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Automatic Wall Plastering Machine

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***Abstract*-The building construction is time consuming sector because lot of work is labor based there is too much shortage of skilled labor, increase in labor cost and technological advances are forcing rapid change in the building construction. Building construction mainly consists of commercial infrastructure and residential building, but in every sector plastering work is must. We are introducing new machine to automate the plastering work which is very much demand for construction field. The machine consists of AC/DC motor, Gear box, wire rope, pulley, hopper, tray mechanism, guide ways, etc. The present work developed model of wall plastering machine. The model is fabricated by considering the normal constructed brick wall. The model is tested and different analyses are done.**

***Index Terms*- building construction labor cost, plastering work , AC/DC motor, Gear box, wire rope, pulley, hopper, tray mechanism, guide ways, etc.**

I. INTRODUCTION

Plastering is that the plaster work that is understood as ornamentation done by plasterers on walls by manually in most elements of the globe. The plaster desires a lot of effort of humans and conjointly consumes longer in manual 1.1
method. This innovative machine is exclusive and maybe 1.2
one quite automatic coating machinery ideally appropriate for the construction/building trade. It will plaster the wall mechanically by moving up and down in vertical direction. It will be plastered by one-time in vertical direction. It's two rails for rising and moving mechanically, so it will be used for various height and dimension of the wall. It's massive capability hopper and you'll be able to place the mortar in it one-time. It's simple to work. Simple to maneuver, while not removing any elements of the machine and there are wheels below the machine for simple movement.

With the constant increase within the demand of the development, the contractors forced to extend their construction and conjointly the standard of the development to stay within the competitive market. The development trade in most countries amounts to 10–20% of the gross national product, creating it the biggest economic using sector. It's still labor demand and conjointly most of the work concerned is repetitive. The expansion of any country depends on the development trade therefore it's of prime economic significance to several industrial sectors. Intense competition, shortages of arch labor and technological advances is forcing fast amendment within the industry, so encouraging its automation during this trade [1]. The development of buildings, apartment, complex, shops, homes are basic necessities of creature. During this construction space coating is important for decorating the wall. Coating works refers to construction or ornamentation through with plaster, plaster ornamental moldings on ceilings or walls. This can be conjointly referred to as coating. The method of making plaster referred to as coating. Tools and materials embody trowels, floats, hammers, screeds, a hawk, scratching tools, utility knives, laths, lath nails, lime, sand, plaster of Paris, a spread of cements, and numerous ingredients to make color washes [1].

Plasterers can usually divide an area, (especially an outsized or ceilinged wall) into high and bottom. The one performing on high can do from the ceiling's edge to regarding belly height and remove a milk crate for an 8-foot (2.4 m) ceiling, or remove stilts for 12-foot-high rooms. For cathedral ceilings or terribly high walls, staging is ready up and one works shelter deck, the others any below [1].

1.1 Plastering Technique

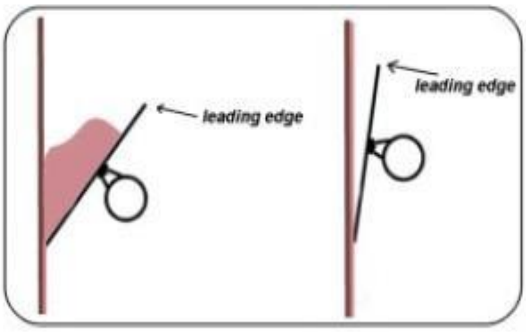

Fig.1.Trowel technique

Fig.1 shows the trowel operation technique in ancient covering technique. The right covering technique is crucial with solely the trowel getting used to use and end the skim coat. Achieving a decent end is that the combination of firm pressure combined with the right angle of trowel (how so much the forefront is from the wall). Covering technique for applying plaster is initiated by trowel loaded with plaster, so forefront of the trowel are an extended approach from the wall. The forefront got to be planate step by step into the wall. With consequent stroke the trowel are used for flattening out the plaster as simply applied. There'll be no plaster on trowel and it'll be fairly flat the forefronts are more or less ten fifteen metric linear unit removed from the wall [1].

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Fig.2.Plastering Technique

As shown in Fig.2 initially the mortar is poured into the hopper in certain amount the hopper is equipped with mixing mechanism to mix and force the mortar to flow in downward direction on the inclined plate. When the inclined plate moves up with the help of guide way's and by keeping clearance between inclined plate and wall the mortar gets stick to the wall and the roller mechanism is assembled below the inclined plate which then finishes the plaster done on the wall.

1.3 Pre-plastering requirements

The masonry/brick substrate should be put in strict accordance with the manufacturer's specifications and suggested installation procedures. All inform shall be flush finished. The makers needed set time should be allowed when placement of the bricks to confirm all of the inform has utterly cured and also the walls have stable. Failing to permit the inform too completely cure will cause excess shrinkage and cracking on the inform lines when the walls are plastered. The finished look of the wall is extremely hooked into the quality of the wall construction. Application cannot start until; all the surfaces that area unit to be coated area unit level. There should be no quite a 3mm deviation within the surface alignment over a 1200mm radius [2].

