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AC Manufacturing

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Abstract: *This industrial training report presents a comprehensive study of Air Conditioner (AC) Manufacturing, with emphasis on the manufacturing, assembly, refrigeration, electrical, quality-control, safety, and testing activities involved in the production of split and room air-conditioning systems. The training was undertaken at PG Technologies Pvt. Ltd., Supa, Parner, Ahilya Nagar, with the objective of connecting theoretical engineering knowledge with practical industrial manufacturing processes. The study covers major AC components such as the compressor, condenser, evaporator, expansion device, blower and fan motors, copper refrigerant tubing, sheet-metal parts, plastic components, sensors, PCB/controller and electrical wiring. It explains important manufacturing operations including sheet-metal fabrication, plastic component manufacturing, heat-exchanger production, copper-tube preparation and bending, brazing, compressor installation, indoor and outdoor unit assembly, PCB and electrical assembly, evacuation, refrigerant charging, leak detection and pressure testing. The report also focuses on quality practices such as incoming quality control, in-process inspection, mistake-proofing, electrical safety testing, cooling-performance evaluation, preventive maintenance, 5S and lean manufacturing. Safety practices, environmental management, material handling, packaging and troubleshooting of common manufacturing defects are also discussed. The industrial training provided practical understanding of how mechanical, electrical, refrigeration and control systems work together to produce a reliable and efficient air-conditioning system. Overall, the training enhanced practical knowledge, technical skills, quality awareness, safety consciousness and understanding of industrial production practices.*

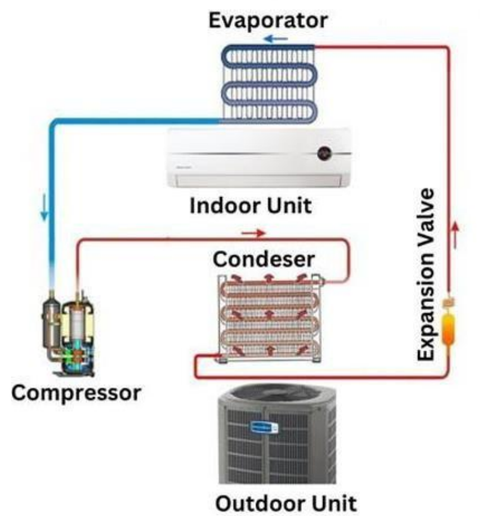
Keywords: Air Conditioner Manufacturing, Split AC, Refrigeration Cycle, Compressor, Heat Exchanger, Copper Tubing, Brazing, Indoor Unit Assembly, Outdoor Unit Assembly, PCB Assembly, Quality Control, Leak Testing, Refrigerant Charging, Electrical Safety, Industrial Training

I. INTRODUCTION

Air conditioning is an important application of mechanical, electrical, thermal and control engineering used to maintain a comfortable and controlled indoor environment. An air conditioner removes heat from indoor air and transfers it to the outside through a refrigeration cycle. The manufacturing of an air conditioner is therefore a coordinated process involving sheet-metal fabrication, plastic component manufacturing, heat-exchanger production, copper-tube preparation, brazing, compressor installation, electrical and PCB assembly, and final testing. The quality and performance of the finished product depend on the accuracy and control maintained at every stage of manufacturing.

A split air conditioner mainly consists of two major assemblies: the Indoor Unit (IDU) and Outdoor Unit (ODU). The indoor unit generally contains the evaporator coil, blower, air filter, louver, drain arrangement, control panel and indoor fan motor. The outdoor unit contains the compressor, condenser coil, outdoor fan and motor, service valves and electrical enclosure. These units are connected through refrigerant piping and electrical wiring to operate as an integrated refrigeration and control system.

The manufacturing process begins with incoming material inspection and continues through component fabrication, sub-assembly and final assembly. Important operations include cutting and bending of sheet metal, injection moulding of plastic parts, manufacturing of fin-and-tube heat exchangers, cutting and bending of copper tubes, brazing of refrigeration joints, compressor and motor installation, and electrical wiring and PCB integration. Each operation requires proper dimensional accuracy, component identification, controlled assembly and inspection to prevent defects from affecting the final product.



