



Application of Industry 4.0 in Forging Operations

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ABSTRACT

In today's world, there are various Production Industries where the forging operations are done on a large scale as well as small scale, but there are various problems associated with these forging machines. To overcome the problems there is a need for a machine which can able to do the operations more effectively. The requirement of a Machine with modern technology such as Industry 4.0 is much needed in Industry. To have more depth in the subject the critical literature survey has been done, after survey it has been found that, the forging machine using various modern technologies such as microcontroller, AI will make manufacturing more easy and effective. After a brief study, Development of Forging Machine using Industry 4.0 platform is proposed. After the development of automatic forging machine, the expected outcomes are minimization in rejection rate, to obtain maximum accuracy, increase in production rate, preventing accidents, industry digitalization and proper utilization of resources.

Keywords: Automatic Forging, microcontroller, industry digitalization, Industry 4.0.

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I. INTRODUCTION

1.1 Industry 4.0

There was a huge development in Industrial area since last few decades, these development also lead to an enormous changes on human civilization. These developments as brought various technological changes in field of production industries, to make production more valuable in terms of quality and efficiency. The one of the recent change in technology involves Industry 4.0.

The term "Industry 4.0" is refers as the fourth revolution in Industry where machines can work on their own and can take smart decisions using their own Intelligence. The most important terms in the Industries are to have maximum profit, expanding business and to fulfill customer requirements by producing quality products at economical cost. The revolution in industry, made it possible to produce high quality products with the help of modern machines and robots. These modern machines working on Industry 4.0 platform are equipped with Artificial Intelligence, which gives production industries upper hand on any other traditional machines.

1.2 Technologies Used for Industry 4.0 Platform

1.2.1 Internet of Things (IoT)

IoT systems allow users to achieve deeper automation, analysis, and integration within a system. They improve the reach of these areas and their accuracy. IoT utilizes existing and emerging technology for sensing, networking, and robotics.

1.2.2 Cloud Storage

Cloud storage is a service that maintains data, manages and backup remotely and made data available to users over the network. Access to the application can be done anytime, anywhere provided that they should be connected to the internet.

1.2.3 Artificial Intelligence

Artificial Intelligence is the method of developing Computers or Robots which can take decisions and learn from the previous mistakes on their own using Intelligence, similar to human beings. The computers equipped with AI can think similarly like human beings or may be more effectively while solving any problem.

1.3 Forging Machine

Forging is one of the most widely used method of manufacturing in Industry, it is one of the non-material removal process. The parts produced by using forging operation has high strength, hence it is used for production of various machine elements in Industry. The forging operation is carried out by applying compressive forces on the workpiece to have desired shape. The compressive forces are applied using presses or hydraulic hammers. The workpiece is placed on work station over a die and then compressive force is applied over the workpiece, due to this extreme force material takes desired shape. The most common use forging operation is hot forging operation as shown in following figure:



Fig 1. : - Hot forging

II. LITERATURE SURVEY

2.1 Problems Associated with Traditional Machines

2.1.1 High skilled operator:

The traditional machines are manually operated, which requires manpower for the operation. The manpower required should have high skills and experience in field of manufacturing and handling forging machine. If any experienced worker quits his job, then industry has to recruit new worker, who has to pass through critical training, which requires time as well as capital. These above factors lead to loss of time and capital of Industry, thus increasing cost of overall production process.

2.1.2 Production risk and Accidents in Industry:

The high risk is involved in these type of production process as material used is at high temperature, which makes handling of workpiece a very critical job. The small negligence can cause huge disaster to the person operating machine.

2.1.3 Low Efficiency:

The traditional machines used in industry are manually operated, which make them low efficient after some work or after continuous work. After continuous working for hours, manpower is hit with fatigue and stress which make them less efficient at the end of the day, there are various human related factor are involved which make production process less efficient.

2.1.4 The higher rejection rate of products:

After working for hours, manpower faces problem of fatigue, which may cause inaccuracy in product produced. The various human related errors, called as parallax errors can lead to inaccuracies in product produced. The in accurate products are rejected during quality check and cause loss of capital, time and wastage of energy.

