AUTOMATION OF STATOR INSULATION PROCESS IN ALTERNATOR MANUFACTURING INDUSTRIES

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Abstract- **In automobiles alternators are used to charge the battery and to power up automobiles electric system when its engine is running. The main components of an alternator are rotor assembly, stator and carbon brushes with rectifier. The rotor and the stator are the two components that generate power. The stator must be insulated before and after winding the coil on the stator in order to isolate the winding from other components. This procedure is essential to avoid any chance of short circuit. Insulation provided before the winding is called as inner insulation. This is done by inserting paper pieces inside the slots provided in stator for winding. At present a standard semi-automated paper insertion machine is used for this process. This project named 'Automation of stator insulation process in alternator manufacturing industries' is aimed at automating the insulation process and integrating the sealing operation along with insulation process hence simplifying the overall process. The scope of this process is limited to these parameters, to reduce the man power and to reduce the whole cycle time, and to increase the productivity**.

Index terms- **Stator insulation, feeing units, robotic arms**

1. INTRODUCTION

Due to increasing global competition, manufacturing industries are now more concerned with their productivity and are more sensitive to their investment with respect to flexibility and efficiency of production equipment. Researchers believe that increasing the quality of production and reducing the cost and time of production are very important factors in achieving higher productivity. Achieving this goal requires reconsidering the current production methods that could lead to introduction of new production techniques and methodologies.

Generally non-traditional processes incorporate high capital cost and operating costs. Therefore when machine economy is of concern, manufacturing companies prefer traditional techniques for manufacturing. According to studies, when production quantity is high and variety is low, the universal machine tools give best result. But when a variety of components are to be produced CNC is the better option. For high production with lesser variety, SPMs gives the best solution and is considered as most economic method of production.

A. Re-engineering

Unlike the past, now days the market is controlled by the buyers. Customers seek for customized products rather than the standard products. So, manufacturing firms have to switch their production methodologies to suit for the production of customized products in more variety. At the same time, to gain competitive advantage, the product must be must be manufactured at the minimum possible cost and maximum possible quantity and more importantly at minimum time. Today's manufacturing systems are mainly designed to produce standard products with high volume and low variety. In order to meet the market needs, the companies have to re-engineer the outdated manufacturing processes still in practice. Thus the concept of re-engineering becomes essential. The process of re-engineering is defined by Hammer and champy as "the

fundamental re-thinking and radical re-design of business processes to achieve dramatic improvement in performance such as cost, speed, quality and service.

B. Automation

Automation is mainly intended to reduce the burden of work on human beings and increase the comfort level. Automation has brought lot of advantages to mankind and lead to a new revolution in all walks of life. Starting from toys to control of a space craft, shaving razors to machining of a complex die, automation plays a vital role. Automation has changed the way of life, added value to the products and services in all sectors.

Globalization has led to more competition among industries. Quality along with appropriate cost is a key factor for survival. Markets are more fluctuating, forcing firms to focus on better systems of planning, manufacturing, sales and services. Companies are compelled to produce more out of less, that is lean strategies are widely being adopted. Necessity to address many other issues like labor shortage, pollution control, safety issues, resource allocation points to the importance of automation in industries. Advantages of automation seem to out-weigh the drawbacks when concerned with application of automation in industries.

Automation makes control of process better, helps to improve qualities of products, enhance the reliability and performance, reduces wastage of resources and improves labor safety. Evolution and development of electronic technology also lead to the unforeseen growth of computer technology which in turn gave better ways of controlling automated system.

C. Automated manufacturing system

Automated manufacturing systems operate in the factory on the physical product. They perform operations such as processing, assembly and inspection or material handling in some cases, accomplishing more than one of these operations in the some system.

They are called automated because they perform their operations with a reduced level of human participation compared with the corresponding manual process. In some highly automated systems, there is virtually no human participation.

Automated assembly system refers to use of mechanized and automated devices to perform the various assembly tasks in an assembly line or cell. Much progress has been made in the technology of the assembly automation in recent years. Some of this progress has been motivated by advances in the field of robotics and by designing special purpose machines to perform a fixed sequence of assembly operations. Most automated systems are designed to perform a fixed sequence of assembly steps on specific products that is produced in very large quantities. Assembly processes in automated assembly system includes adhesive bonding, snap fitting, insertion of components, soldering, spot welding etc. An automated assembly system performs a sequence of automated assembly operations to combine multiple components into a single entity. This single entity may be a final product or a sub assembly in a large product

D. Significance of work

At present, the process of insulating the stator is carried out by a semi-automated paper insulation machine. The time wasted in handling the parts plays a big role in high production time. The aim of this project is to reduce the cycle time and in turn increase the productivity and to integrate two individual processes simplifying the process line.

