# Modification of the Coil Winding Machine



A Project Report

*Submitted by*


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*in partial fulfillment for the award of the degree*
of

**Bachelor of Engineering**
**in**
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**DEPARTMENT OF MECHANICAL ENGINEERING**
**KUMARAGURU COLLEGE OF TECHNOLOGY**
**COIMBATORE – 641 006**

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**APRIL– 2006**

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## BONAFIDE CERTIFICATE

Certified that this project report entitled "**Modification of the Coil Winding Machine**" is the bonafide work of

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# DEPARTMENT OF MECHANICAL ENGINEERING

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## COIMBATORE 641 006

ROOTS

SL. No. : [illegible]

Date : 12.04.2006

## PROJECT / INPLANT TRAINING / INTERNSHIP CERTIFICATE

This is to certify that Mr. / ~~Ms.~~ K. RAGHUPATHY BE (MECHANICAL) IV year student of KUMARAGURU COLLEGE OF TECHNOLOGY has done / ~~undergone~~ / a Project / ~~Inplant training~~ / ~~Internship~~ on DESIGN OF AUTOMATIC ENAMEL REMOVAL IN SINGLE SPINDLE COIL WINDING MACHINE in our ROOTS INDUSTRIES LIMITED during the period from JAN-2006 to MAR-2006

During this period his / ~~her~~ conduct was GOOD

(KAVIDASAN)
GENERAL MANAGER - CORPORATE HRD.

# ABSTRACT

Manufacturing imposes various constraints over the dimensional and mensurational parameters. It should be achieved accurately within certain tolerances. Another challenging aspect in any industry is the minimization of man power and materials along with the standardization of measurements and methods.

Machines and methods are to be designed in such a way that it not only fulfills the competitive edge in deciding the survivors in the market but also the activities of management.

With the above in mind, the efficiency has to be designed to the peak capacity .Our project deals with the **Modification of the Coil Winding Machine** which was sponsored by and done at **Roots Industries Limited.** In the modification, we attached an automatic enamel removal arrangement to the existing coil winding machine. Enamel has to be removed at the contact points of the spool assembly, to allow the current to pass through the coil in order to produce the sound in the horn. The enamel at the required position is removed with the help of the grinding wheel set up. A through study is made in the process and the design is made taking various factors such as life of the coil, quality of horn, less wastage etc. into consideration.

Automation of the grinding wheel is made by the pneumatic system which moves the rotating arm in a circular path, where the pneumatic cylinder's actuation is obtained from the signal produced from the control unit at the break turn time.

The various pneumatic parts and the automation methods are studied and detailed report for the same is produced. Our project helps in the reduction of the coil wastage, around 20mm of coil is saved for each spool and the life of the coil is increased due to the proper removal without any depression.

# ACKNOWLEDGEMENT

We express our gratitude from the bottom of our heart to our guide Professor **C.R.Kamalakannan M.E,** for his able guidance and suggestions during all stages of our project.

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We are truly thankful to **Mr.M.Vijaya Kumar M.E** Head MFE, **Roots Industries** Ltd for his valuable help and support during the project.

We express our gratitude to **Mr.Kavidasan**, Head Corporate HRD and **Mr.N.Sampath Kumar**, Associate Head Training & Development of Roots Industries Limited for providing us this opportunity to do the project in their organisation.

Our thanks must also to be mentioned to the operators and maintenance personnel at Roots Industries Ltd who helped us during our project.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| F | Force |
| P | Pressure |
| Lf | Load Factor |
| Q1 | Flow rate |
| V | Forward stroke velocity (m/sec) |
| D | Diameter of cylinder (m) |
| L | Stroke length (m) |
| A | Cross sectional area of cylinder bore |

# CHAPTER 1 INTRODUCTION

## 1.1 COMPANY PROFILE

Started in the year 1970 in the name American auto service, roots industries ltd as it is known today has emerged as the $11^{th}$ largest Electric horn manufacturing company in the world.

In 1974,it launched the electrically operated air horn followed by the high frequency electric horn in 1982 that was an industry first. By 1983,roots became the largest horn manufacturing company in India and the brand name won a major market share. Presently its customers include ford, Daimler-Chrysler, Hyundai, Toyota-kirloskar, TVS etc.

Various Quality certificate obtained by the company are listed below.

ISO/TS 16949:2002 for QMS

ISO 14001:1996 for EMS

ISO/TS 16949:1999 by TUV Rhineland India Pvt.Ltd, Bangalore.

## 1.2 QUALITY POLICY OF ROOTS

We are committed to provide world-class products and services with due concern for the environment and safety of the society.

This will be achieved through total employee involvement, technology innovations, cost reduction and continual improvement in

1. Quality of the products and services.
2. Quality management system.
3. Compliance to QMS requirements.
4. Quality will reflect in every thing we do and think
5. Quality in behavior.
6. Quality in governance.
7. Quality in human relation.

## 1.3 PROCEDURE FOR MANUFACTURING ENGINEERING

To establish and maintain a procedure for developing a capable process design, verification, implementation and improvement, taking into consideration the effectiveness of the existing operations, with focus on plant, facility and equipment planning and tooling management.

Scope:

The scope covers all the process related to electric horns.

Responsibility:

Head- Manufacturing Engineering is responsible for establishing and maintaining this process.

Procedure:

General:

The Manufacturing engineering (MFE) is the functional interface between product engineering and manufacturing to convert the design intent to the final product, which meets the customer requirements by establishing the required process and facilities.

The departmental organisation structure with related job description is given in head-MFE identifies the training needs for manufacturing Engineering personnel based on the functional requirements.

## 1.4 DIVISION SELECTED FOR THE PROJECT:

American Auto Service

## 1.5 SHOP DETAILS:

Two units are there in this section for making the components of the horn assembly. They are

1. Riveting section.
2. Spool winding section.

### 1.5.1 Riveting Section.

This section mainly deals with the riveting of the point plate assembly and the point holder assembly which comes in the horn assembly. This point holder plays a major role in avoiding the slipping of spool and the most important work of this point plate is to provide the current supply to the coil in the spool when the current is passed.

Various types of point plate and holders riveted here in this section, some of the currently doing types.

1. R10
2. R3
3. R2/2
4. R70
5. FC4
6. FD4
7. R14

These were the types that have been riveted in the American Auto Service section.

### 1.5.2 Spool Winding Section.

Here in this section various spools are been winded, the spool is the major component of the horn. The spool plays a major role of passing the current around the magnet in the housing, which produces the required sound. The spool part has to be seated in the housing with a sort of pressure applied in the top portion and the turning screw at the bottom part where there is a slot provided in the housing. Various types have been winded here in this section, depending on the need the types have been changed in the section. Some of the types currently in progress are,

1. FD4
2. Roots 90
3. Wind tone
4. Spider low tone.
5. TVS R70 (Low tone)

## 1.6 INTRODUCTION TO THE PROJECT:

Our project is done in the coil winding division of American Auto Service horn section. The components of the horn which forms the whole unit of the horn

1. Point plate assembly
2. Spool assembly
3. Housing with sprang.
4. Terminal base plate.

# EXPLODED SPOOL LOCKING SEQUENCE

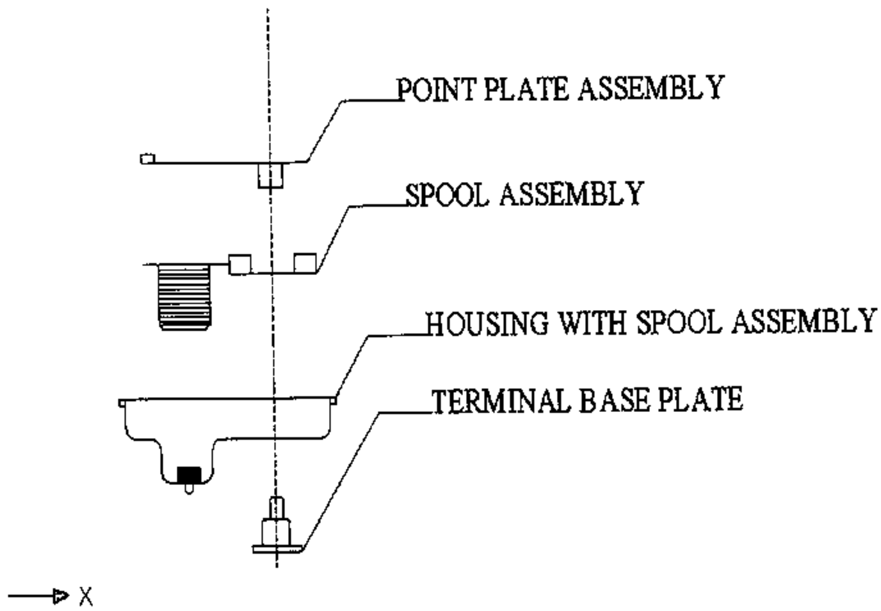


**FIGURE 1.1 EXPLODED SPOOL LOCKING SEQUENCE**

Among them spool is the major component as it helps in producing sound when the current is passed. This is done with the help of the magnet which is the core of the housing. The enamel at the two contact ends has to be removed to enable the current to flow through the coil when it is been supplied.