2.2 Automatic Machine

The future in production Industry depends on the new technologies and researches which are under peer review. The Industry 4.0 can be the asset in developing and brining new revolution in Industries. The idea of Automatic machine involves use of robots, AI and super computers.

Makino, in collaboration with their digital technology partner iTSpeeX LLC, is the first machine tool OEM to introduce a voice-enabled assistant for machine tool operation. ATHENA is the world's first voice-enabled, interoperable virtual assistant specifically designed for machine tool control and overall operation [18]. With simple commands and little training, operators of all skill levels can interact with ATHENA to more efficiently operate a machine tool. With simple commands and little training, operators of all skill levels can interact with ATHENA. Using ATHENA's voice interaction software, machine operators have access to setup, instructions and inspection diagrams—right at the machine.

III. RESEARCH GAPS

3.1 Traditional forging machines V/S Automatic Forging Machines

Forging is one of the oldest metalworking processes. Traditionally, forging is performed by a smith using hammer and anvil, though introducing water power to the production and working of iron in the 12th century allowed the use of a large trip hammer or power hammers that increased the amount and size of iron that could be produced and forged. The smithy has evolved over centuries to become a facility with engineered processes, production equipment, tooling, raw materials and products to meet the demands of customers.

In modern times, industrial forging is done either with presses or with hammers powered by compressed air, electricity and hydraulics. These hammers may have reciprocating weights in the thousands. It also eliminates the weld mates required for operations and also reduces the labor cost. The testing and inspection time also get reduces which helps in maximizing the operation time. The production rate also gets increases which lead to completing before or during delivery time.

3.2 Differentiate Between Traditional and Automatic Forging Machines.

| Parameters | Traditional forging machines | Automatic forging machines |
|------------------|--|--|
| Range | It has to perform the operation at the workshop. | Commands are feed through a computer screen at workshop or computer lab. |
| Control | Operation is controlled manually. | Manually and by feeding commands. |
| Human efforts | High. | Moderate. |
| Production rate | Less. | Medium. |
| Rejection rate | High. | Less as there is some interaction of human. |
| Skilled operator | Highly skilled operator required. | less-skilled operator required as compared to traditional machine. |

IV. RESEARCH PROBLEMS AND OBJECTIVES

4.1 Research Problems

To have detailed information and understanding of problems related to traditional forging machine, various industrial surveys have been done. After these survey and critical learning, various problems have come forward.

These problems are as follows:

1. Requirement of huge manpower
2. High rejection rates.
3. Loss of energy and capital in wastage.
4. Higher risk of accidents.

4.2 Objectives

1. The main objective of project is Industry digitalization.
2. Production of high quality products.
3. Economical Production
4. Reducing risks in production.
5. Reducing loss of energy and wastage.

V. SPECIFICATIONS OF MACHINE COMPONENTS

5.1 Actuator

A linear actuator is a device which converts electrical energy into mechanical energy to create motion in a straight line, contrasted with the circular motion of an electronic motor.

A selected Actuator Specification is given below: -

| Parameters | Specifications |
|----------------|----------------|
| Input | 12V |
| Load | 1500N |
| Stroke sped | 3mm/sec |
| Stroke length | 60mm |
| House material | Aluminum |

5.2 Chatterbot

Chatterbot is a device which simulates human conversation through voice commands using AI. It is placed at the top left side of the panel; the panel is positioned on the upper side of the frame. The elements of CHATTERBOT and their position are as follows:

- 1] Microphone: A microphone is a device that captures audio by converting sound waves into an electrical signal. They are placed at both ends of CHATTERBOT.
- 2] Voice to text converter: It is used to convert any voice into plain text. The position of the converter is placed between two microphones.

5.3 NodeMCU ESP8266

NodeMCU is an open-source microcontroller which is used for prototype or build for IoT product. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems. It takes the input from chatterbot and after processing gives output to Motor driver.