The refrigeration system is a critical part of AC manufacturing. The compressor circulates and compresses the refrigerant, while the condenser rejects heat to the surrounding air. The expansion device reduces refrigerant pressure, and the evaporator absorbs heat from indoor air. Manufacturing practices such as proper tube preparation, leak-tight brazing, evacuation, moisture control, refrigerant charging and pressure testing are essential for reliable refrigeration performance. Modern AC manufacturing also gives significant importance to electrical safety, quality assurance, energy efficiency and environmental responsibility. Electrical and PCB assemblies must be correctly wired, insulated and tested. Incoming quality control, in-process inspection, mistake-proofing, final functional testing, preventive maintenance, 5S and lean manufacturing practices help maintain consistent product quality and reduce manufacturing defects. Safety measures are also necessary because AC production involves electrical systems, rotating machinery, hot brazing operations and pressurized refrigerant circuits.

The industrial training at PG Technologies Pvt. Ltd., Supa, Parner, Ahilya Nagar provided an opportunity to understand these manufacturing activities and observe the relationship between materials, machines, operators, quality systems and the finished AC product. The training helped in connecting theoretical engineering concepts with practical industrial operations and provided knowledge of manufacturing processes, assembly methods, testing procedures, quality control, safety practices and troubleshooting involved in AC manufacturing.

Motivation

The motivation for selecting Air Conditioner Manufacturing as the subject of industrial training was to understand how the theoretical concepts studied in engineering are applied in a real manufacturing environment. An air conditioner is a complex product in which mechanical, electrical, electronic, refrigeration and control systems work together. Studying its manufacturing process provides practical knowledge of how individual components are produced, inspected, assembled and tested to obtain a reliable and efficient final product.

Objectives

1. To understand the overall manufacturing process of split and room air conditioners from raw materials to final assembly.
2. To study the major AC components and their functions, including the compressor, condenser, evaporator, fan, motor, PCB and refrigeration circuit.

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3. To observe manufacturing and assembly operations such as sheet-metal fabrication, heat-exchanger production, copper-tube bending, brazing and unit assembly.
4. To understand quality-control, inspection, testing, electrical safety and leak-detection practices used in AC manufacturing.
5. To develop practical industrial skills and relate theoretical E&TC engineering knowledge to real-world AC manufacturing processes.

II. LITERATURE SURVEY

1. Bureau of Indian Standards (BIS)

Bureau of Indian Standards (BIS) guidelines related to room air conditioners provide important requirements for construction, safety, inspection and performance testing of air-conditioning units. The report refers to IS 1391 and related guidance for indoor and outdoor unit air conditioners. These standards emphasize controlled manufacturing, electrical safety, refrigeration-circuit integrity and performance verification. Such requirements are important for ensuring that the finished AC operates safely and consistently.

2. BIS Product Manual and Testing Guidelines

BIS product manuals and testing guidance for room air conditioners provide a basis for inspection and testing procedures. The report highlights that production control, sampling, testing frequency and acceptance criteria are important parts of quality assurance. Cooling capacity, power consumption and other performance characteristics must be evaluated according to applicable requirements. This literature supports the use of systematic inspection and testing throughout the AC manufacturing process rather than depending only on final inspection.

3. Electronics Sector Skills Council of India (ESSCI)

The Electronics Sector Skills Council of India (ESSCI) participant handbook for RAC assembly operators provides information related to air-conditioning manufacturing and assembly practices. The report uses this type of industry-oriented material to emphasize operator responsibilities, component handling, assembly procedures, safety practices and process discipline. Proper training of operators is important because the quality of an AC depends on correct component identification, wiring, fastening, tube routing and other repetitive manufacturing activities.

4. Integrated Air Conditioner Manufacturing

Industry information on integrated AC manufacturing indicates that production may involve several coordinated activities such as plastic component manufacturing, sheet-metal fabrication, fan and heat-exchanger production, copper-tube preparation and controller assembly. Such integration helps maintain dimensional consistency and improves coordination between component manufacturing and final assembly. The report therefore considers AC manufacturing as a complete production-and-quality system rather than simply an assembly operation.

5. Refrigeration Cycle and Manufacturing

The refrigeration cycle is fundamental to AC manufacturing because the compressor, condenser, expansion device and evaporator must work together correctly. The compressor raises refrigerant pressure, the condenser rejects heat, the expansion device reduces pressure and controls refrigerant flow, and the evaporator absorbs heat from indoor air. Literature and technical information discussed in the report show that accurate component manufacturing, leak-tight joints, proper evacuation and controlled refrigerant charging are essential for reliable refrigeration performance.