To remove the enamel at the contact points we proposed a grinding wheel setup with a backup plate designed for the enamel removal in the winding section. The automation is done using pneumatics, it is chosen since the pneumatic system is fast and accurate, instant reversibility is possible, highly reliable and cost effective compared to other systems.

## 1.7 BACKGROUND OF THE PROBLEM:

At present the process of removing the enamel is being done manually. Manually they are removing the enamel at the contact points with the help of knife. It is time consuming and there is lot of wastage of the materials which is quite costly. To avoid the coil wastage and to increase the coil life we have planned to design the automatic enamel removal. Our idea deals with designing the arrangement of grinding wheel and moving the arm with pneumatic cylinder.

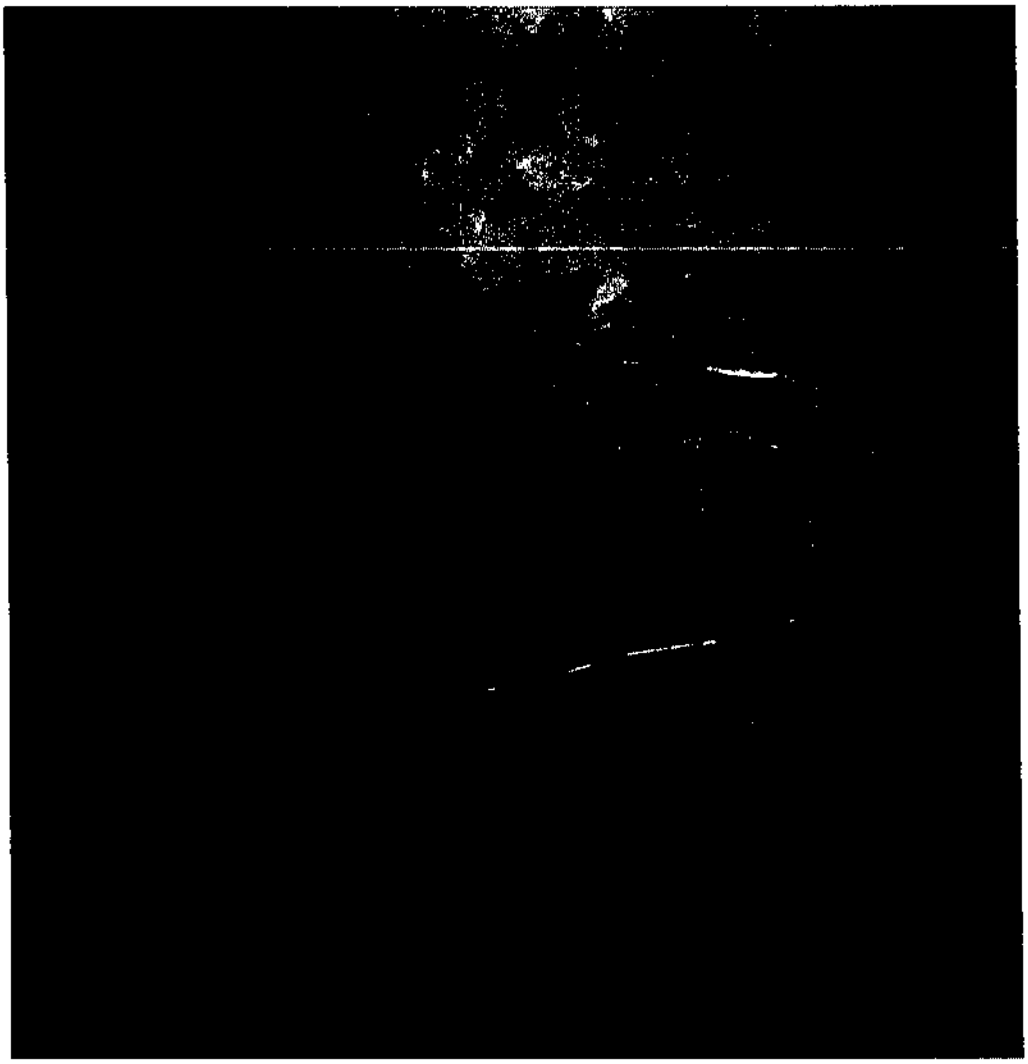

**FIGURE 1.2 SPOOL ASSEMBLY WITH ENAMEL REMOVED**

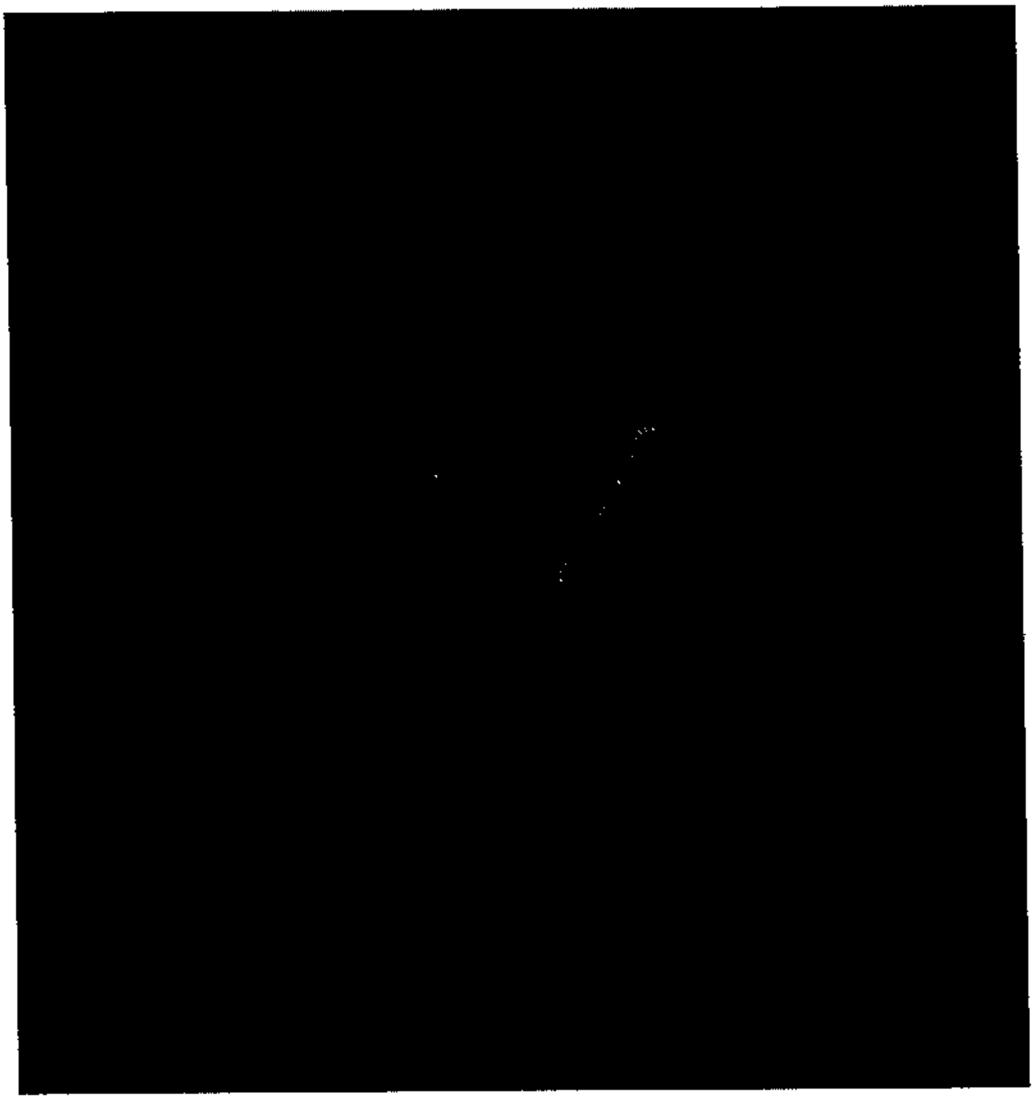

**FIGURE 1.3 SPOOL ASSEMBLY**

## 1.8 IMPORTANCE:

In the current market level the product have to manufacture in a competitive manner. To sustain the market one has to improve the standards and the quality of the product being manufactured. When the enamel is removed through the manual process with the help of the knife, there are various problem encountered, they are

1. Non uniform removal of the enamel.
2. Depression in the coil is made.
3. Prevent the flow of the current.
4. Coil breakage is possible.