Fig2 : - NodeMCU ESP8266

Following are the specifications NodeMCU: -

| Parameters | Specification |
|-------------------|---------------|
| Operating Voltage | 3.3V |
| Digital I/O pins | 12 |
| Built in Wi-Fi | 2.4GHz |
| Clock Speed | 80MHz/160MHz |
| Flash | 4mb |
| Length | 64.3mm |
| Width | 29.1mm |

5.4 Motor Driver

L293D Motor Driver is a typical Motor driver which allows DC motor to drive on either direction. It is used to start and stop the motor and to give directional stability. The position of the motor driver is between Chatterbot and Nodemcu.

Following are the specifications Motor driver: -

| Specifications | Parameters |
|----------------------|------------|
| Model No. | L293D |
| Operating Voltage | 5V-36V |
| No. of motor control | 2 |
| Current supplied | 600mA |
| Weight | 10 grams |

VI. WORKING

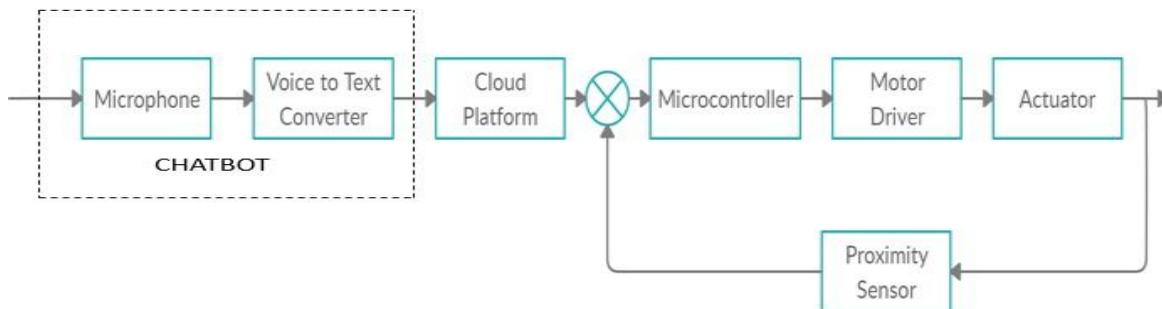


Fig 3 : - Architecture diagram of the system

An architecture diagram of control system consists of various electronic devices and sensors that we are using in the control system. Though this machine is voice-operated, the first input will pass from Chatterbot which then it will pass through voice detector where the voice will be detected and from voice detector it will transfer the signal from voice to text converter. Voice to text converter is used to convert voice signal into a text signal this is done because microcontroller cannot sense the signal in a voice form, so it is necessary to convert signal in the form that microcontroller can read and gives output depending on it.

With the help of the Cloud platform, the voice command can be given to microcontroller from long distance. The operator can give the voice command through mobile, computer and chatterbot (install at different stations) from anywhere to perform operations. The voice command given from these devices is transferred to the cloud and it saves. The cloud then delivers the data saved from the operator and delivers it to the microcontroller.

There are two IR sensors which are connected in parallel whose output is taken to the summing point. It controls the direction of the actuator, the ramming length is controlled using this sensor. All signals are taken to the microcontroller, the microcontroller consists of reset program in it, according to which it runs the further operations. From microcontroller the signal goes through the motor driver, it is used to control the speed as well as the direction of the motor. The motor driver is directly connected to the actuator, the actuator is a device which gives output in mechanical form. The upper die connected to actuator moves downward and presses the workpiece in the required shape. When the lower sensor senses the lower die, the motor driver changes the direction of the motor and actuator moves upward. After the operation is done the feedback is taken to the summing point via feedback sensor for further improvement.

VII. DESIGN OF MACHINE

7.1 Selection of Actuator:

7.1.1 Finding torque of Actuator:

$$T = \frac{0.5 \pi d^3 \tau}{16}$$

Work piece Material- Aluminum 1100.0, BHN 23 and $S_y = 310$ MPa.

Assume FOS = 3.5.