Technical trends in construction automation

As discovered, the robots and systems for building construction were principally developed within the mid-1980 and early Nineteen Nineties and knowledgeable about severe economy lasting from the mid-1990 up to now. The presently used systems and robots, concrete floor finishing robots, steel structure fastening robots, etc., well-tried their advantage and managed to survive the economic hardship. Further, enhancements area unit expected to be created in those systems and robots in order that they'll expand their applications within the future. On the opposite hand, new sorts of robots area unit being developed for the rising social desires, increase of renewal works of previous buildings and also the rising issues on environmental issues [1].

The construction sector employs eighty three percent casual staff and therefore, is comparable to the Indian work force demographic. It conjointly represents an outsized majority of the work force because it is that the second largest leader once agriculture.

1.4 Shortage of skilled construction workers

The Indian industry comprising infrastructure and assets sectors use over twenty six million casual staff and area unit the country's second largest leader once agriculture. The look commission of Republic of India has projected that the development sector would force another forty seven million folks within the manpower over consequent decade (FICCI 2010:13). Despite such significance to the Indian economy, there's no specific policy for ability building within the construction sector. Table below shows the present pool of the development manpower in Republic of India contains principally unskilled workers [3].

Category	Percentage of employment	Total employment
Unskilled workers	83%	25.6 million
Skilled workers	10%	3.3 million
Engineers	3%	0.8 million
Technicians	2%	0.6 million
Clerical	2%	0.7 million

(Source: Report of Working Group on Construction for the Eleventh Five year Plan, Planning Commission, Government of India)

II. OBJECTIVES

Automation is one in every of the numerous and evolving disciplines among all technologies. Our aim of this innovative plan is to render the plasters on walls mechanically. This concept aims in reducing the work of trained worker. It's possible, light-weight weight, cheap and easy structure scrutiny to the present machine. This innovative method keeps up with the ever ever-changing world of building automation.

1. It reduces the human work.
2. It straight forward in construction and simple to control.
3. Scrutiny with ancient application technique, higher quality of the plaster can acquire.
4. Application will be worn out optimum time.
5. Straightforward to maneuver from one place to a different place.

III. NEED

1. The automatic wall plastering machine will help to save labor cost.
2. To avoid the wastage of the mortar, thus to save the cost.
3. To save the work time.
4. Shortage of skilled labor.

IV. METHODOLOGY

Analytical Study
- Research paper
- Design of components required for the machine
- Fabrication of the machine
- Testing of the machine
- Result and analysis

V. LITERATURE REVIEW

1. *Design and Fabrication of Automatic wall plastering Machine*

Author Name: Mahesha P.K, Sree Rajendra

Journal Name: IOSR Journal of Mechanical and technology

Result: This work includes applying the mortar into the wall and additionally pressuring mortar with a creating surface level. The model has been developed and tested with success.

With this development the 2 major downside construction industries presently facing are often reduced. They're consummate labor shortage and Quality within the construction method with less wastage. Through the trials it's noted that the machine is a lot of productive compare to the labor with relevancy the rendering work and additionally the standard achieved is sort of admire the labor.

2. *Automatic Plastering Machine*
Author Name: Arivazhagan.B
Journal Name: International Journal of Advanced analysis in physics, Communication & Instrumentation Engineering and Development
Result: Machine-driven rendering machine is exclusive and maybe one reasonably machine-driven rendering machinery ideally appropriate for the construction/building business. Machine-driven rendering machine works with typical cement mortar that brings it to a swish, flat end with variable and adjustable thickness to suit every application. Machine-driven rendering machine makes rendering easier, faster, and easy as compare to manual application. This concept also can additional increased by interfacing liquid crystal display & computer keyboard for creating the method while not external supply. This point and cash saving machine, keeps up with the ever dynamical world of building automation.

3. *Automation and Robotics in construction:Opportunities and challenges*
Author Name: S.M.S. Elattar
Journal Name: Emirates Journal for engineering analysis
Result: Robots square measure progressively concerned in construction operations to take care of extremely correct actions and to scale back venturous risks achieving improved management and safety. Machine-driven constructions are often additional developed to include: design, engineering, maintenance of existing and planned structures. Several analysis works counsel extremely autonomous robotic system for the development performance. The "Sense-and-Act" could so become a reality within the development of a lot of advanced robotic systems for construction applications. Efforts ought to be paid to persuade professionals in building management to seem into the likelihood of integration AI and building automation along to enhance the standard of services for contemporary intelligent buildings. All new concepts for Automation or robotizing on the vacant lot need to be generated by a mix of recent design, new forms and new materials that meet the necessities for building in a very metropolis.However,many Problems in construction engineering cannot be absolutely addressed through improvement and computation. With intelligence activities reminiscent of generalization, analysis and decision-making for multi-objectives, there are often a higher understanding of the development engineering downside.

VI. DESIGN OF MACHINE COMPONENTS

The Machine design is that the creation of recent and higher machines and up the present ones. A replacement or higher machine is one that is a lot of economical within the overall price of production and operation. The method of design may be a long and time intense one. From the study of existing ideas, a replacement plan must be formed. The concept is then studied keeping in mind its industrial success and given form and type within the variety of drawings. Within the preparation of those drawings, care should be taken of the supply of resources in cash, in men associated in materials needed for the booming completion of the new plan into an actual reality. In planning a machine part, it's necessary to own honest information of the many subjects equivalent to arithmetic, Engineering Mechanics, Strength of Materials, Theory of Machines, Workshop Processes and Engineering Drawing.