6. Heat Exchanger Manufacturing

Heat exchangers are critical components because they directly influence heat-transfer performance and cooling capacity. The report describes fin-and-tube construction using copper tubes and aluminium fins, with attention to tube forming, fin

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spacing, joining and leak testing. Proper manufacturing and handling are necessary because damaged fins, incorrect tube geometry or contamination can reduce airflow and heat-transfer effectiveness.

Existing system

The existing air-conditioner manufacturing system is a structured production process in which different components are manufactured, inspected, assembled and tested through a sequence of controlled operations. The system begins with the receipt and inspection of raw materials such as sheet metal, aluminium fins, copper tubes, engineering plastics, electrical components, motors, sensors and other required parts. Incoming Quality Control (IQC) is performed to verify component identification, quantity, dimensions, surface condition and other specified characteristics before materials are released for production. In the existing system, sheet-metal components are produced through cutting, punching, bending, deburring and finishing operations to form cabinets, brackets and structural parts. Plastic components such as covers, grilles, louvers, fan housings and drain components are produced using moulding processes. Heat exchangers are manufactured using copper tubes and aluminium fins, while copper tubes are cut, bent and prepared for joining. These components are then inspected for dimensional accuracy, surface condition, deformation and other manufacturing defects before being transferred to assembly operations.

The refrigeration assembly involves joining copper tubes and refrigeration components through controlled brazing operations. The compressor is installed in the outdoor unit using suitable fastening and vibration-isolation arrangements. The indoor unit is assembled with the evaporator coil, blower, motor, drain tray, filter, louvers, sensors and electrical components, while the outdoor unit includes the compressor, condenser coil, fan and motor, electrical enclosure and service valves. Electrical and PCB assemblies are connected using specified wiring routes, connectors, sensors and protective arrangements.

After mechanical and electrical assembly, the refrigeration circuit undergoes evacuation to remove air and moisture, followed by controlled refrigerant charging. Leak detection and pressure testing are carried out to verify the integrity of the refrigeration circuit. The completed AC then undergoes end-of-line functional testing, which may include checking power consumption, running current, fan and compressor operation, temperature response, abnormal noise, vibration and electrical safety. Units that do not satisfy the required acceptance criteria are isolated for diagnosis and corrective action.

The existing system also incorporates quality-control practices throughout production rather than depending only on final inspection. Incoming inspection, in-process inspection, poka-yoke, visual controls, gauges, traceability, electrical testing and final functional testing are used to reduce manufacturing defects. Maintenance, 5S, lean manufacturing, material handling and operator training support production efficiency and consistent product quality. The system therefore provides a controlled approach for converting raw materials into a tested and packaged air-conditioning product.

III. PROPOSED SYSTEM

1. Improved Manufacturing and Assembly Approach

The proposed system focuses on improving the existing AC manufacturing process by integrating better process control, inspection, traceability and systematic assembly practices. The complete production sequence is planned from incoming material inspection to final testing so that each component is verified before it moves to the next manufacturing stage. This approach aims to reduce assembly errors, rework and production losses while maintaining the required quality of the finished air conditioner.

2. Enhanced Incoming Material Inspection

The proposed system gives greater importance to Incoming Quality Control (IQC) before components enter production. Sheet metal, copper tubes, plastic components, heat exchangers, compressors, motors and electrical parts are checked for correct identification, dimensions, condition and specifications. Defective or non-conforming materials are segregated before production to prevent repeated defects and unnecessary assembly problems.

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3. Standardized Component Manufacturing

Component manufacturing is proposed to follow standardized work instructions and controlled operating procedures. Sheet-metal cutting, punching and bending, plastic moulding, heat-exchanger production and copper-tube preparation should maintain consistent dimensions and quality. Proper fixtures, gauges and inspection points can be used at the relevant stages to identify defects close to their source and reduce variation in subsequent assembly operations.