These problems will lead to the failure of the horn to avoid those problems it has been suggested to do the removal in the automatic way. So with this automatic removal method the standard will increase and the quality, which will help in increasing the market.

## 1.9 SCOPE:

There is a wide scope for this project since the removal is made in an automatic process. The quality and the standard of the spool is increased. The other benefits of the projects are listed down which would add profit.

1. Reduction of coil wastage- around 20 mm of the coil wastage is reduced.
2. Proper removal of enamel- grinding method will assure the complete removal.
3. Coil life is increased- unnecessary depression is avoided which will increase the coil life.
4. Pneumatic cylinder has been chosen to automate, which will make the removal rate faster, another advantage is that the retrieval rate is faster.
5. Reduction of time- since the removal is done in the winding section itself, the time for transferring the spool to the enamel removal section is reduced.

# CHAPTER2 AUTOMATION

## 2.1 GENERAL INTRODUCTION:

Automation is a continuous evolutionary that began many decades ago. It is generally believed that the industrial revolution when began to take over the work previously performed by manual labor. Industry is going to depend more and more on automation in order to increase productivity. The hydraulic and pneumatic system, which provides the muscle for automation in modern industrial system, has special significances in study of automation.

## 2.2 DEFINITION OF AUTOMATION:

Automation is a technology concerned with the application of mechanical, electronic and computer based system to operate and control production with little or no human participation.

Automation is concerned with the physical activities in manufacturing. Automated production systems are designed to accomplish the processing, assembly, material handling and inspection activities. This technology includes:

1. Automatic machine tools to process parts.
2. Automatic assembly machines.
3. Industrial robots.
4. Automatic material handling and storage system.
5. Automatic inspection systems for quality control.
6. Feed back control and computer process control.
7. Computer system for data collection and decision making to support manufacturing activities.

## 2.3 TYPES OF INDUSTRIES

There is a wide variety of basic industries including not only manufacturing but all other as well. However, our interest is on industries firms that are engaged in production.

Basic industries that are engaged in the production of variety of items ranging from metal, chemical, textile to sophisticated electronic products can be grouped under the category of "Manufacturing industries" or "Production Industries."

Manufacturing companies are typically identified with discrete item production: cars, computers, machine tools and the components that go into these products.Chemicals and plastics, petroleum products, food processing, soaps, steel and cement represent process industries.

## 2.4 TYPES OF PRODUCTION:

Based on the production quantity, a production activity in an industry can be categorized into three types as given below:

1. Job shop production.
2. Batch production
3. Mass production.

The classification is normally associated with discrete product manufacture, but it can also serve for plants used in the process industries. For example, some chemicals are produced in batches (batch production), whereas others are produced by continuous flow process (mass production).

### 2.4.1 Job Shop Production:

The distinguishing feature of job shop production is low volume. The manufacturing lot size are small, often one of a kind. Job shop production is commonly used to meet specific customer orders and there is a great variety in the type of plant must do. Therefore, the production equipment must be flexible and general purpose to allow for this variety of work. Also the skill level of job shop workers must be relatively high so that they can perform a range of different work assignments. Examples of products manufactured in a job shop include space vehicles, aircraft, machine tool, special tools and equipment and prototype of future products.

### 2.4.2 Batch Production:

This category involves the manufacture of medium sized lots of the same item or product. The lots may be produced only once or they may be produced at regular intervals. The purpose of batch production is often to satisfy continuous customer demand for an item. However, the plant is capable of a production rate that exceeds the demand rate. Therefore the shop produces to build up an inventory of the item. Then it changed over to the other orders. When the stock of the first item becomes depleted, production is repeated to build up the inventory again.

The manufacturing equipment used in batch production is general purpose but designed for higher rates of production. For example, turret lathes capable of holding several cutting tools are used rather than the engine lathes the machine tools used in batch production are often combined with specially designed jigs and fixtures, which increase the output rate. Example of items made in batch type shops include industrial equipment, furniture, text books and parts for many assembled foundries, plastic molding factories and press working shops. Some types of chemical plants are also in the general category. It has been estimated that as 75% of all parts manufacturing is in lot sizes of 50 pieces or less. Hence, batch production constitutes an important portion of manufacturing activity.

**2.4.3. Mass Production:**

This is a continuous specialized manufacture of identical products. Mass production is characterized by very high production rates, equipment that is completely dedicated to the manufacture of particular product, and very high demand rates for the product. Not only is the equipment dedicated to one product, but the entire plant is often designed for the exclusive purpose of producing the particular product. The equipment is special purpose rather than general purpose. The investment in the machine and specialized tooling is high. In a sense, the production skill has been transferred from the operator to the machine.

Two categories of mass production can be distinguished.

1. Quantity production
2. Flow production.

Quantity productions involve in mass production of single parts on fairly standard machine tools such as punch press, injection moulding machines and automatic screw machines. These machines have adapted to the production of the particular parts by means of special tools die sets, mould and foam cutting tools respectively designed for the part in question. The production equipment is devoted fill time to satisfy a very large demand rate for the item. In mass production the demand rates and production rates are approximately equal. Example of items in quantity production includes components for assembled products that have demand rates (automobile, some house hold appliances, light bulb etc), hardware items such as screws, nuts, nails and many plastic moulded parts.

Flow production is other category of mass production. The term suggests the physical floe of the product in oil refineries, continuous chemical parts and food processing.

## 2.5 FUNCTIONS IN MANUFACTURING:

For any of the three types of production, there are certain basic functions that must be carried out to convert to raw material into finished product. For a firm engaged in making discrete products, the functions are:

1. Processing
2. Assembly
3. Material handling and storage
4. Inspection and testing
5. Control

The first four functions are physical activities and fifth function, control is required to coordinate and regulate the physical activities. Out of first four physical activities, Processing and assembly operation add value to the product.

### 2.5.1 Processing Operation:

Processing operation transform the product from one state of completion into more advanced state of completion. No materials or components are assembled are added to accomplish the transformation. Instead of energy (i.e., mechanical, heat, electrical, chemical, etc) is added to change the shape of the part, remove material from it, alter its physical properties or accomplish other forms of work to change it. Processing operation can be classified into the following categories.

1. Basic process
2. Secondary process
3. Operations to change the physical properties

4. Finishing operations

Basic process are those, which give the work material in its initial form. Metal casting and plastic moulding are examples. In both the cases the raw materials are converted into the basic geometry of the desired product. It is common for additional processing to be required to achieve the final shape and size of the work piece.

Secondary processing follows the basic process and is performed to give the work piece its final desired geometry. Examples in these categories include machining (turning, drilling and milling) and press working operations (blanking, forming, drawing etc).

Operations to enhance physical properties do not perceptibly change the physical geometry of the work piece. Instead the physical properties of the material improved in some way. Heat – Treating operations to strengthen metal part is an example in this category.

Finishing operations are the final process performed on the work piece. Their purpose, is for example, to improve the appearance, or to provide protective coating on the part, example in this fourth category include polishing, painting and chrome plating.

**2.5.2 Assembly Operations:**

Assembly and joining process constitute the second major type of manufacturing operations. In assembly, the distinguishing feature is that two or more separate components are joined together. Include in this category are mechanical fastening operations, which make a use of screw, nuts, rivets and so on, and joining process such as welding, brazing and soldering. In the fabrication of a product the assembly operation follow the processing operation.

**2.5.3 Material Handling and Storing:**

A means of moving and storing material between the processing and assembly operations must be provided. In most manufacturing plants, material spent more time being moved and stored than being processed. In some cases, the majority of labor cost in the factory is consumed in handling, moving and storing materials. It is important that this function be carried out as efficiently as possible.

### 2.5.4 Inspection and Testing:

Inspection and testing are generally considered part of quality control. The purpose of inspection is to determine whether the manufactured product meet the established design standards and specification. For example, inspection examines whether the actual dimensions of a mechanical part are with in the tolerances on the engineering drawing for the part.

Testing is generally concerned with the functional specification of the product rather than the individual part that go into the product. For example, final testing of the product ensures that it functions and operates in the manner specified by the product designer.