Classifications of Machine design
The machine design is also classified as follows
1. Accommodative design.
In most cases, the designer's work cares with adaptation of existing designs. This kind of design desires no special information or ability and might be tried by designers of normal technical coaching. The designer solely makes minor alternation or modification within the existing designs of the merchandise.
2. Development design.
This type of design desires goodish scientific coaching and design ability so as to change the present designs into a replacement plan by adopting a replacement material or totally different technique of manufacture. During this case, although the designer starts from the present design, however the ultimate product could dissent quite markedly from the initial product.
3. New design.
This type of design desires ton of analysis, technical ability and artistic thinking.
Only those designers UN agency have personal qualities of a sufficiently high order will take up the work of a replacement design.

The designs, relying upon the strategies used are also classified as follows:
(a) Rational design.
This type of design depends upon mathematical formulae of principle of mechanics.
(b) Empirical design.
This type of design depends upon empirical formulae supported by the observe and past expertise.
(c) Industrial design.
This type of design depends upon the assembly aspects to manufacture any machine part within the trade.
(d) Optimum design.
It is the most effective design for the given objective operates beneath the required constraints. It should be achieved by minimizing the undesirable effects.
(e) System design.
It is the planning of any advanced system sort of a motor automobile.
(f) Element design.
It is the planning of any part of the system like piston, crankshaft, rod, etc.
(g) Computer power-assisted design.
This type of design depends upon the utilization of pc systems to help within the creation, modification, analysis and improvement of a design.

General concerns in machine design

Following are the overall concerns in planning a machine component:

1. Form of load and stresses caused by the load.

The load, on a machine part, could act in many ways.

2. Motion of the components or mechanics of the machine.

The booming operation of any machine depends for the most part upon the best arrangement of the components which can offer the motion needed.

The motion of the components could be:

(a) Rectilinear motion which incorporates uni facial and mutual motions.

(b) Curved motion which incorporates rotary, oscillating and straightforward harmonic.

(c) Constant rate.

(d) Constant or variable acceleration.

Choice of materials.

It is essential that a designer ought to have intensive information of the properties of the materials and their behavior beneath operating conditions. A number of the vital characteristics of materials are: strength, durability, flexibility, weight, resistance to heat and corrosion, ability to solid, welded or hardened machinability, electrical physical phenomenon, etc.

Form and size of the components.

The form and size are supported judgment. The tiniest practicable cross-sectional is also used, however it should be checked that the stresses elicited within the designed cross-sectional are fairly safe. So as to design any machine half for type and size, it's necessary to grasp the forces that the half should sustain. It's conjointly vital to anticipate any suddenly applied or impact load which can cause failure.

Frictional resistance and lubrication.

There is continually a loss of power thanks to resistance and it ought to be noted that the friction of beginning is over that of running friction. It is, therefore, essential that a careful attention should run to the matter of lubrication of all surfaces that move to bear with others, whether or not in rotating, sliding, or rolling bearings.

Convenient and economical options.

In planning, the operational options of the machine ought to be rigorously studied. The beginning, dominant and stopping levers ought to be settled on the premise of convenient handling. The adjustment for wear should be provided using the assorted take up devices and arrangement them so the alignment of elements is preserved. If elements are to be modified for various product or replaced on account of damage or breakage, quick access ought to be provided and also the necessity of removing alternative elements to accomplish this could be avoided if attainable. The economical operation of a machine that is to be used for production or for the process of fabric ought to be studied, so as to be told whether or not it\'s the utmost capability in keeping with the assembly of fine work.

Use of ordinary elements.

The use of ordinary elements is closely relating to price, as a result of the value of ordinary or stock elements are simply a fraction of the value of comparable elements created to order. The quality or stock elements ought to be used whenever possible; elements that patterns are already living corresponding to gears, pulleys and bearings and elements which can be selected from regular look stock corresponding to screws, barmy and pins. Bolts and studs ought to be as few as attainable to avoid the delay caused by dynamic drills, reamers and faucets and additionally to decrease the amount of wrenches needed.

Safety of operation.

Some machines are dangerous to control, particularly those that are speed up to insure production at a most rate. Therefore, and moving a part of a machine that is among the zone of a employee is taken into account an accident hazard and should be the reason behind an injury. It is, therefore, necessary that a designer should offer safety devices for the security of the operator. The security appliances ought to in no approach interfere with operation of the machine.

Workshop facilities.

A design engineer ought to be acquainted with the restrictions of his employer's workshop; so as to avoid the requirement of getting work tired another workshop. It's typically necessary to set up and supervise the workshop operations and to draft ways for casting, handling and machining special elements.

General Procedure in Machine design

In planning a machine part, there's no rigid rule. The matter is also tried in many ways that. However, the overall procedure to resolve a design drawback is as follows:

1. Recognition of need.

First of all, build an entire statement of the matter, indicating the requirement, aim or purpose that the machine is to be designed.

2. Synthesis (Mechanisms).

Select the attainable mechanism or cluster of mechanisms which can provide the specified motion.

3. Analysis of forces.

Find the forces performing on every member of the machine and also the energy transmitted by every member.