2. OBJECTIVE OF THE PROJECT

Objectives of this project are limited to three parameters:

- To understand the existing system.
- To simplify and automate the existing system.
- To reduce the overall cycle time.

- To reduce the manual labor in the process.
- To increase the production rate.

The scope of current study is limited to automating the existing process of insulation of stator model [k1-65A] manufactured at Rajamane Industries pvt ltd to supply to Bosch Auto parts.

A. Importance of stator in an alternator

Alternators are used in modern automobiles to charge the batteries and to power the electrical system when its engine is running. Automotive alternators require a voltage regulator which operates by modulating the small field current to produce a constant voltage at the battery terminals.one of the biggest advantages of using alternators is that we do not have to use commutator. Therefore, the alternator becomes simpler, lighter and less expensive. Opening the alternator reveals a large cylinder with triangular finger poles around the circumference. This is the rotor. A basic alternator is made up of series of alternating finger pole pieces placed around coil wires called field windings that wrap around an iron core or the rotor shaft. Since the pulley attaches to the shaft the rotor spins inside the stator. The rotor assembly fits inside the stator with enough room or tolerance between the two, so the rotor can spin at high speed without striking the stator wall on each end of the shaft since a brush and a slip ring

The rotor assembly rotates within the stator winding, the alternating magnetic field from the spinning rotor induces an alternating voltage into the stator winding. The stator is made with three sets of windings. Each of them is placed in a different position compared with the others. When engine rotates the alternator pulley, the rotor spins the three stationary stator windings, surrounding the fixed iron core called as the stator. The coil winding are evenly spaced at intervals of 120 degrees around the iron shaft. The alternating magnetic field from the rotor produces a subsequent alternating current in the stator. This AC current is fed through stator leads in to connecting set of diodes. Two diodes connect to the stator leads to regulate the current. Since batteries need DC current, the diodes becomes one way valves that will only allow current to pass in one direction. The inner and outer insulation provided on the stator core, isolates the windings from other components in an alternator.

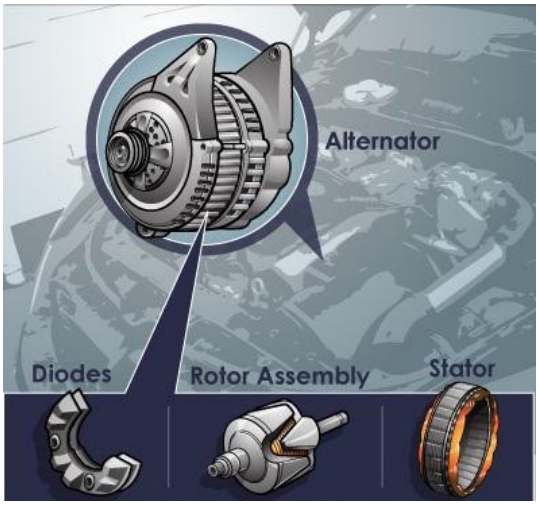


Figure 1: Components of an alternator

B. Control system

Control system is a collection of electronic devices and equipment which are used to ensure the stability, accuracy and smooth transition of a process. As a result of rapid advancement of technology, complex control tasks can be accomplished with a highly automated control system which consists of programmable logic controllers and a host computer. Every single component in a control system plays an important role. Control systems can be classified into open loop control system and closed loop control system

3. DESIGN AND WORKING

A. Steps involved design of the system

Step 1: Concept Generation and Selection

Concept selection has to be done in case of the arm configuration and input and output systems. Different arm configurations has been studied and considered. Initially articulated configuration was considered, but after thorough analysis it was found inappropriate for this particular application. The rectangular coordinate system proved more

appropriate due to its simplicity in design, load carrying capacity and accuracy.