### 2.5.5 Control:

The control function manufacturing includes both the regulation of individual processing and assembly operations and the management of plant level activities. Control at the process level involves the achievement of certain performance objectives by proper manipulation of the inputs to the process. Control at the level includes effective use of the labor, maintenance of equipment, material movement and cost control. Manufacturing control at the plant level represents the major points of interaction between the physical operations in the factory and information processing activities that occur in production.

## 2.6 PLANT LAYOUT:

The term "plant layout" refers to the arrangement of the physical facilities in a production plant. The layout suited to flow type mass production is not appropriate for job production, and vice verse. There are three principle types of plant layout associated with traditional production shops:

1. Fixed position layout.
2. Process layout.
3. Product flow layout.

There is considerable correlation between the type of plant layout and the type of production classified in the previous section. The salient feature of each type of layout is described below.

### 2.6.1 Fixed Position Layout:

In this type of layout, the term fixed position refers to the product. Because of its size and weight the product remains in one location and equipment used in its fabrication is brought to it. Large aircraft assembly and ship building are the examples f operations in which fixed position layout is utilized. Another arrangement of facilities, similar to the fixed position type is project layout. This is used for construction jobs such as building, bridges and dams. As with fixed position layout, the product is large and the construction equipment and workers must be moved to the product. Unlike the fixed position arrangement, when the job is completed, the equipment from the construction site. In fixed position layout, the product is eventually moved out of the plant and the plant remains for the next job. This type of arrangement is often quantities.

### 2.6.2 Process layout:

In a process layout, the production machines are arranged into groups according to the general type of manufacturing process. The lathes into one department, drill press are in another, plastic moulding in another and are so on. The advantage of this type of layout is its flexibility. Different parts each requiring its own unique sequence of operations can be routed through the respective departments in the proper order. Fork lift trucks and hand carts are used to move materials from one work center to the next.

## 2.7 TYPES OF AUTOMATION:

1. Fixed automation.
2. Programmable automation.
3. Flexible automation.

### 2.7.1 Fixed Automation:

Fixed automation is a system in which the sequence of processing and assembly operation is fixed by the equipment configuration. The operations in the sequence are usually simple. It is the integration and coordinates of much such operation into piece of equipment that make system complex. The typical features of fixed automation are:

1. High initial investment for customer engineered equipment.
2. High production rate.
3. Relatively inflexible in accommodating product changes.

The economics justification for fixed automation is found in product with very high demand rates and volumes. The initial cost the equipment can be spread over large number of units. Thus making the unit cost attractive compared alternative methods of production. Examples of fixed automation includes mechanized assembly lines where the product moved along mechanized conveyors and transfer lines.

### 2.7.2 Programmable Automation:

In programmable automation, the product equipment is designed with the capability to change the sequence of operations to accommodate different configurations. The operations sequence is controlled by programmable, which set of instructions coded so that the system can read and interpret them .New programs can be prepared and entered into the equipment procedure new products. Some the features that characterize programmable automation include:

1. High investment in the general purpose equipment.
2. Low production rates relative to fixed automation.
3. Flexibility to deal with change product configuration.
4. Most suitable for batch production.

Automated production systems that are programmable are used in low and medium volume production. The parts or products are typically made in batches. To produce each new batch of a new product the system must be programmed with a set of medium instructions that correspond to new products. The physical se up of the machine must also be changed over. Tool must be changed, fixtures must be attached to the machine table and the required machine settings must be entered. This change over takes time. Consequently, the typical cycle for the given product include a period during which the set up and the reprogramming takes place, followed by period in which the batch is produced. Examples of programmable automation include numerically controlled machine tools and industrial robots.

### 2.7.3 Flexible Automation:

Flexible automation is an extension of programmable automation. A flexible automated system is one which is capable of producing a variety of products virtually no time lost for change over from one product to next. There is no production time lost while reprogramming the system and altering the physical set up (tooling, fixture, machine set up) consequently the system can produce various combinations and schedules of products, instead of requiring that they be made in separate batches. The features of flexible automation can be summarized as follows:

1. High investment for custom engineered system.
2. Continuous production of variable mixtures of products
3. Medium production rates
4. Flexibility to deal with production design variations

The essential features that distinguish flexible automation from programmable automation are:

1. Capacity to change part programs with no lost production time.
2. Capacity to change over physical set up again with no lost production time.

These features allow the automated production system to continue production without the down time between batches that is the characteristics of programmable automation. Changing the part programs is generally accomplished by preparing the programs off-line computer system and electronically transmitting the programs to the automated production systems. Therefore the time required to do programming for the next job does not interrupt production of the current job. Advances in computer systems technology are largely responsible for this programming capability in programming automation. Changing the physical setup between the is accomplished by making the changeover off-line and then moving it into place simultaneously as the next parts come into position for processing. The use of pallet fixtures that hold the parts and transfer into position at the work place is one way of implementing this approach. For these approaches to be successful, variety of parts that can be made on flexible automated production system is usually more limited than a system controlled by programmable automation.

## 2.8 REASONS FOR AUTOMATING

Increased productivity

Automation of manufacturing operations holds the promise of increasing the productivity. This means greater output per hour of labor input. Higher production rates are achieved with automation tan with the corresponding manual operations.

Highest Cost of Labor

The trend in the industrialized societies of the world has been towards ever increasing labor costs. As result, higher investment in automated equipment has become economically justifiable to replace manual operations. The machines can produce at higher rates of output, the use of automation results in a lower cost per unit of product.

Safety

By automating the operation and transferring the operator from an active participation to a supervisory role, work is made safer.

Higher Cost of Raw Material

The cost of raw material in manufacturing results in the need for greater efficiency in using these materials. The reduction of scrap is one of the benefits of automation.

Reduce Manufacturing Lead Time

Automation allows the manufacture to reduce the time between customer order and product delivery. This gives the manufacture .this gives the manufacture competitive advantage in promoting good consumer service.

Reduction in Process Inventory

Holding large inventories of work in process represents a significant cost to the manufacture because it is ties up capital. In-process inventory is of on value. It is servers none of the purposes of raw material stock for finished product inventory. Accordingly, it is to manufacturer's advantage to reduce work in-progress to a minimum. Automation trends to accomplish this goal by reducing the time a work part spends in the factory.

High Cost not Automating

A significant competitive advantage is gained by automating a manufacturing plant. The advantage cannot easily be demonstrated on a company's product authorization form. The benefits of automation often show.

## 2.9 AUTOMATION STRATEGIES:

There are a certain fundamental strategies that can be employed to improve productivity in manufacturing operations. Since these strategies are often implemented by means of automation technology, we refer to them as automation strategies. Each strategy is discussed in the following list.

Specialization of Operation:

The first strategy involves the use of the special purpose equipment designed to perform one operation with the greatest possible efficiency. This is analogous to the concept of labor specialization which can be employed to labor productivity.

Combination Operation

Production occurs as a sequence of operations. Complex parts mat require dozens, or even hundred, of processing steps. The strategies of combined operations involve reducing the number of distinct production machine or workstation through which the part must be routed. This is accomplished by performing more than one operation at a given machine, thereby reducing the number separate machines needed. Since each machine typically involves a setup. Setup time can be usually saved as a consequence of this strategy. Material handling effort and operation time are also reduced.

Simultaneous Operation

A logical extension of combined operations strategy is to perform at the same time the operations that are combined at one workstation. In effect, two or more processing operation is being performed simultaneously on the same work plant, thus reducing tool processing time.

Increased Flexibility

The strategy attempts to achieve maximum utilization of equipment for the job shop and medium volume situation by using the same equipment for a variety of products. It involves the use of flexible automation concepts. Prime objectives are to reduce the setup time and the programming time for the production machine. This normally translates into lower manufacturing lead time and lower work in process.

Improved Material Handling and Storage

A great opportunity for reducing nonproductive time exists in the use of the automated material handling and storage systems.

On-Line Inspection

Inspection for quality is traditionally performed after process. This means that any poor quality product has already been produced by the time it is inspected. Incorporating inspection into the manufacturing process permits correction to the process as product is being made. This reduces scrap and brings overall quality to product closer to nominal specification intended by the designer.

Process Control and Optimization

This includes wide range of control schemes intend to operate the individual process and associated equipment more efficiently. By this strategy, the individual process times can be reduced and product quality improved.

Plant Operation Control

Where as the previous strategy was concerned with the control of the individual manufacturing process. This strategy is concerned with control at the plant level. If attempts to manage and coordinate the aggregate operations in the plant more efficiently. Its implementation usually involves a high level of computer net working with in the factory.