4. Material choice.

Select the fabric best suited to every member of the machine.

5. Design of parts (Size and Stresses).

Find the scale of every member of the machine by considering the force performing on the member and also the permissible stresses for the fabric used. It ought to be unbroken in mind that every member must not deflect or deform than the permissible limit.

6. Modification.

Modify the scale of the member to believe the past expertise and judgment to facilitate manufacture. The modification can also be necessary by thought of producing to cut back overall price.

7. Careful drawing.

Draw the careful drawing of every part and also the assembly of the machine with complete specification for the producing processes prompt.

8. Production.

The part, as per the drawing, is factory-made within the workshop.

Design of Hopper

It is a Galvanised iron sheet material hopper to store the mortar into it up to 25kg. We have considered the volume of the hopper.

Amt of material top be filled in the hopper =(Volume * Density of Cement Concrete Material)

$$26\text{Kg} = \text{Volume} * 1750$$

$$\text{Volume} = 0.014745 \text{ m}^3$$

Therefore,

$$\text{Volume of the hopper} = 0.014745 \text{ m}^3$$

We have divided the hopper into four parts according to our drawing and according to consideration of gravitational force.
Therefore,
The hopper is divide into two rectangular and two right angled triangle sections.
First Rectangular Section
$[Area]_1$ = width * breadth
= 290 * 235
= 68150 mm^2
$[Volume]_1$ = $[Area]_1$ * depth
= 68150 * 130
= 8859500 mm^3
Volume of first rectangular section = 8859500 mm^3
First Triangular Section
$[Area]_2$ = ½ * a * b
= ½ * 55 * 235
= 6462.5 mm^2
$[Volume]_2$ = $[Area]_2$ * depth
= 6462.5 * 290
=1874125 mm^3
Volume of first triangular section = 1874125 mm^3
Second Triangular Section
$[Area]_3$ = ½ * a * b
= ½ * 193 * 115
= 11097.5 mm^2
$[Volume]_3$ = $[Area]_3$ * depth
= 11097.5 * 290
=3218275 mm^3
Volume of second triangular section = 3218275 mm^3
Second Rectangular Section
$[Area]_4$ = width * breadth
= 48 * 290
= 13920 mm^2
$[Volume]_4$ = $[Area]_4$ * depth
= 13920 * 57
= 793440 mm^3
Volume of second rectangular section = 793440 mm^3

Total Volume = $[Volume]_1$ + $[Volume]_2$ + $[Volume]_3$ + $[Volume]_4$
Total Volume =8859500 mm^3 + 1874125 mm^3 +3218275 mm^3 + 793440 mm^3
Total Volume = 14745340 mm^3


Fig.3.Hopper

Design of Upper Shaft
Motor Specification to lift the tray mechanism with the help of rope and pulley
Motor Specification:
Power of Motor = 40 watt
Frequency = 60 Hz
Torque = 120 kg-cm
= 11.77 * 10^3 N-mm

$$P= 2\pi NT/60$$

40=2*3.14*N*11.77/60
N=32.45RPM

$$N \cong 33RPM$$

N=33RPM
Now,
Material for Shaft Fe360
Syt = 220 N/mm^2
Sut = 360 N/mm^2
Now According to A.S.M.E Code

$$\tau = 0.18 * Syt$$

= 0.18*220
=39.6 N/mm^2

$$\tau = 0.3 * Sut$$

=0.3*360
=180 N/mm^2

Maximum load consideration = Hopper wt + Motor wt + other wt
= 65 Kg
Load = 65 * 9.81 = 637.65 N
There are two different sides so, weight on single side or load on single side = 637.65/2 = 318.825 N
Now,
Taking reaction of B
-318.825 * 30 – Rc * 295 +318.825 *325 = 0
-9564.75 – 295R_c + 103618.125 = 0
94053.375 = 295R_c
R_c = 318.825 N
R_b = 318.825 N
Now, bending moment of both sides is same
M = R_c * 30
= 318.825 * 30
= 9564.75 N-mm

Now, we know that

$$T_e = \sqrt{(K_b M_b)^2 + (K_t T)^2}$$

$$= \sqrt{(1.5 * 9564.74)^2 + (1 * 11.77 * 10^3)^2}$$

T_e = 18557.275 N-mm

$$T_e = \frac{\pi}{16} d^3 \tau$$

$$18557.275 = \frac{\pi}{16} * d^3 * 39.6$$

d = 13.363 mm
d = 15 mm

Hence standard diameter for shaft is 15 mm.

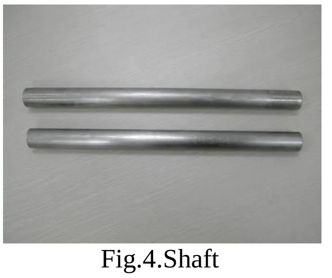
Fig.4.Shaft

Design of Lead Screw

Material Used for power screw-Steel 30C8
Syt = 400 N/mm^2
Consider Factor of Safety = 5

Consider weight = 100kg = 100 * 9.81 = 981 N

$$\sigma = Syt/FOS$$

= 400/5
= 80 N/mm^2

Now, $\sigma = \frac{W}{\frac{\pi}{4} * d_c{}^2}$

80 = 981/$d_c{}^2$ *(π/4)
d_c = 3.95 ≅ 4 mm
d_c = 4 mm

Nominal diameter is very less which is not available in the market and it is difficult to manufacture, So we assume the Core diameter which is available.