4. Controlled Refrigeration Assembly

The proposed system emphasizes controlled preparation and assembly of the refrigeration circuit. Copper tubes should be correctly cut, bent, cleaned and routed before brazing. Brazed joints should be visually inspected and subsequently verified through appropriate pressure and leak testing. Evacuation and moisture control should be completed before controlled refrigerant charging so that the refrigeration system remains clean, sealed and reliable.

5. Improved Electrical and PCB Integration

The proposed system includes systematic electrical and PCB assembly with proper component identification, connector verification, wiring routing and earthing. Sensors and electrical harnesses should be positioned according to the specified arrangement, while wires should be protected from sharp edges, hot surfaces and moving components. Electrical safety checks such as continuity, insulation and other applicable tests should be performed before final product acceptance.

IV. SYSTEM DESIGN

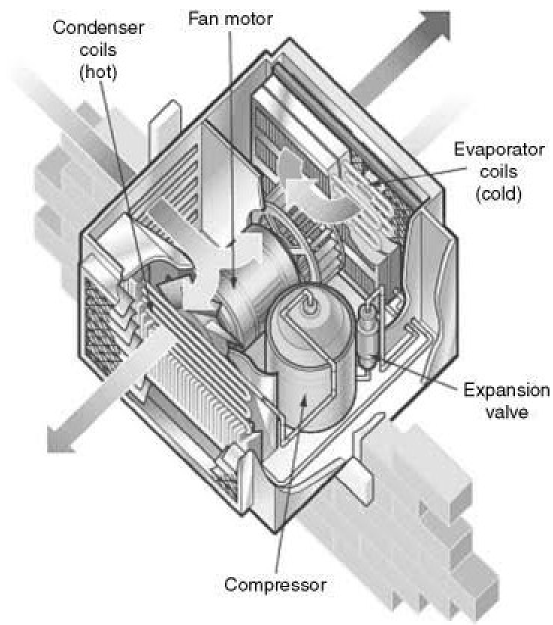

Fig. 1 Block Diagram

System Design

1. Overall System Structure

The proposed AC manufacturing system is designed as an integrated production system in which raw materials are converted into a finished, tested air-conditioning unit through a sequence of controlled manufacturing and assembly operations. The system consists of material inspection, component manufacturing, refrigeration assembly, electrical assembly, indoor and outdoor unit assembly, quality inspection, testing and final packaging. Each stage is connected so that the output of one operation becomes the controlled input for the next operation.

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2. Material and Component Preparation

The first section of the system deals with the identification, inspection and preparation of raw materials and components. Sheet metal, copper tubes, aluminium fins, plastic materials, compressors, motors, electrical components, sensors and PCB assemblies are inspected according to their required specifications. Accepted materials are supplied to the appropriate manufacturing stations, while non-conforming materials are separated to prevent their accidental use in production.

3. Mechanical Component Manufacturing

The mechanical manufacturing section produces the structural and functional components required for the AC. Sheet-metal parts are cut, punched, bent, deburred and finished to obtain cabinets, brackets and supports. Plastic components are produced through moulding processes, while heat exchangers are prepared using copper tubes and aluminium fins. Dimensional and visual inspections are performed to ensure that the components can be correctly fitted during final assembly.

4. Refrigeration Circuit Design

The refrigeration section consists of the compressor, condenser, expansion device, evaporator and connecting copper tubes. Copper tubes are cut, bent and prepared according to the required routing. Brazing is used to produce permanent refrigeration joints, followed by inspection and leak testing. The circuit is then evacuated to remove air and moisture before controlled refrigerant charging. This arrangement ensures that the refrigeration circuit is clean, sealed and capable of providing the required cooling performance.

5. Indoor Unit Assembly

The indoor-unit assembly section integrates the evaporator coil, blower, motor, drain tray, filter, louvers, sensors, electrical harnesses and plastic housing. Components are positioned according to defined assembly requirements, and wiring is routed through designated paths. The blower is checked for free rotation, the drain passage is kept clear and the panels are inspected for proper fit and appearance.

6. Outdoor Unit Assembly

The outdoor-unit assembly section combines the base structure, compressor, condenser coil, outdoor fan and motor, electrical enclosure, service valves and refrigeration connections. The compressor is secured using suitable fastening and vibration-isolation arrangements. Copper tubes and electrical wires are routed carefully to maintain clearance from moving parts and sharp edges. The completed outdoor unit is then subjected to mechanical, electrical and refrigeration inspections.