## 2.10 AUTOMATED FLOW LINES

An automated flow line consists of the several machines or workstations, which are linked together by work handling devices that transfers parts between the stations. The transfer of work parts occurs automatically and the workstation carry out their specialized functions automatically. A raw work part enters one end of the line and the processing steps are performed sequentially as the part moves from one station to which are difficult and economical to automate. These various features of mechanized flow lines will be discussed in subsequent sections.

Automated flow lines are generally the most appropriate means of production in case of relatively stale product life, high product demand, which requires high rate of production and where the alternative method of manufacturing would involve a large labor content, the objectives of automated flow lines are:

1. To increase production rates.
2. To reduce labor costs.
3. To reduce work in progress.
4. To minimize distances moved between operations.
5. To achieve specialization of operations.
6. To achieve integration of operations.

There are actually to generally form that the workflow can take. These two configurations are in line and rotary

In Line Type

The in line configuration consists of a sequence of workstations in more or less straight line arrangement. The flow of work can take a few 90 degree turns, either for work piece reorientation, factory layout limitations, or other reasons, and still qualifies as a straight line configuration. A common pattern of workflow of example is rectangular in shape, which would allow the same operator to load the starting work pieces and unload the finished work pieces.

Rotary Type

In the rotary configuration the work parts are indexed around a circular table or dial. The work stations are stationary and usually located around the outside periphery of the dial. This type of equipment often referred to as an indexing machine or dial index machine.

## 2.11 PARTIAL AUTOMATION

There are many examples of flow lines in industry that contain both automated and manually operated workstations. These cases of partially automated production lines occur for two reasons.

First, mechanization of a manually operated flow line is often introduced gradually. Automation of a simpler manual operation is carried out initially and the transition towards a fully automated line is accomplished progressively. A long period of time may elapse before the transformation has been completed.

Second reason for partial automation is based strictly on economics. Some manual operations are difficult to automate and it may be uneconomical to do so. Another problem is that the automatic device can only check the defect for which it was designed, whereas a human operator is capable of sensing a variety of unforeseen imperfections in the part.

## 2.12 FACTORS TO BE CONSIDERED FOR AUTOMATION

In designing an automated system, some of the details to be considered are the following:

1. Size, weight, geometry and materials of the work piece.
2. Size, weight and number of components in an assembly.
3. Tolerance requirements.
4. Type and sequence of operations.
5. Production rate requirements.
6. Type of transfer system.
7. Method of fixturing and locating work piece.
8. Methods of orienting and feeding components in assemblies.
9. Reliability of individual stations and transfer mechanisms.
10. Buffer storage capability.

11. Ease of maintenance.

12. Control features desired.

13. Floor space available.

14. Flexibility of line in terms of possible future changes.

15. Initial cost of the line.

16. Operational and tooling cost of the line.

With the above factors in mind if automate the process it facilitates the usage and its maintenance.

# CHAPTER 3    COIL WINDING

Coil is winded in the spool part of the horn assembly; the various types of the spool part have been discussed earlier. A study has been made in the coil winding types and various new types are found. In addition to this the enamel study has also made and the machines which are used to coat the coil is shown in figures in the corresponding section.

## 3.1TYPES OF COIL WINDING MACHINE

1. Single spindle coil winding
2. Multi spindle coil winding

### 3.1.1 Single Spindle Coil Winding

In this type of coil winding there will be only one spindle for each machine. There will be a control unit for each machine in which the program is loaded according to the type of the horn in current process. There will be specifications on the board to control the winding process.

It is a semi automatic process in which the workers will mount the spool onto the spindle in the shaft and winds the coil through the spool part. The winding is automated by the control unit which also takes care about number of turns to be winded into the spool which varies from horn to horn. The worker has to guide the coil in order to ensure proper winding of the coil into the spool. Otherwise the coil will remove from its order which results in improper winding.

In the American auto service section there are 7 single spindle coil winding machines are in progress. Wounded spools from this section are transported to the enamel removal section done in private contract. The picture is shown in fig- 3.1.

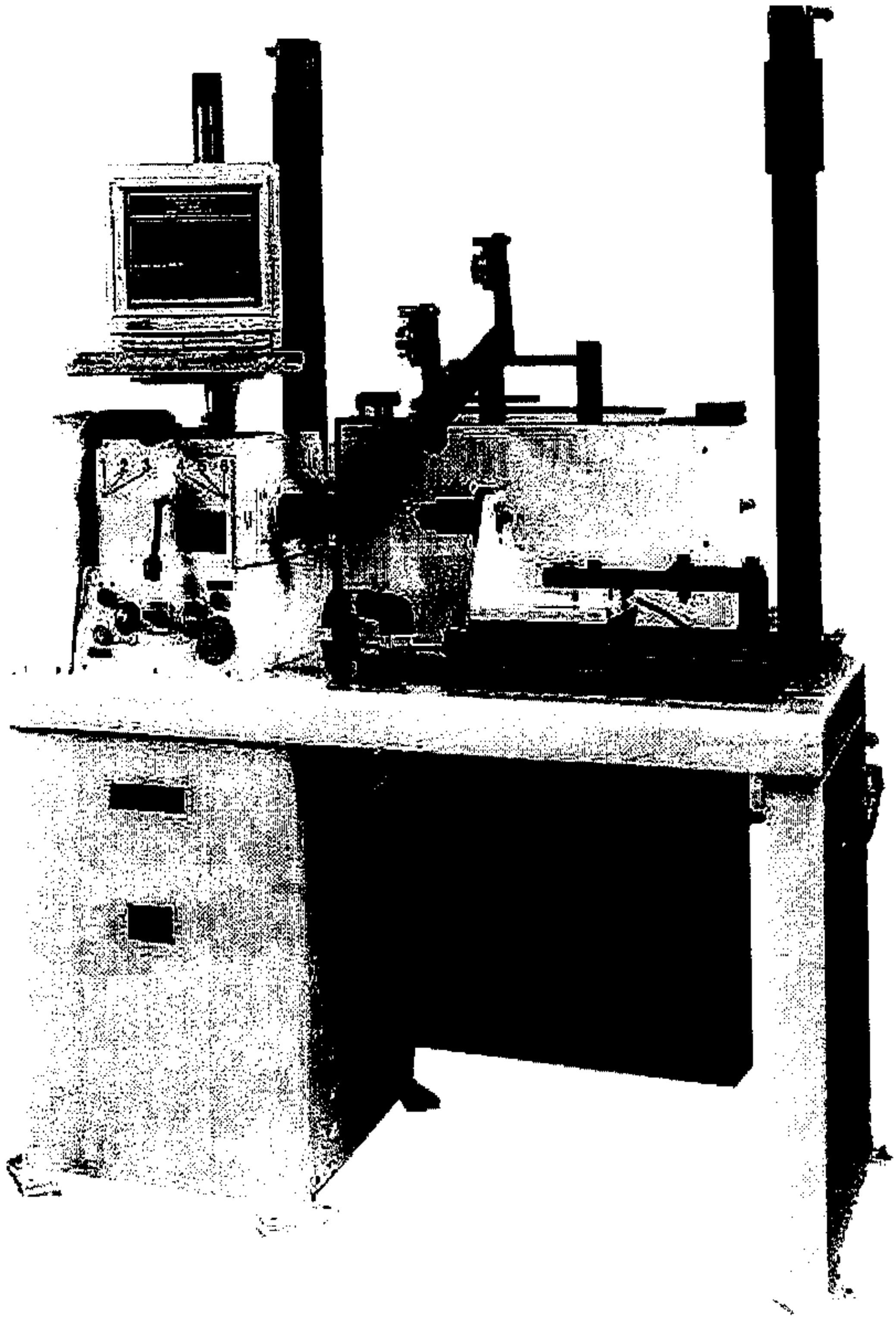

**FIGURE3.1 SINGLE SPINDLE COIL WINDING MACHINE**

## TABLE 3.1 TIME STUDY OF SPOOL ASSEMBLY

| Cycle No | FD 4 | | Roots 90 | | Wind tone | | Spider | | TVS | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Sec | Min | Sec | Min | Sec | Min | Sec | Min | Sec |
| 1. | | 19 | | 20 | | 15 | | 30 | | 20 |
| 2. | | 44 | | 41 | | 36 | 1 | 03 | | 42 |
| 3. | 1 | 06 | | 58 | | 53 | 1 | 35 | 1 | 03 |
| 4. | 1 | 23 | 1 | 19 | 1 | 11 | 2 | 08 | 1 | 24 |
| 5. | 1 | 45 | 1 | 42 | 1 | 29 | 2 | 43 | 1 | 45 |
| 6. | 2 | 04 | 2 | 02 | 1 | 47 | 3 | 17 | 2 | 04 |
| 7. | 2 | 22 | 2 | 24 | 2 | 03 | 3 | 43 | 2 | 24 |
| 8. | 2 | 42 | 2 | 44 | 2 | 20 | 4 | 16 | 2 | 43 |
| 9. | 3 | 00 | 3 | 04 | 2 | 36 | 4 | 51 | 3 | 04 |
| 10 | 3 | 19 | 3 | 25 | 2 | 54 | 5 | 24 | 3 | 24 |
| 11 | 3 | 43 | 3 | 42 | 3 | 13 | 5 | 59 | 3 | 44 |
| 12 | 4 | 03 | 4 | 15 | 3 | 31 | 6 | 28 | 4 | 05 |
| 13 | 4 | 20 | 4 | 39 | 3 | 50 | 6 | 52 | 4 | 28 |
| 14 | 4 | 39 | 5 | 00 | 4 | 08 | 7 | 22 | 4 | 48 |
| 15 | 5 | 03 | 5 | 21 | 4 | 26 | 7 | 53 | 5 | 10 |