Assume Core Diameter d_c = 20.32 mm
Therefore,

$$\sigma_c = \frac{W}{\frac{\pi}{4} * d_c{}^2}$$

$$80 = \frac{W}{\frac{\pi}{4} * (20.32^2)}$$

W = 24525 N

Therefore the weight we considered is 2500Kg.

Now,
We Select M24 Screw threaded Power Screw Having Following Property
Pitch = P = 3 mm
Core Diameter = d_c = 20.32 mm
Major Diameter = d_m = 24 mm
Depth of the threads = t = 1.840 mm
Nominal Diameter = d = 22.051 mm
Type of thread = V thread
Now,

$$d_m = d - 0.5 * P$$
= 22.051 – 0.5 * 3
= 20.551 mm

Lead = Number of Start * Pitch
L = 2 * 3
= 6 mm

Now we know that

$$\tan\alpha = \frac{l}{\pi * d_m}$$

$$\tan\alpha = 0.0929$$
$$\alpha = 5.309^0$$

Now,

$$\mu = \tan\varphi$$

$$\tan\varphi = 0.15$$
$$\varphi = 8.53^0$$

Since $\varphi > \alpha$ Therefore, Screw is self locking.
Torque required lowering the load

$$M_t = \frac{W * d_m}{2}\tan(\varphi + \alpha)$$
= (24525 * 20.551/ 2) * tan 13.839
= 62.08068 * 10^3 N-mm

Now

$$\tau = \frac{16 * M_t}{\pi * d_c{}^3}$$
$$= \frac{16*62.08068*10^3}{\pi*20.320^3}$$

= 37.68 N/mm^2

$$\sigma_c = \frac{W}{\frac{\pi}{4} * d_c{}^2}$$
$$= \frac{24525}{\frac{\pi}{4}*20.320^2}$$
= 75.62N/mm^2

Now bending moment is given by

$$M_b = P * l$$
P = 0.45*200
P = 90N

$$M_b = 90 * 230$$
= 20700 N-mm

$$\sigma_b = \frac{32 * M_b}{\pi * d_c{}^3}$$

$$= \frac{32*20700}{\pi*20.320^3}$$

= 25.13 N/mm^2

Now, The principal shear stress at the section-XX is given by,

$$\tau_{max} = \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + (\tau)^2}$$
$$= \sqrt{\left(\frac{25.13}{2}\right)^2 + (37.68)^2}$$
= 39.72 N/mm^2

$$\text{Factor of safety} = \frac{0.5*S_{yt}}{\tau_{max}}$$
$$= \frac{0.5*400}{39.72}$$
= 5.30

Since,(Factor of Safety)$_{\text{Intial}}$ < (Factor of Safety)$_{\text{calculated}}$ i.e. 5 < 5.30
So, Our Design is safe.

Fig.5.Lead Screw

Design of Handle

$$P * l_h = M_t$$

$$90 * l_h = 62.08068 * 10^3$$

$l_h = 690$ mm

We know that,

$$\sigma_b = \frac{32 * M_b}{\pi * d_c{}^3}$$

$$M_b = P * l_h$$

= 90 *690

= 62100 N-mm

$$\sigma_b = \frac{32 * M_b}{\pi * d_c{}^3}$$

Now substituting the value in above equation

$$80 = \frac{32 * 62100}{\pi * d_h{}^3}$$

$$d_h = 20 \text{ mm}$$

Hence we got diameter of the handle rod as 20 mm.

Design of Worm Gear

Consider,

$(Sut)_{worm\ wheel}$ = 700 N/mm^2 (Case harden steel)

$(Sut)_{gear}$ = 240 N/mm^2(Phosphor bronze)

Assume

Number of teeth on worm wheel = Z_w = 3

Number of teeth on Gear = Z_g = 18

Therefore, Gear ratio = (Z_g/Z_w) = (18/3) = 6

Beam strength of worm gear

$$F_b = (\sigma_b)_g * b * m * Y * \cos\lambda$$

$$\tan\lambda = \frac{Z_w}{q}$$

Assume q = 10

$$\tan\lambda = \frac{3}{10}$$

$$\lambda = 16.69^0$$

Now, Face width = b = 0.73*d_w = 0.73 * m * q = 0.73 * m * 10 = 7.3m

Lewis form factor

$$Y = 0.484 - \frac{2.87}{Z_g}$$

$$= 0.484 - \frac{2.87}{18}$$

= 0.3245

Bending Stress of gear

$$(\sigma_b)_g = \frac{(S_{ut})_g}{3}$$

=240/3

= 80 N/mm^2

Now substituting all value in beam strength formula

$$F_b = 80 * 7.3m * m * 0.3245 * \cos 16.69$$

$$= 189.508m^2 \text{ N}$$

Now calculating wear strength of worm gear

$$F_w = d_g * b * k$$

$$d_g = m * Z_g$$

= 18m

Face width = b = 10m

Standard wear load factor for phosphor bronze gear

k = 0.83 N/mm^2

$$F_w = d_g * b * k$$

= 18m * 7.3m * 0.83

= 109.062 m^2 N

Now,

As $F_w < F_b$ Gear pair is weaker in pitting. Hence it is required to design a gear pair against the pitting failure.