The need to provide continues input to insulating machine and stacking the processed material as the insulation completes demanded for a new technic in input and output systems. Initially different conveyor systems were considered for this task. But due to the high investment in the case of implementing conveyors and requirement of additional manual support for this system, thoughts were concentrated on a system that needs less human attention. The revolver barrel type input system was thus designed using a power screw to lift the stack of stators and indexing mechanism to perform the indexing function of the barrel.

Step 2: Embodiment Design

It consists of three design modes like product architecture, configuration design, and parametric design.

- Machine Structure

Here the arrangements of physical elements to carry out the function are done, like selection of motors, cylinders, sensors etc.

- Configuration Design

Here the preliminary selection of materials, manufacturing methods, modelling and sizing of parts are done.

- Parametric Design

Here the robust design is done with all the limits and tolerances that are the final dimensions are given at this stage.

Step 3: Detail Design

Here the detail drawings with all the specifications like type of material, drawing no, machining specifications, quantity required, list of materials, scale used etc., are done.

Step 4: Manufacturing Of Components

As per the detail drawing the components are manufactured by using Lathe, Vertical milling machine, Grinding machines, CNC machine etc.

Step 5: Assembly of Sub-Components

After manufacturing all the parts, individual are assembled separately by using hydraulic pressing machine, welding machine, by using fasteners etc.

Step 6: Assembly of Main Machine

Here the individual sub-assembly workstations are assembled together to form the final automated system.

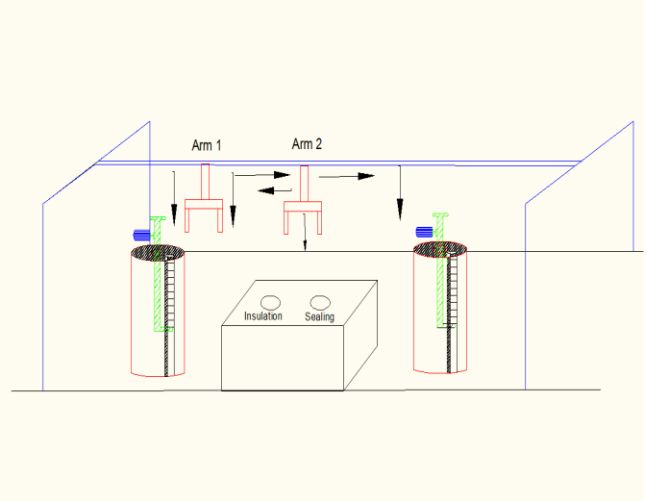


Figure 2: Design of the system

B. Technical specifications

Technical specifications of stator core

- Height : 25mm
- Diameter : 125mm
- Weight : 800gm
- No: of inside notches : 36
- No: of outside notches : 4