### 3.1.2 Multi Spindle Coil Winding Process:

In the multi spindle process there is more than one spindle in function. Each spindle have separate control unit which is feed with the program to do the winding operation. The rate of the spool winded is more than compared to single spindle process, since more spindles will run simultaneously. Fig-3.2.

## 3.2 ENAMEL STUDY:

To enhance the coil life usually the coil will be coated. In all cases the coil winding will be single strand 'enamel' insulated also known as magnet wire. The coating is usually of poly vinyl acetyl, polyester or polyurethane. The last of these is self fluxing during soldering.

It is manufactured to tightly controlled specifications laid down in standards such as BS4520 and NEMA MW*. It can stand temperatures up to 120C or move for long periods.

The types of enamel coating found to be are,

1. Conventional enamel.
2. Self fluxing enamel.

### 3.2.1 Conventional Type Enamel.

This is usually dark brown in color. In a particular environment it is removed by a special rotary stripping machine. For prototype construction thick (70.2mm) wire is stripped with a scalped blade. Rest the wire on a firm flat surface and scrape the blade along at right angles to the wire. Thinner wire is best situated with fine sandpaper or emery cloth although this is very slow. The process can be speeded up by a fine gas jet. This is much easier to sand away. Sand away is removing the enamel coating with the rubbing of the sand paper over the coil to expose the inner surface. But this is a dusty process in evolution and it involves manual work. Fig-3.3 & Fig-3.4

