effectors, various kinematic structures as well as suitable drive technologies for a plastering robot are discussed in detail [11].

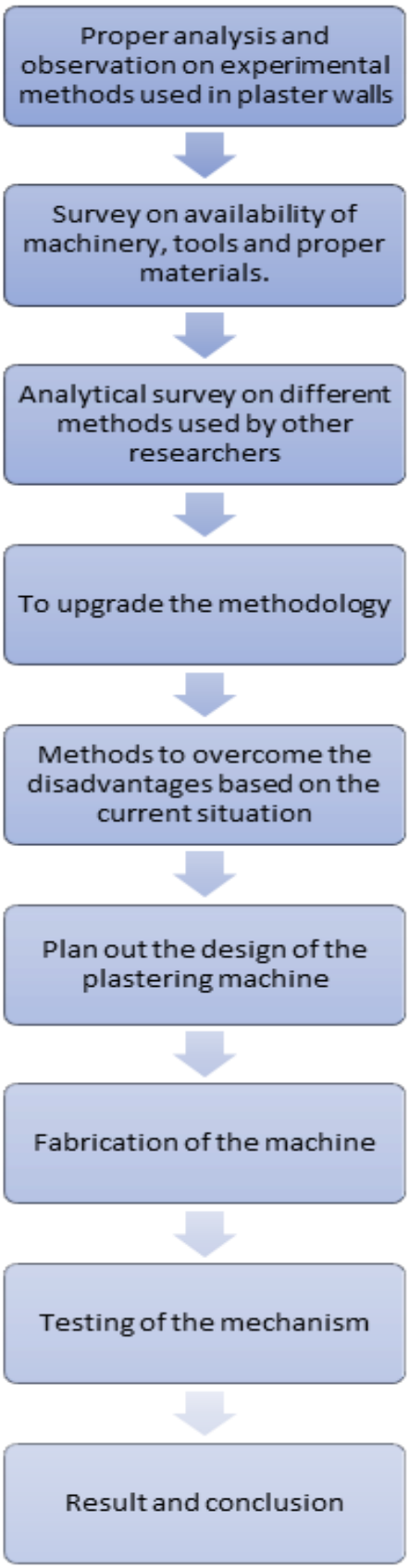
Bulgakov et al. discussed the scope of automation in the file of construction. He developed a machine to increase the efficiency of plastering and which also provides with an outstanding finishing at the end of the operation. Their paper revolves around methods and concepts of how to design a block diagram and make an automatic finishing robotic system [12].

Li et al. made a scalable plastering machine with its virtual prototype. They used tools of PRO/E and ADMAS to create that and also presented the stimulation of kinematics analysis of the machine to showcase all the aspects of the machine. They observed the machine in its working conditions and established important points regarding the machine heads dynamics and torque required. They made a graph of displacement vs speed for the plastering machine head and stated that the virtual prototype model acts a mirror of physical prototypes for everything. So they finally concluded that the developed was perfect [13].

Thakare et al. studied the conventional plastering methods in detail and stated that it is high time that new methods should be used in the construction world for carrying out plastering work. He backed his views by saying that this will not only increase the efficiency but also reduce the labor cost, time, wastage of materials and also will be a safe approach. A new semi-automatic or automatic plastering system will marginally reduce the labor working time and can be used to build the structures faster. This system will solve problems like a Shortage of Skilled Labour and Scaffoldings in the field of plastering [14].

7. METHODOLOGY

In India, many innovative ideas have been formulated on this plastering machine but no one has used the methods by using pneumatic cylinders, so as seen this method is distinctive. The main thing in this project is the stability of the plastering machine and steps to be taken to prevent it to drop. Also considering pneumatic cylinder, the speed of the piston rod in the cylinder will be very high so to control them, the pressure is being reduced by a three-port valve.



8. SPECIFICATIONS & CALCULATIONS

Pneumatic Cylinder Specifications

Bore = 50mm

Stroke = 1200mm

Pressure = 6 Bar = 6 * 10^5 (N/mm^2)

Weight to be lifted in Forward stroke against gravity

Volume of container = 1 ft^3

= 0.3*0.3*0.3 = 0.027 m^3

Cement Density = 1.44 (gm/cm^3)

= 1.44 *10^6 (gm/m^3)

= 1.44 * 10^3 (kg/m^3)

Therefore, Maximum cement weight in the container = Density * Volume

W = 1.44 * 10^3 * 0.027 m^3

= 39 kgs

Cylinder Pushing force

F = Pressure*Area

F = 6*10^5 (N/mm^2) * π*d^2 / 4

= 6*10^5 (N/mm^2) * 3.14*(50*10^-3) / 4

= 12500*10^-1*3.14 / 4

= 981 N = 98 kgs (Approx.)

This shows that the pneumatic cylinder has sufficient pressure to lift the cement during the plastering process [15].

9. CONCLUSIONS

From this study it can be stated that there is a need for automating the plastering process in the construction industry and at present there is need for such type of semi-automation systems which can reduce the labor cost ,working time ,plastering cost ,wastage of plastering mortar on plastering site ,etc. Furthermore, changing the driving process of this machine from an electric motor to a pneumatic cylinder has its own advantages. One of them is that no complex chain and sprocket systems are required which substantially decrease the weight of the machine and the volume occupied by it. Also, we can increase and decrease the speed of plastering as per our needs with the help of a throttle valve. All this integrated with a Bluetooth chip will help operate the machine wirelessly. The pneumatic cylinder is cheaper to buy as compared to a respective servomotor. This plastering machine will reduce unnecessary wastage of time on the construction site. We can also say for sure that this machine solves future problems like shortage of skilled labor and scaffolding.

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