The shear stress τ is given by,

$$\tau = \frac{0.5 \pi S_y}{3.5}$$

$$\tau = 44.28 \text{ MPa.}$$

Torque T is given by,

$$T = \frac{\pi d^3 \tau}{16} \times 10^3$$

$$T = \frac{\pi d^3 44.28 \times 10^3}{16}$$

$$T = 8.689 \text{ Nm} = 9 \text{ Nm.}$$

The required speed is 10 rpm, $N = 10$ rpm.

Power P is given by,

$$P = \frac{2 \pi T N}{60}$$

$$P = \frac{2 \pi \times 10 \times 9}{60}$$

$$P = 9.42 \text{ W}$$

7.1.2 Finding pressing force required to press the work piece:

Pressing force F is given by,

$F = \text{Perimeter} \times \text{Shear stress} \times \text{thickness of sheet. Perimeter} = 10 \text{ mm}$

Thickness = 3 mm

Selection of material of sheet Aluminum- 1100.0, BHN = 23 and Shear stress = 40 MPa.

$F = 10 \times 42 \times 3$

F = 1260 N

From above calculations force required for pressing is 1260 N, hence actuator with pressing force 1500 N is selected.

7.2 Designing of critical element i.e. bolts.

7.2.1 Calculating primary forces F_p :

$$F_p = \frac{1500}{4}$$

$$F_p = \frac{1500}{4}$$

$$F_p = 375 \text{ N}$$

$$F = \frac{1500 \times 270}{270^2}$$

$$F = \frac{1500 \times 270}{270^2}$$

$$F = 5.55 \frac{\text{N}}{\text{mm}^2}$$

7.2.2 Secondary shear force F_s is given by,

$$F_s = F \times r$$

$$F_s = 5.55 \times 13.5$$

$$F_s = 75 \text{ N}$$

$$F_r = \sqrt{375^2 + 75^2 + 2 \times 375 \times 75 \times \cos(0)}$$

$$F_r = \sqrt{375^2 + 75^2 + 2 \times 375 \times 75 \times 1}$$

$$F_r = 450 \text{ N}$$

Hence assume $F_r = 500 \text{ N}$, $\tau =$

$$0.5 \frac{500}{\text{mm}^2}$$

$S_y = 350 \text{ MPa}$ --- P.S.G 1.3

$$\tau = \frac{0.5 \times 350}{4}$$

$$\tau = 43.75 \text{ MPa}$$

$$\tau = \frac{1500}{34}$$

$$\text{Area } A = 11.3 \text{ mm}^2$$

$$\text{Diameter } d = 5 \text{ mm}$$

hence select bolt size M5 --- P.S.G 5.42

From imperial relation $d_c = 0.84 \times d$
 $d = 5.95 \text{ mm} = 6 \text{ mm}$.