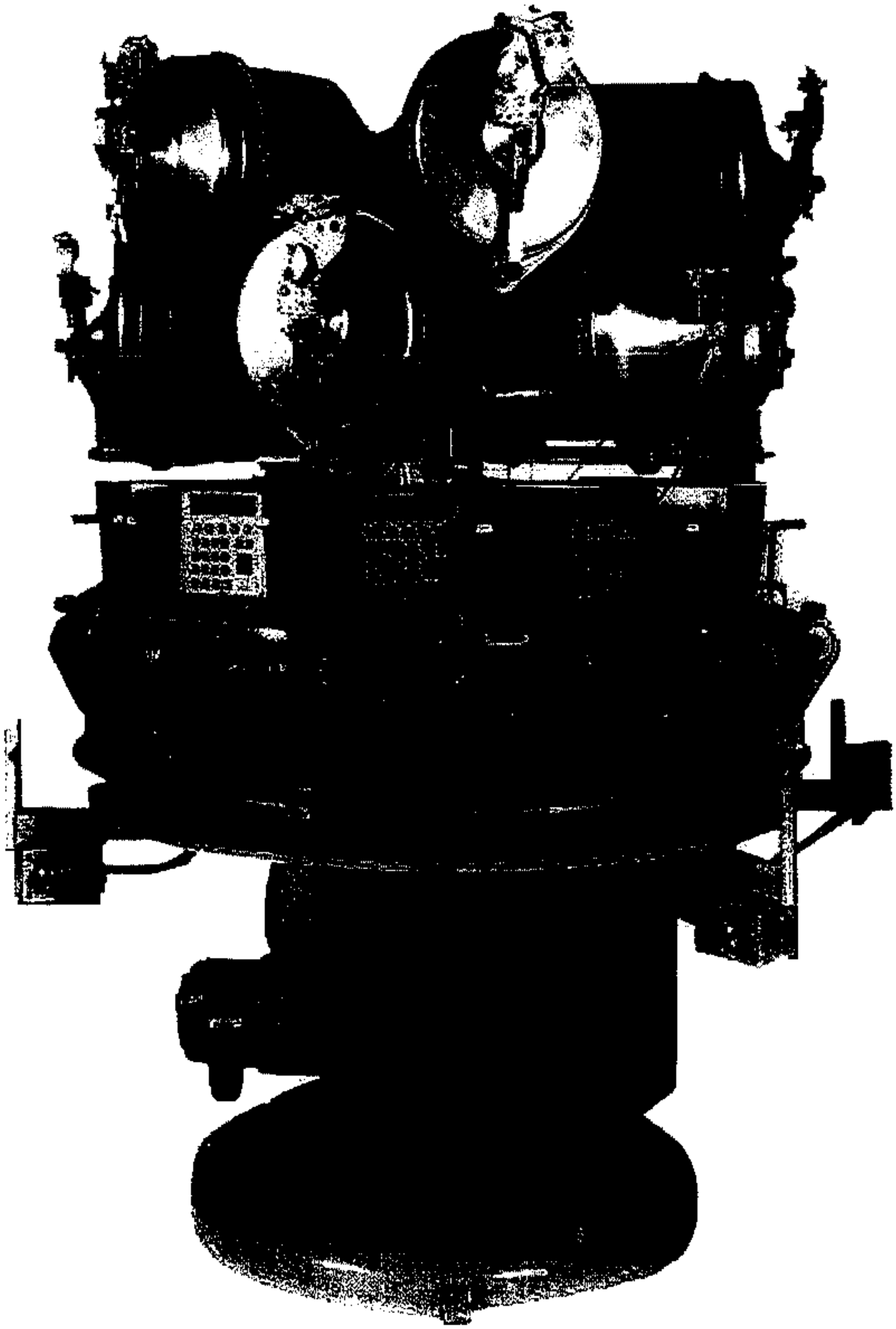

**FIGURE 3.2 MULTI SPINDLE COIL WINDING**

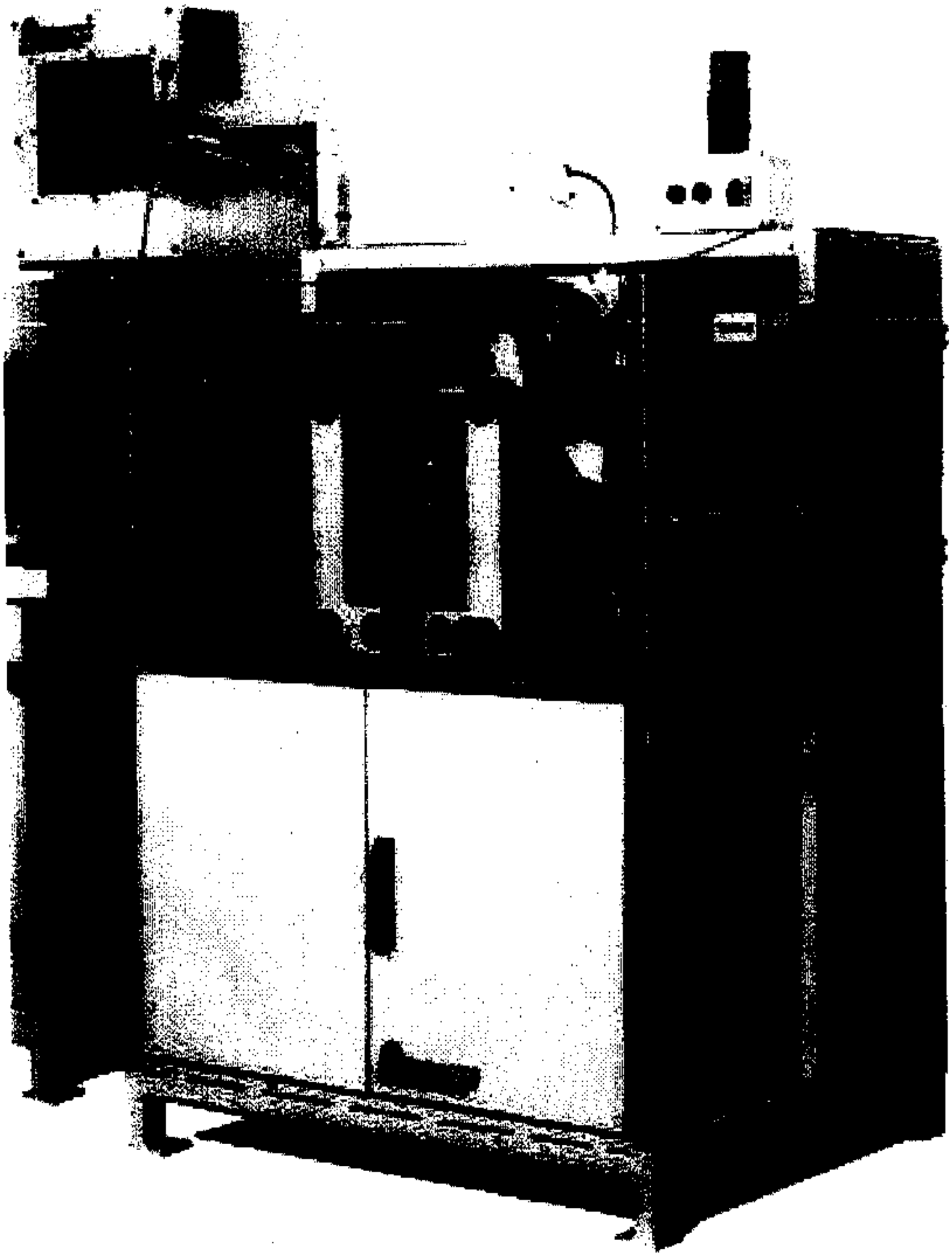

**FIGURE 3.3 ENAMEL TYPE.**

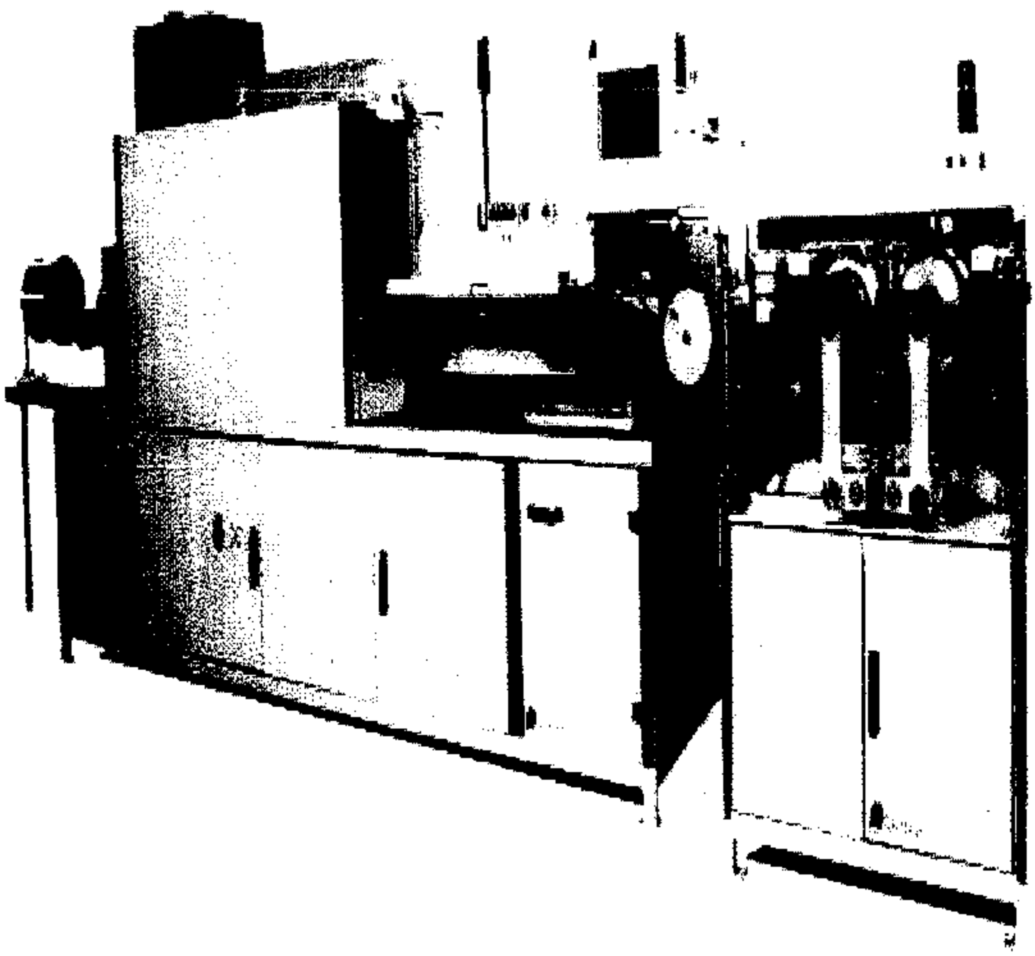

FIGURE 3.4 ENAMEL WITH SELF FLUXING

### 3.2.2 Self fluxing Enamel:

This is usually pink colored. If you have a solder pot then simply dip the end of the wire in for a few seconds. The enamel will melt readily leaving you with a ready tinned end. You can also remove the insulation if you have a soldering iron hot enough to melt it about 400C. Most thermostatically controlled irons can be adjusted to run at this temperature. When this happens the fumes emitted contain a small quantity of toluene di-isocyanide gas which is toxic and irritant.

1. Use an iron fitted with a fume extraction system.
2. Use a desk fan to blow fumes away from your face.
3. Do not work in a confined space.
4. Keep a window open.

## 3.3 STEPPER MOTOR

The coil winding machine will have a stepper motor to control the motion of the spindle when it comes to rest or starts winding. The detailed study of stepper motor is discussed in the following topics.

A stepper motor is an electro mechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates indiscrete step increments when electrical command pulses are applied to it in the proper sequence. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied. Stepper Motor Advantages and Disadvantages

**Advantages**

1. The rotation angle of the motor is proportional to the input pulse.
2. The motor has full torque at stands till(if the windings are energized)
3. Precise positioning and repeatability of movement since good stepper motors have an accuracy of3 – 5% of a step and this error is non cumulative from one step to the next.
4. Excellent response to starting/stopping/reversing.

5. Very reliable since there are no contact brushes in the motor. Therefore the life of the motor is simply dependant on the life of the bearing.
6. The motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.
7. It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.
8. A wide range of rotational speed scan be realized as the speed is proportional to the frequency of the

**Disadvantages**

1. Resonances can occur if not properly controlled.
2. Not easy to operate at extremely high speeds.

### 3.3.1 Open Loop Operation

One of the most significant advantages of a stepper motor is its ability to be accurately controlled in an open loop system. Open loop control means no feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. Your position is known simply by keeping track of the input step pulses.

### 3.3.2 Stepper Motor Types

There are three basic stepper motor types.

They are:

1. Variable-reluctance
2. Permanent-magnet
3. Hybrid

Variable-reluctance (VR)

This type of stepper motor has been around for a long time. It is probably the easiest to understand from a structural point of view. Figure 1shows a cross section of a typical V.R. stepper motor. This type of motor consists of a soft iron multi-toothed rotor and a wound stator. When the stator windings are energized with DC current the poles become magnetized. Rotation occurs when the rotor teeth are attracted to the energized stator poles.

Permanent Magnet (PM)

Often referred to as a "tin can" or" can stock" motor the permanent magnet step motor is a low cost and low resolution type motor with typical step angles of 7.5° to 15°. (48 – 24steps/revolution) PM motors as the name implies have permanent magnets added to the motor structure. The rotor no longer has teeth as with the VR motor. Instead the rotor is magnetized with alternating north and south poles situated in a straight-line parallel to the rotor shaft. These magnetized rotor poles provide an increased magnetic flux intensity and because of this the PM motor exhibits improved torque characteristics when compared with the VR type.

Hybrid (HB)

The hybrid stepper motor is more expensive than the PM stepper motor but provides better performance with respect to step resolution, torque and speed. Typical step angles for the HB stepper motor range from 3.6° to 0.9°(100 – 400 steps per revolution). The hybrid stepper motor combines the best features of both the PM and VR type stepper motors.

The rotor is multi-toothed like the VR motor and contains an axially magnetized concentric magnet around its shaft. The teeth on the rotor provide an even better path which helps guide the magnetic flux to preferred locations in the air gap. This further increases the detent, holding and dynamic torque characteristics of the motor when compared with both the VR and PM types. The two most commonly used types of stepper motors are the permanent magnet and the hybrid types. If designer is not sure which type will best fit his applications requirements he should first evaluate the PM type as it is normally several times less expensive. If not then the hybrid motor maybe the right choice.