Calculate the Effective load on worm gear

$$F_{eff} = \frac{K_a * F_{gt}}{K_v}$$

Velocity Factor

$$K_v = \frac{6}{(6 + V_g)}$$

Velocity of Gear

$$V_g = \frac{\pi * d_g * N_g}{60 * 10^3}$$

$$= \frac{\pi * 18m * 55}{60 * 10^3}$$

= 0.0518m m/sec

Therefore Velocity factor

$$K_v = \frac{6}{(6 + V_g)}$$

$$= \frac{6}{(6 + 0.0518\text{m})}$$

Now, Maximum tangential force

We know that

$$P_o = F_{gt} * V_g$$

Where, P_o = Output Power

Now Efficiency = $\frac{P_o}{P_i}$

$$\text{Efficiency} = \frac{\tan\lambda}{\tan(\varphi_v + \lambda)}$$

$$\tan\varphi_v = \frac{\mu}{\cos\varphi_n}$$

$$= \frac{0.03}{14.5}$$

$$\varphi_v = 1.7748$$

Now,

$$\text{Efficiency} = \frac{\tan\lambda}{\tan(\varphi_v + \lambda)}$$

$$\eta = \frac{\tan 16.69}{\tan 18.4648}$$

= 0.8979

Now ,we know that Input power

$$\text{Input power} = \frac{a^{1.7}}{34.5(i+5)}$$

Where, a = Centre distance and i= gear ratio

$$\text{Input power} = \frac{a^{1.7}}{34.5(i+5)}$$

$$P_i = \frac{(10.5m)^{1.7}}{34.5(6+5)}$$

$$P_i = \frac{54.45(m^{1.7})}{379.5}$$

$$\text{Efficiency} = \frac{P_o}{P_i}$$

$$0.8979 = \frac{P_o}{\frac{54.45(m^{1.7})}{379.5}}$$

$$P_o = \frac{48.89(m^{1.7})}{379.5}$$

Assume Input power Pi = 75 watt

Therefore Output Power = (P_i/ Efficiency) = (75/0.8979) = 83.52watt

$$P_o = 83.52\text{watt}$$

$$P_o = F_{gt} * V_g$$

$$83.52 = F_{gt} * 0.0518m$$

$$F_{gt} = \frac{1612.35}{m}$$

Now, we know that

$$F_{eff} = \frac{K_a * F_{gt}}{K_v}$$

$$109.062(m^2) = \frac{1.25 * \frac{1612.35}{m}}{\frac{6}{(6 + 0.0518m)}}$$

By arranging equation we got,

$$109.062m^3 - 17.399m - 2015.4 = 0$$

$$m = 2.66 \cong 3 \text{ mm}$$

Hence we got module as Module = 3 mm

Dimension of the worm gear are as follow :

Diameter of worm gear = d_g =18m =18 * 3 = 54 mm

Diameter of worm wheel = d_w = m * q = 3 * 10 = 30 mm

Axial pitch = P_a = π * m = π * 3 = 9.42 mm

Face width = 0.73 d_w = 0.73 * 30 = 21.9 mm

Center Distance = C.D = $\frac{(d_w+d_g)}{2} = \frac{30+54}{2}$ = 42 mm

Addendum = h_a = 1m = 1 * 3 = 3 mm

Dedendum = h_f = 1.25m = 1. 25 * 3 = 3.75 mm

Length of the worm = P_a * Z_w = 9.42 * 3 = 28.26 mm

Fig.6.Worm gear

Design of Spur Gear

Consider,

$(S_{ut})_{pinion} = (S_{ut})_{gear}$ = 580 N/mm^2 Plain carbon steel 40C8

Number of teeth on Pinion = Z_p = 15

Number of teeth on Gear = Z_g = 45

Gear ratio = G = $\frac{d_g}{d_p} = \frac{45}{15} = 3$

Now,

Check whether gear is weaker or pinion is weaker

We know that,

$$(\sigma_b)_p = (\sigma_b)_g = \frac{(S_{ut})_{pinion\ and\ gear}}{3} = \frac{580}{3} = 193.33N/mm^2$$

Lewis form factor is,

$$Y_p = 0.484 - \frac{2.87}{Z_p}$$

$$= 0.484 - \frac{2.87}{15}$$

$$= 0.2927$$

Now when material is same for pinion and gear in such condition always pinion is weaker.

Calculate the beam strength of pinion

$$F_b = (\sigma_b)_p * b * m * Y_p$$

Face width = b = 10m

$$F_b = 193.333 * 10m * m * 0.2927$$

$$F_b = 565.87m^2N$$

Calculate the wear strength of gear pair

$$F_w = d_p * b * Q * K$$

For external gear pair

$$Q = \frac{2 * Z_g}{(Z_g + Z_p)}$$

$$= \frac{2 * 45}{60}$$

$$= 1.5$$

Diameter of pinion = d_p = Z_p * m =15 * m = 15m

Now For steel gear and steel pinion

$$K = 0.16 * \left(\frac{BHN}{100}\right)^2 N/mm^2$$

$$= 0.16 * \left(\frac{218}{100}\right)^2$$

$$= 0.76 \text{ N/mm}^2$$

Wear strength

$$F_w = d_p * b * Q * K$$

$$F_w = 15m * 10m * 1.5 * 0.76$$

$$= 171m^2 \ N$$

As, $F_w < F_b$ gear pair is weaker in wear. Hence, it is required to design a gear pair against the wear failure.