VIII. SPECIFICATIONS OF MACHINE PARTS

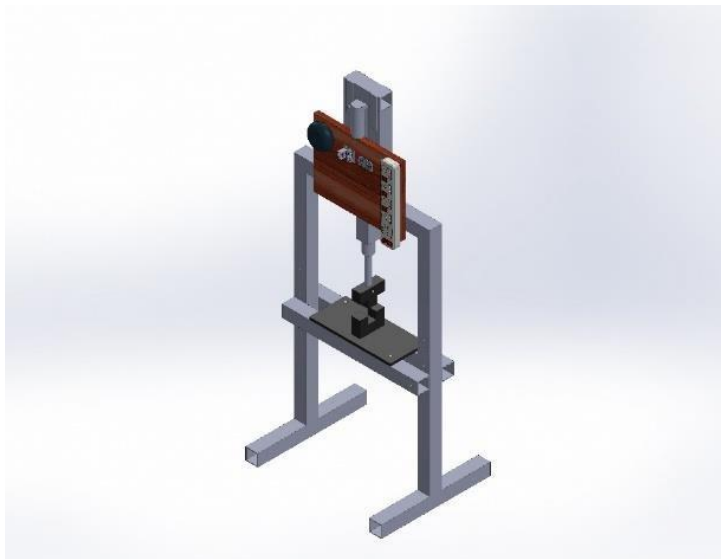


Fig 4: - Isometric view

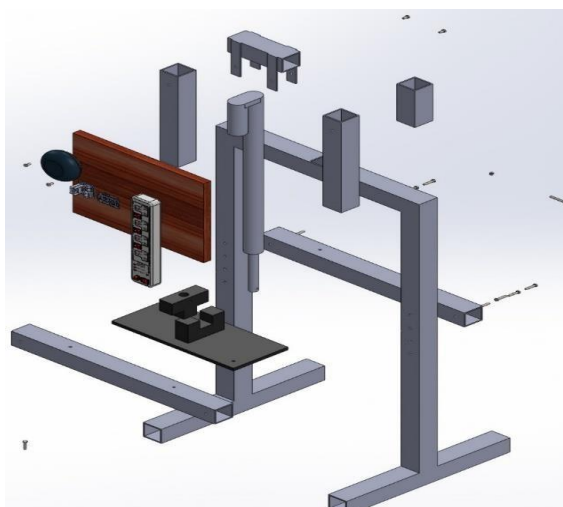


Fig 5: - Explode view

IX. ANSYS REPORT

The static analysis on frame is done, while keeping some end conditions which are as follows,

1. Mesh type: Solid Mesh
2. Mesher used: Standard mesh
3. Jacobian point: 4 points
4. Elemental size: 27.8214 mm
5. Tolerance: 1.39107mm
6. Total nodes: 133488
7. Total element: 57072
8. Maximum aspect ratio: 44.065

The software used for analysis is Solid works. Here the fixed support is given to the base of the base Frame on which the whole machine is standing. The Actuator applies the load on the lower die, so the downward force is applied on the lower die of 1500N. The result obtain is shown below.

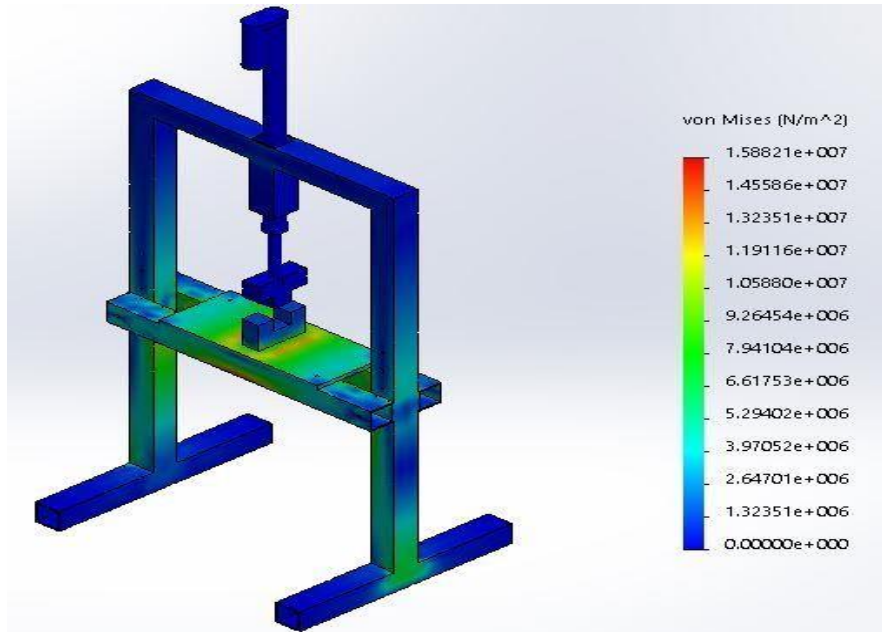


Fig 6: - Analysis of stress

The analysis shows the distribution of stress on a frame, it has been found that the design is safe under the stress condition. The maximum stress induced is on the bed which ranges between $3.9702e+006\text{N/m}^2$.