Technical specifications of input and output barrel

- Height : 1200mm
- Diameter : 1000mm
- No: of columns : 15

- Diameter of each column : 130mm
- Stators per each column : 40pieces

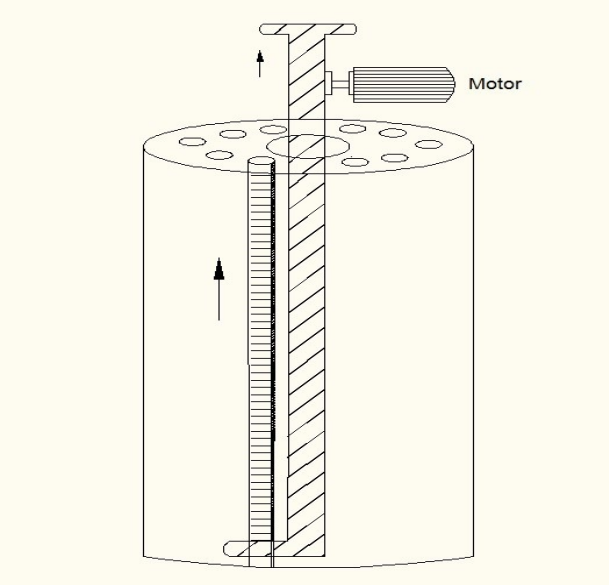


Figure 3: Input barrel

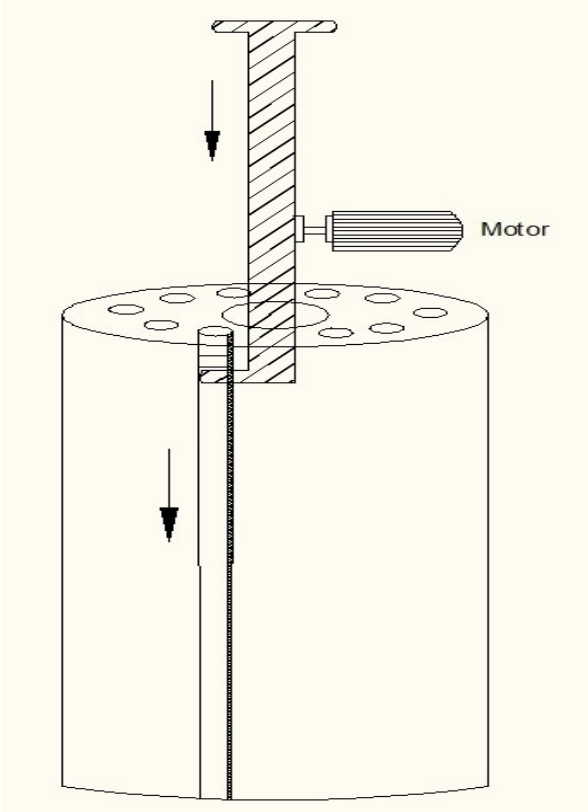


Figure 4: Output barrel

C. Hardware components used

1. Pneumatic cylinders

Pneumatic cylinders are widely used to generate force and motion on a vast range of OEM equipment. They can move products directly or indirectly by different mechanical movements. Cylinders are available in variety of types to meet the requirement of various situation in which they are applied. They fall into two main categories: singe acting and double acting. Single-acting cylinders have compressed air supplied to only one side of the piston; the other side vents to atmosphere. Double-acting cylinders use compressed air to power both the extend and retract strokes, moving the rod back and forth. This arrangement makes them ideal for pushing and pulling loads.

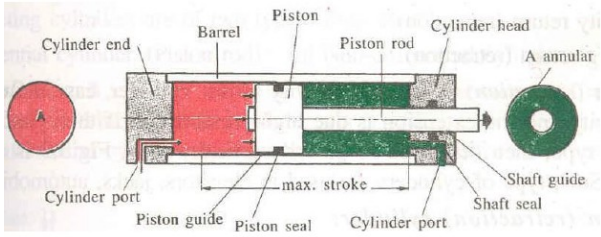


Figure 5: Double acting cylinder

2. Flow control valves.

Pneumatic control valves are used to control the flow of pressurized air. Another medium such as water or electricity can be used as actuators. In some cases the valves are operated manually. A solenoid valve is an electro mechanical device used for controlling liquid or gas flow. The solenoid valve is controlled by electrical current which is running through a coil.

Figure 6: Flow control valve

3. Manifold

A pneumatic manifold is a manifold that regulates air flow between main supply and actuators and other components in a pneumatic system. It is like a switch board in an electric circuit because it lets the operator control how much air flows between each component of a pneumatic machinery.

Figure 7: Manifold

4. Induction motor

An induction or asynchronous motor is an AC motor in which current is induced in the rotor winding by the magnetic field of the stator winding, by electromagnetic induction.

Three phase induction motors are widely used in the industrial drives because they are rigid, reliable and economical

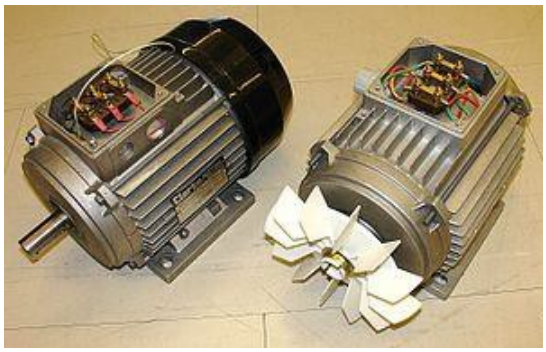


Figure 8: Induction motor

5. Variable frequency drive

A variable frequency drive is a type of adjustable speed drive used in electro mechanical drive system to control AC motor speed and torque by varying motor input frequency and voltage. Many fixed speed motor load applications that are supplied direct from AC line can save energy when they are operated at variable speed

Figure 9: Variable frequency drive

6. Proximity sensor

A sensor is a device that measures a physical quantity and converts into a signal which can be read by a observer or an instrument. There are different types of sensors that can be used to take measurements of various things such as temperature, density, humidity, pressure and even speed. Some other types of sensors emits signals and take measurements by either measuring how the area reacts to the emitted signal or by measuring the reflection of the bounced signal.