Calculate the effective load on gear pair

$$F_{eff} = \frac{K_a * K_m * F_t}{K_v}$$

Now

Velocity factor

$$K_v = \frac{6}{(6 + V)}$$

$$V = \frac{\pi * d_p * N_p}{60}$$

$$= \frac{\pi * 15m * 33}{60}$$

V = 25.9181m mm/sec

= 0.02591m m/sec

Tangential force

$$F_t = \frac{P}{V}$$

Where, P = Power = 40 watt

$$F_t = \frac{40}{0.02591m}$$

$$F_t = \frac{1544.40}{m} \ N$$

Now

Velocity factor

$$K_v = \frac{6}{(6+V)}$$

$$K_v = \frac{6}{(6+0.02591m)}$$

Now,
Effective load on gear pair

$$F_{eff} = \frac{K_a * K_m * F_t}{K_v}$$

Where, $K_a = 1.75$ and $K_m = 1.5$

$$F_{eff} = \frac{1.75 * 1.5 * \frac{1544.40}{m}}{\frac{6}{(6+0.02591m)}}$$

$$F_{eff} = \frac{4054.05 + 17.499m}{m}$$

$$F_w = FOS * F_{eff}$$

$$171m^2 = 2 * \frac{4054.05 + 17.499m}{m}$$

By solving above equation we got,

$$171m^3 - 34.98m - 8108.1 = 0$$
$$m = 3.63 \cong 4$$

Module = m = 4 mm
Calculate dimensions of gear pair
Module = m = 4 mm
Face width = b = 10 m = 10 * 4 = 40 mm
Diameter of Pinion = d_p = m * Z_p = 4 *15 = 60 mm
Diameter of Gear = d_g = m * Z_g = 4 * 45 = 180 mm
Center distance $= C.D = \frac{(d_p+d_g)}{2} = \frac{(60+180)}{2} = 120\ mm$
Addendum = h_a =1m = 1 * 4 = 4 mm
Deddendum = h_f = 1.25 * m = 1. 25 * 4 = 5 mm

Now, calculate the dynamic load by using Buckingham's equation

$$F_d = \frac{21V(bC + (F_t)_{max})}{21V + \sqrt{bC + (F_t)_{max}}}$$

$$(F_t)_{max} = K_a * K_m * F_t$$

But,

$$F_t = \frac{1544.40}{4} \quad N$$

$$F_t = 386.1\ N$$

Therefore,

$$(F_t)_{max} = 1.75 * 1.5 * 386.1$$
$$(F_t)_{max} = 1015.5125\ N$$

Pitch error for grade 7

$$e = 11 + 0.9[m + 0.25\sqrt{d}]$$

Pitch error for pinion

$$e_p = 11 + 0.9\left[m + 0.25\sqrt{d_p}\right]$$
$$e_p = 11 + 0.9[4 + 0.25\sqrt{60}]$$
$$e_p = 16.34\ \mu m$$

Similarly, Pitch error for gear

$$e_g = 11 + 0.9\left[m + 0.25\sqrt{d_g}\right]$$
$$e_g = 11 + 0.9[4 + 0.25\sqrt{180}]$$

$$e_g = 17.62\ \mu m$$

Total Pitch error

$$e = e_p + e_g$$
$$e = 16.34 + 17.62$$
$$e = 33.95\ \mu m$$
$$e = 33.95 * 10^{-3}\ \text{mm}$$

Deformation factor

$$C = 0.111 * e\left[\frac{E_p * E_g}{E_p + E_g}\right]$$

$$= 0.111 * 33.95 * 10^{-3} * \left[\frac{207 * 10^3 * 207 * 10^3}{207 * 10^3 + 207 * 10^3}\right]$$

$$= 395.68\ \text{N/mm}$$

Velocity

V = 0.02591m m/sec
= 0.02591 * 4
= 0.10364 m/sec

The dynamic load by using Buckingham's equation

$$F_d = \frac{21V(bC + (F_t)_{max})}{21V + \sqrt{bC + (F_t)_{max}}}$$

$$F_d = \frac{21 * 0.10364(40 * 395.68 + 1013.51)}{21 * 0.10364 + \sqrt{(40 * 395.68 + 1013.51)}}$$

$$F_d = 277.67\ N$$

Calculate the available factor of safety
Effective load

$$F_{eff} = (F_t)_{max} + F_d$$
$$F_{eff} = 1013.51 + 277.67$$
$$F_{eff} = 1291.18\ N$$

As,gear pair is weaker in pitting

$$F_w = FOS * F_{eff}$$

$$FOS = \frac{F_W}{F_{eff}}$$
$$F_W = 171m^2$$
$$F_W = 171 * 16$$
$$F_W = 2736\ N$$

$$FOS = \frac{2736}{1291.18}$$

$$FOS = 2.11899\ > 2$$

As the available factor of safety of gear pair is higher than the required factor of safety the design of gear pair is safe.