7. Electrical and Control System

The electrical and control section integrates the PCB, sensors, motors, electrical harnesses, connectors and protective components. Correct connector identification, polarity, wiring, insulation and earthing are verified during assembly. The control system coordinates important functions such as compressor operation, fan operation, temperature sensing, display and protection functions. Appropriate electrical safety tests are performed to verify the reliability of the completed electrical system.

8. Quality Inspection and Testing

Quality control is incorporated throughout the system rather than being limited to the final stage. Incoming inspection, in-process inspection, visual checks, dimensional checks, leak detection, pressure testing and electrical testing are performed at appropriate stages. At the end of the process, the completed AC undergoes functional testing to evaluate parameters such as compressor and fan operation, temperature response, power consumption, running current, noise and vibration. Test results can be recorded against the product identification for traceability.

VI. OUTCOMES FROM THE SYSTEM

1. Improved Understanding of AC Manufacturing

The system provides a clear understanding of the complete air-conditioner manufacturing process, starting from raw-material inspection and component preparation through assembly, refrigeration processing, testing and final packaging. It helps in understanding how different manufacturing stages are interconnected to produce a complete AC unit.

2. Better Component and Assembly Quality

The implementation of controlled manufacturing, dimensional inspection and standardized assembly practices helps improve the consistency of AC components and assemblies. Proper inspection of sheet-metal parts, plastic components, heat exchangers, copper tubes and electrical components reduces the possibility of defective parts reaching subsequent production stages.

3. Reliable Refrigeration Performance

Controlled tube preparation, brazing, evacuation, moisture control, leak detection and refrigerant charging help maintain the integrity of the refrigeration circuit. These practices support reliable cooling performance and reduce the possibility of refrigerant leakage and related performance problems.

4. Improved Electrical and Functional Safety

Systematic electrical assembly and testing help ensure correct wiring, connector installation, insulation and earthing. Electrical safety checks and end-of-line functional testing provide greater confidence in the safe operation of the completed air conditioner.

5. Reduction in Manufacturing Defects and Rework

The use of incoming inspection, in-process inspection, poka-yoke, visual controls and final testing helps identify defects at an earlier stage. Early detection of incorrect wiring, poor brazing, missing fasteners, incorrect component placement and other assembly problems can reduce rework and prevent defective products from progressing through the production line.

6. Improved Traceability and Process Control

Recording inspection and testing results against product identification improves traceability throughout the manufacturing process. When a unit fails during testing, its production history can be reviewed to support diagnosis and root-cause analysis. This also helps identify repeated manufacturing problems and supports corrective actions.

VIII. CONCLUSION

The industrial training on AC Manufacturing provided a comprehensive understanding of the complete manufacturing and assembly process of air-conditioning systems, from incoming material inspection and component manufacturing to refrigeration assembly, electrical and PCB integration, testing and final packaging. The study helped in understanding the functions of major components such as the compressor, condenser, evaporator, expansion device, heat exchangers, motors, sensors and control systems, along with practical processes such as sheet-metal fabrication, plastic component manufacturing, copper-tube bending, brazing, evacuation, refrigerant charging and leak testing. The training also provided valuable knowledge of quality control, electrical safety, preventive maintenance, 5S, material handling and troubleshooting practices. Overall, the industrial exposure successfully connected theoretical E&TC engineering concepts with practical manufacturing operations and improved technical knowledge, industrial awareness, safety consciousness and understanding of quality-oriented production practices.

IX. FUTURE SCOPE

The future scope of AC manufacturing includes the adoption of advanced automation, smart manufacturing systems, improved quality-monitoring techniques and digital traceability to increase production accuracy and efficiency. Further

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development can focus on energy-efficient compressors, motors, heat exchangers and advanced electronic control systems to reduce power consumption while maintaining cooling performance. Improved brazing, leak-detection, evacuation and refrigerant-charging methods can enhance refrigeration reliability, while predictive maintenance and real-time monitoring can reduce equipment downtime and manufacturing defects. Sustainable manufacturing practices such as material optimization, waste reduction, responsible refrigerant handling and recycling can also improve environmental performance. In addition, greater use of sensors, PCB-based control, Industry 4.0 technologies and data-based process improvement can provide better system monitoring, product quality and manufacturing efficiency.

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