Proximity sensors are class of sensors that detects the presence of nearby objects without making physical contact with the object. Sensing objects at a distance involves using the physical properties of the material being sensed or actively probing the nearby environment to find object

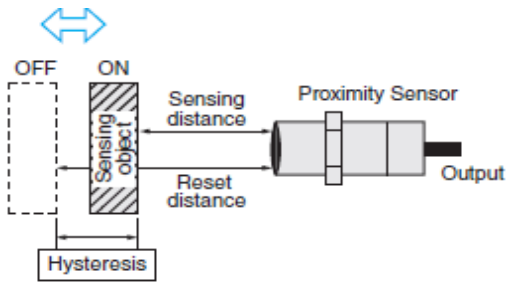


Figure 10: Proximity sensor

7. GIC PLC

Features of GIC PLC are as follows:

- Integrated, ready to use, wide range of programmable functions including 16 timers, 16 (retentive selectable) counters, 16 time switches, 16 compare counters, 16 soft text messages, 64 auxiliary relays and 12 analog comparators.
- 8 digital inputs & 4 relay outputs. Two analog inputs (0 -10V) in 12 -24VDC, model
  which can be used as digital inputs.
- Ability to add up to three(3) extension modules expanding I/O" s to 32 digital inputs, 16 relay outputs.
- Communication module allows programmable relay to be connected to a Modbus network through NX-Communication link
- Backlit LCD screen for display and modification of pre-selected parameters of function blocks, viewing I/O status and programming on the device.
- Ladder programming using software on PC as well on the device with the help of keypad & LCD Display
- Memory back up allowing programs to be transferred or copied into another Genie-NX with the help of a memory card.
- Compact size –only 72mm (2-53/64") wide x 90mm (3-35/64") high x 65 mm (2-9/16) deep, reducing panel area requirements for lower installed costs.
- Soft keys for convenient creation and editing of programs on the device.
- Available in both: AC (110 - 240 VAC) &DC (12 - 24 VDC) models.
- Password & Parameter lock facility.

Figure 11: GIC PLC

8. Extension module

Extension Module can be used with base module to increase I/O capacity of Genie-NX. Every extension module has 8 digital inputs & 4 digital outputs. Connections are made in Daisy chain fashion. Genie- NX can be expanded by connecting 3 extension modules, to obtain a maximum configuration of 32 inputs and 16 outputs.

Figure 12: Extension module

9. Grippers

One of the most common effectors is the gripper. In its simplest manifestation it consists of just two fingers which can open and close to pick up and let go of a range of small objects. Fingers can for example be made of a chain with a metal wire run through it. Hands that resemble and work more like a human hand include the Shadow Hand, the Rowboat hand. Hands that are of a mid-level complexity include the Delft hand. Mechanical grippers can

come in various types, including friction and encompassing jaws. Friction jaws use all the force of the gripper to hold the object in place using friction. Encompassing jaws cradle the object in place, using less friction. Vacuum grippers are very simple astrictive devices, but can hold very large loads provided the pretension surface is smooth enough to ensure suction. Pick and place robots for electronic components and for large objects like car windscreens, often use very simple vacuum grippers.

Figure 13: Gripper

10. Power screw jack

A power screw is also known as a translation screw. It is used as a linkage in a machine to translate turning motion into linear motion. Because of the large area of sliding contact between their male and female members, screw threads have larger frictional energy losses compared to other linkages. Power screws are classified by the geometry of their threads. V-threads are less suitable for lead screws than others such as acme because they have more friction between the threads. Their threads are designed to induce this friction to keep the fastener from loosening. Lead screws on the other hand are designed to minimise friction. Therefore in most commercial and industrial use V-threads are avoided for lead screw use. A lead screw nu and screw mate with rubbing surfaces and consequently they have a relatively high friction and stiction compared to mechanical parts which mate with rolling surfaces and bearings. Lead screw efficiency is typically between 25-70% and with higher pitch screws tending to be more efficient. A higher performing but more expensive alternative is the ball screw. Due to inherently high stiction the typical screw is self-locking and is often used in applications where back driving is unacceptable like holding vertical loads. Lead screws are typically used well-greased with an appropriate nut, they may run dry with somewhat higher friction. The mechanical advantage of a lead screw is determined by the screw pitch and lead. For multi start screws the mechanical advantage is lower but the travelling speed is higher. Backlash can be reduced with the use of a second nut or a tensioning spring to create a static loading force known as preload.