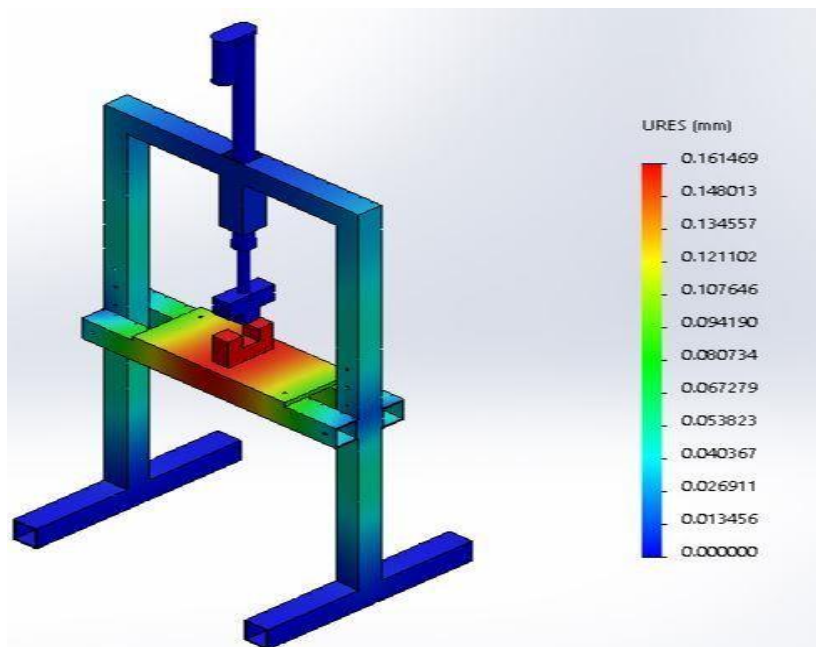


Fig 7: - Analysis of deformation

The third analysis is done to find the deformation in the frame, when stress is induces the maximum deformation of 0.1614mm is taken place at die and on a bed, which is negligible.

X. CASE STUDY

After manufacturing of the machine, it was install in Raj surgical. There we conducted 10 days of trail. After the trail, we came to know that the total time required for manufacturing 1 piece of scissor is it takes 7 seconds. With the manual method, the time required was 12 seconds. The working hour of the company was 9 hours per day, and weekly 6 days. So the total manufacturing per day using the manual method was 450 pieces, and with the use of Automatic machine, it was increased by 771 pieces. So due to the automatic machine, the production rate per day increased by 321 pieces.

It has been observed the rejection rate by comparing it with the manual method. The rejection rate for

the manual method was 10%-15%. To overcome this problem, with the help of Automatic Machine we tested for it for 10 days and the result was obtain is given as follow:-

| Days | Scissors manufactured | Scissors Rejected | Rejection rate |
|------|-----------------------|-------------------|----------------|
| 1 | 771 | 25 | 3.24% |
| 2 | 770 | 22 | 2.85% |
| 3 | 771 | 24 | 3.11% |
| 4 | 768 | 25 | 3.24% |
| 5 | 770 | 23 | 2.98% |
| 6 | 771 | 22 | 2.85% |
| 7 | 770 | 24 | 3.11% |
| 8 | 770 | 21 | 2.72% |
| 9 | 771 | 23 | 2.98% |
| 10 | 770 | 25 | 3.24% |

Rejection rate per day using Automatic Machine

From the above observation table, it is observed that the rejection rate using Automatic Machine has been decreased by 4%, where it was 10%-15% for the Manually operated machine. So the Rejection rate has drastically decreased which helped in maximum utilization of the resources.

XI. RESULTS AND DISCUSSION

The result obtained after testing of Automatic Forging Machine are as follows;

1. The Automatic Forging Machine has eliminated the manual working process, by introduction of Industry 4.0 platform.
2. The use of sensors and other electronic accessories helped in reducing accidents and risk factor.
3. The product produced are of high accuracy and thus reducing the rejection rate.
4. Automatic machine made effective and efficient use of resources possible.
5. Artificial Intelligence had given edge over other traditional machines in terms of quality of product.
6. Industry 4.0 have allowed industry to get digitalized and helped in reducing human intervention.