Fig.7 (a). Spur gear

Fig.7 (b). Spur pinion

Design of Rope

As, Used wire rope is standard so, Specification of wire rope are as below :

Type of Wire Rope = 7 * 19
Material of wire rope is stainless steel wire
Minimum Breaking Stress = 1770MPa
Minimum load capacity = 588 kg
Nominal diameter = 3 mm
Actual load capacity = 65 kg
Weight of wire rope =0.05168 kg

Stresses in wire rope

Direct Stress

$$\sigma_d = \frac{(W + w)}{A}$$

Where,
W = Load lifted
w = weight of the rope
A =Cross-sectional Area

$$\sigma_d = \frac{17.555168}{\frac{\pi}{4} * 3^2}$$

$$\sigma_d = 2.4830\ N/mm^2$$

Therefore,
The direct stress in the wire is $\sigma_d = 2.4830\ N/mm^2$

Design of Bearing

Upper Shaft Bearing
Specification of the selected bearing
Designation of the Bearing = 6202
Bore Diameter = d = 15 mm
Outside Diameter = D =35 mm
Width = B = 11 mm
Greece Lubrication = 19000
Oil Lubrication = 24000
Dynamic Load = C = 7800N
Static Load = C_o = 3550N
Now,
Step:1
Calculate Radial load & Axial load
Radial Load = F_r = 318.825 N
Axial load = F_a = 0 N
Step:2
Calculate Equivalent dynamic load
Consider X =1 and V =1

$$P_e = [X * V * F_r + Y * F_a]$$
$$P_e = [1 * 1 * 318.825 + 1 * 0]$$
$$P_e = 318.825\ N$$

Step:3
Calculate the required dynamic load capacity

$$L_{10} = \left(\frac{C_r}{P_e}\right)^a$$

Consider, Ball bearing a = 3
Assume L_{10} = 8000 hr

$$8000 = \left(\frac{C_r}{318.825}\right)^3$$

$$C_r = 6376.5\ N$$

Since, C_r < C then selected bearing is suitable.

Selection of bearing for wheel and hopper and rotating handle
Specification of the selected bearing
Designation of the Bearing = 6000
Bore Diameter = d = 10 mm
Outside Diameter = D = 26 mm
Width = B = 8 mm
Greece Lubrication = 30000
Oil Lubrication = 36000
Dynamic Load = C = 4620N
Static Load = C_o = 1960N
Now,
Step:1
Calculate Radial load & Axial load
Radial Load = F_r = 196.2 N
Axial load = F_a = 0 N
Step:2
Calculate Equivalent dynamic load
Consider X =1 and V =1

$$P_e = [X * V * F_r + Y * F_a]$$
$$P_e = [1 * 1 * 196.2 + 1 * 0]$$
$$P_e = 196.2\ N$$

Step:3
Calculate the required dynamic load capacity

$$L_{10} = \left(\frac{C_r}{P_e}\right)^a$$

Consider, Ball bearing a = 3
Assume L_{10} = 8000 hr

$$8000 = \left(\frac{C_r}{196.2}\right)^3$$

$$C_r = 3753.17\ N$$

Since, C_r < C then selected bearing is suitable.

Fig.8.Bearing

VII. FABRICATION OF MACHINE

The structures are fabricated by using required necessary components like steel frame, sheet metal, metal bars, lead screw, AC/DC motors, wheels, nut and bolts. All these are well assembled as for the requirement. This will be controlled by controller through control toggle switch.

Fig.9.Automatic wall plastering machine

VIII. WORKING OF THE MACHINE

Initially, the machine must be placed close to the wall that is to be plastered. The machine needs to be placed in horizontal position. Then the cement mixture that consists of cement and sand within the magnitude relation of roughly around 1:4 is poured into hopper of the receptacle. The machine is raised up with the assistance of lead screw mechanism to lock the machine at one location. The receptacle and hopper assembly is raised with the assistance of motor. The lifting force is given by a rope and machine mechanism. The linear movement to the assembly is given through a guide manner. Hopper is provided with commixture mechanism to combine and force the mortar to flow in downward direction on the inclined plate. Once the inclined plate moves up with the assistance of guide way's and by keeping 7-8 metric linear unit clearance between inclined plate and wall the mortar gets continue the wall and also the roller mechanism is assembled below the inclined plate that then finishes the plaster done on the wall.

IX. SCOPE FOR A FUTURE WORK

The present model is semi-automatic and it does not have an automatic loading of mortar. The automation of loading mortar has needed to be carried out. The machine is developed to do plastering work for straight wall, hence it is suitable only for commercial buildings like apartment which has large in size and not for the construction of a curved wall as it does not have to make curved blade. Hence upgrading is required by making some changes to use the machine for any size and for the corners and joining of two walls.

X. CONCLUSION

The present work includes applying the mortar into the wall and also pressuring mortar with a making surface level. The model has been developed and tested successfully. With this development the two major problem construction industries currently facing can be reduced. They are skilled labor shortage and Quality in the construction process with less wastage. Through the trials it is noted that the machine is more productive compare to the labor with respect to the plastering work and also the quality achieved is almost equivalent to the labor.

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