Figure 14: Screw jack

4. WORKING

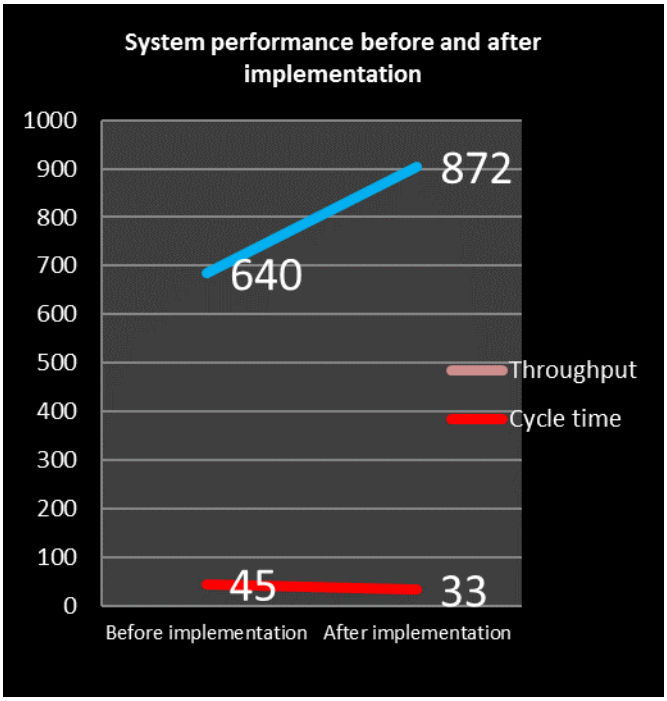
- The input barrel is initially loaded manually.
- When the system is switched ON the motor of power screw mechanism in the input barrel starts rotating lifting the stator stack by 25mm.
- The topmost stator core that pops out of the barrel is picked by the first arm.
- The sensors provided in the grippers of the arm ensure proper picking.
- The picked stator is placed in the insulating chuck of the paper insertion machine.
- The sensors provided in the chuck detect proper placing of the stator core and gives a signal to main controller to start the machine.
- The first arm after placing the stator core in insulation chuck proceeds to the input system to pick the next stator core that is popped up.

- After the insulation process is over the second arm picks the stator core from insulation chuck and places it on the sealing chuck.
- Sensors at the sealing chuck ensure the proper placing of stator core. The limit switch mechanism provided detects the notch for sealing and the stator is sealed.
- Arm 2 picks the stator core after sealing and places it in the output barrel.
- The power screw mechanism provided in the output barrel moves the screw 25mm downwards after the stator is placed making space for the next stator.
- Each cylinder in input and output system is designed to hold 40 stators at a time. Once the first cylinder is emptied or filled the rotary indexing mechanism indexes the barrel once bringing the next cylinder in place of the first. And the operation continues.
- An alarm is produced after whole cylinder is emptied or filled so that the input barrel can be refilled and the output barrel can be emptied.

5. RESULTS

Table 1: Comparison of results before and after automation

Specifications	Before automation	After automation
No: of working days per month	26	26
No: of working hours per day	8	8
Cycle time	45sec/piece	33 sec/piece
Throughput of components per day	640 pieces	872 pieces
No: of workers	2	1 (for periodical checking)
Total cost of workers per day	2X288=576	1X288=288
Cost on each component	Rs.0.9	Rs. 0.33



Graph 1: System performance before and after implementation

6. CONCLUSION

The project presents the details of work done on designing, manufacturing, fabricating and materials used for automating the insulation process of stators in alternator manufacturing industries.

There are several important conclusions drawn out of this project:

- By implementing automation principles that is Understand Simplify and Automate principle this project is carried out successfully.
- It is worthy automation migration case.
- Available space has been optimally used.
- Number of workers is reduced to mitigate the labour shortage.
- PLC control provides most convenient way of controlling and economical means of operating the different workstations simultaneously.

All the set objectives are met satisfactorily at the end of project

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