11.1 Advantages.

1. Optimum utilization of resources
2. Smooth product flow
3. Efficient continuous real time tracking
4. Efficient energy consumption
5. Autonomous controlling
6. Greater flexibility meeting high level accuracy
7. Detailed end to end product transparency in real time
8. Secure and reliable backup system for every step-in cloud storage

11.2 Limitations.

1. To work out Industry 4.0 in any Industry strong network infrastructure is required.
2. This proposed platform will collapsed completely if there is fluctuation in electric supply.
3. Artificial Intelligence requires high security and there is always risk of any cyber attack on the system.
4. At first when this platform is introduce in Industry there will be resistance from workforce.
5. To develop high feature infrastructure, initial investment is required.

XII. CONCLUSION AND FUTURE SCOPE

12.1 Conclusions.

This project has met its objective to eliminate the manual method of forging into automatic forging machine. We can do simple operations like pressing, punching which is very useful and helpful to do small works at Industry. We chose a simple compact frame machine which occupies less space which any skill operator can operate. We tested our project by pressing the sheet metal for manufacturing scissors.

12.2 Future scope.

With the help of this technology in future the following machines can be developed :-

- 12.2.1 Design and Development of Voice operated cutting machine.
- 12.2.2 Voice operated lathe and Milling machines.
- 12.2.3 Home automated machines like washing machine, vacuum cleaner, fridge, microwave, etc.

XIII. BILL OF MATERIAL

13.1 Direct cost:

| Sr.No. | Part Name | Quantity | Cost |
|--------|------------------|-----------|--------------|
| 1. | Actuator 1500N. | 1 | 5400 |
| 2. | frame | 1 | 4000 |
| 3. | Google mini | 1 | 4000 |
| 4. | Die | 1 | 2500 |
| 5. | Nodemcu | 1 | 300 |
| 6. | Motor driver | 1 | 200 |
| 7. | Cables and wires | 12 | 350 |
| | Total | 18 | 16750 |

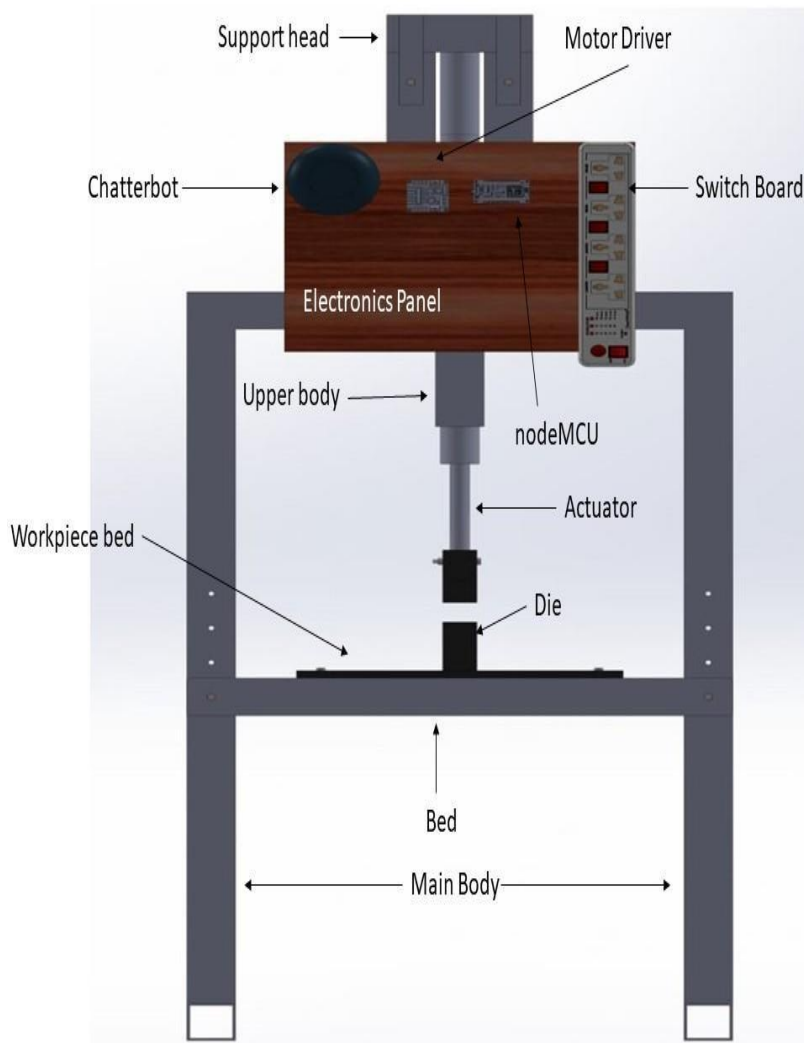
13.2 Total cost:

Grand total = direct cost + indirect cost

= 16750 + 1100

∴ **Grand total = 17850**

XIV. APPENDIX



specification of project

REFERENCES

- [1]. "Design and Development of Pneumatic Punching Machine" Viraj N. Suryawanshi, Nilesh V. Wakade, Prof. Prashant A. Narwade
- [2]. "Design, CAD Modelling and Fabrication Of Automatic Hammering Machine" Abhijeet Dhulekar, Suyash Shirbhate, Rizwan Shaikh, M V Ingalkar.
- [3]. "A study on impact of Industry 4.0 in India" Sagar B S, Praveen D Jadhav
- [4]. "Industry 4.0 Enhanced Manufacturing" Nai Yeen Gavin Lai, Kok Hoong Wong, Dun ant Halim, Jiawa Lu, Hooi Siang Kang.
- [5]. "Industry 4.0: Towards future industrial opportunities and challenges" Keliang Zhou, Taigang Liu, Lifeng Zhou.
- [6]. "Development and Application of Intelligent Manufacturing Based on Industry 4.0" Guo Jian Cheng, Ye Liu, Li Ting Liu.
- [7]. "Automated Speech Recognition System" Manjutha M , Gracy J , Dr P Subashini
- [8]. , Dr M Krishnaveni
- [9]. "Industry 4.0: the Future Concepts and New Visions of Factory of the Future Development" Dragan Vuksanović, Jelena Vešić
- [10]. "Automation Using Internet of Things" Vinay Sagar KN, Kusuma S M.
- [11]. "Advance Automation and Security using Arduino and IOT" Siddharth Wadhvani, Uday Singh, Prakash Singh.
- [12]. "IOT Based Big Data Storage System in Cloud Computing: Perspectives and Challenges" Hongming Cai, Boyi Xu, Lihong Jiang, Athanasios V. Vasilakos.
- [13]. "Artificial Intelligence in 21st Century" Jiaying Liu, Xiangji Kong, Feng Xia, Lei Wang, Ivan Lee.
- [14]. "Artificial Intelligence Revolution in India and scope" Harjit Singh.
- [15]. "Research on Rapid Design and Rapid Quotation system of Forging Machine" Guofo Lian, Hau Lu, Jun Zhong, Changan Zhu.
- [16]. "Comparison of Mechanical Presses and Screw Presses for Closed Dies Forging" T. Altan, A.M. Sabroff.
- [17]. "Basic Features Of The Cold Forging Process" A.M.Cooper.
- [18]. "Design and Analysis of a Forging Die for Manufacturing of Multiple Connecting Rods" C.E Megharaj, P.M Nagaraj, K Jeelan Pasha.
- [19]. "Voice Enabled Smart Drone Control" Abdur Razzak Fayjie, Amir Ramezani, Douki Oualid, Deok Jin Lee.
- [20]. "Design and Implementation of Wireless Voice Controlled Intelligent System" Ling jie Meng.
- [21]. "A Voice Activated Robot With Artificial Intelligence" D.P. Mital, G.Leng.