There also exist some special stepper motor designs. One is the disc magnet motor. Here the rotor is designed as a disc with rare earth magnets, See fig. 5 . This motor type has some advantages such as very low inertia and a optimized magnetic flow path with no coupling between the two stator windings. These qualities are essential in some applications.

### 3.3.3 Size and Power

In addition to being classified by their step angle stepper motors are also classified according to frame sizes which correspond to the diameter of the body of the motor. For instance aside 11 stepper motor has a body diameter of approximately 1.1 inches. Likewise a size 23 stepper motor has a body diameter of 2.3 inches (58 mm),etc. The body length may however, vary from motor to motor within the same frame size classification. As a general rule the available torque output from a motor of a particular frame size will increase with increased body length. Power levels for IC-driven stepper motors typically range from below a watt for very small motors up to 10 –20 watts for larger motors. The maximum power dissipation level or thermal limits of the motor are seldom clearly stated in the motor manufacturers data. To determine this we must apply the relationship

PÊ =V ´Ê I.

For example, a size 23 step motor maybe rated at 6V and 1A per phase. Therefore, with two phases energized the motor has a rated power dissipation of 12 watts. It is normal practice to rate a stepper motor at the power dissipation level where the motor case rises 65°C above the ambient in still air. Therefore, if the motor can be mounted to a heat sink it is often possible to increase the allowable power dissipation level. This is important as the motor is designed to be and should be used at its maximum power dissipation, to be efficient from a size/output power/cost point of view.

### 3.3.4 When to Use a Stepper Motor

A stepper motor can be a good choice whenever controlled movement required. They can be used to advantage in applications where you need to control oration angle, speed, position and synchronism. Because of the inherent advantages is Ted previously, stepper motors have found their place in many different applications. Some of these include printers, plotters, high end office equipment, hard disk drives, medical equipment, fax machines, automotive and many more.

### 3.3.5 The Rotating Magnetic Field

When a phase winding of a stepper motor is energized with current magnetic flux is developed in the stator. The direction of this flux is determined by the "Right Hand Rule" which states:" If the coil is grasped in the right-hand with the fingers pointing in the direction of the current in the winding (the thumb is extended at a 90° angle to the fingers), then the thumb will point in the direction of the magnetic field." Figure 5 shows the magnetic flux path developed when phase B is energized with winding current in the direction shown.

The rotor then aligns itself so that the flux opposition is minimized. In this case the motor would rotate clockwise so that its south pole aligns with the north pole of the stator B at position 2 and its north pole aligns with the south pole of stator B at position 6. To get the motor to rotate we can now see that we must provide a sequence of energizing the stator windings in such a fashion that provides a rotating magnetic flux field which the rotor follows due to magnetic attraction.

### 3.3.6 Torque Generation

The torque produced by a stepper motor depends on several factors.• The step rate• The drive current in the windings• The drive design or type In a stepper motor a torque is developed when the magnetic fluxes of the rotor and stator are displaced from each other. The stator is made up of a high permeability magnetic material. The presence of this high permeability material causes the magnetic flux to be confined for the most part to the paths defined by the stator structure in the same fashion that currents are confined to the conductors of an electronic circuit. This serves to concentrate the flux at the stator poles. The Torque output produced by the motor is proportional to the intensity of the Magnetic flux generated when the winding is energized. The basic relationship which defines the intensity of the magnetic flux is defined by:

$$H = (N ' i) , l$$

Where:

N = The number of winding turns

i = current

H = Magnetic field intensity

l = Magnetic flux path length

This relationship shows that the magnetic flux intensity and consequently the torque is proportional to the number of winding turns and the current and inversely proportional to the length of the magnetic flux path. From this basic relationship one can see that the same frame size stepper motor could have very different torque output capabilities simply by changing the winding parameters. More detailed information on how the winding parameters affect the output capability of the motor can be founding the application note entitled "Drive Circuit Basics".

**3.3.7 Phases, Poles and Stepping Angles**

Usually stepper motors have two phases, but three- and five-phase motors also exist. A bipolar motor with two phases has one winding/phase and a univocal Motor has one winding, with a center tap per phase. Sometimes the univocal Stepper motor is referred to as a "four phase motor", even though it only has two phases.

Motors that have two separate windings per phase also exist—these can be driven in either bipolar or uni-polar mode. A pole can be defined as one of the regions in a magnetized body where the magnetic flux density is concentrated. Both the rotor and the stator of a step motor have poles. contains a simplified picture of a two-phase stepper motor having 2poles (or 1 pole pairs) for each phase on the stator, and 2 poles (one pole pair) on the rotor. In reality several more poles are added to both the rotor and stator structure in order to increase the number of steps per revolution of the motor, or in other words to provide a smaller basic (full step) stepping angle. The permanent magnet stepper motor contains a equal number of rotor and stator pole pairs. Typically the PM motor has 12pole pairs. The stator has 12 pole pairs per phase. The hybrid type stepper motor has a rotor with teeth.

The rotor is split into two parts, separated by a permanent magnet—making half of the teeth south poles and half north poles. The number of pole pairs is equal to the number of teeth on one of the rotor halves. The stator of a hybrid motor also has teeth to build up higher number of equivalent poles (smaller pole pitch, number of equivalent poles = 360/teeth pitch) compared to the main poles, on which the winding coils are wound.

Usually4 main poles are used for 3.6 hybrids and 8 for 1.8- and 0.9-degree types. It is the relationship between the number of rotor poles and the equivalent stator poles, and the number the number of phases that determines the full-step angle of a stepper motor.

Step angle=360 , (NPh ′ Ph)=360/N

NPh = Number of equivalent poles per

phase = number of rotor poles

Ph = Number of phases

N = Total number of poles for all

phases together If the rotor and stator tooth pitch is unequal, a more-complicated relationship exists.

**3.3.8 Mechanical Parameters, Load, Friction, Inertia**

The performance of a stepper motor system (driver and motor) is also highly dependent on the mechanical parameters of the load. The load is defined as what the motor drives. It is typically frictional, inertial or a combination of the two. Friction is the resistance to motion due to the unevenness of surfaces which rubs together. Friction is constant with velocity.

A minimum torque level is required throughout the step in over to overcome this friction. Increasing a frictional load lowers the top speed, lowers the acceleration and increases the positional error. The converse is true if the frictional load is Lowered Inertia is the resistance to changes in speed.

A high inertial load requires a high inertial starting torque and the same would apply for braking. Increasing an inertial load will increase speed stability, increase the amount of time it takes to reach a desired speed and decrease the maximum self start pulse rate. The converse is again true if the inertia is decreased. The rotor oscillations of a stepper motor will vary with the amount of friction and inertia load. Because of this relationship unwanted rotor oscillations can be reduced by mechanical damping means however it is more often simpler to reduce these unwanted oscillations by electrical damping methods such as switch from full step drive to half step drive.

### 3.3.9 Torque vs Speed Characteristics

The torque vs speed characteristics are the key to selecting the right motor and drive method for a specific application. These characteristics are dependent upon (change with) the motor, excitation mode and type of driver or drive method. A typical" speed – torque curve" is shown infigure9.To get a better understanding of this curve it is useful to define the different aspect of this curve. Holding torque The maximum torque produced by the motor at standstill.

Pull-In Curve

The pull-in curve defines a area referred to as the start stop region. This is the Maximum frequency at which the motor can start/stop instantaneously, with a load applied, without loss of synchronism.

Maximum Start Rate

The maximum starting step frequency with no load applied.

Pull-Out Curve

The pull-out curve defines an are referred to as the slew region. It defines the maximum frequency at which the motor can operate without losing synchronism. Since this region is outside the pull-in area the motor must ramped (accelerated or decelerated) into this region.

Maximum Slew Rate

The maximum operating frequency of the motor with no load applied. The pull-in characteristics vary also depending on the load. The larger the load inertia the smaller is the pull-in area. We can see from the shape of the curve that the step rate affects the torque output capability of stepper motor the decreasing torque output as the speed increases is caused by the fact that at high speeds the inductance of the motor is the dominant circuit element.

The bipolar chopper type drivers which Ericsson Components produces will maximum the speed - torque performance from a given motor. Most motor manufacturers provide this speed - torque curves for their motors. It is important to understand what driver type or drive method the motor manufacturer used in developing their Curves as the torque vs. speed characteristics of an given motor can vary significantly depending on the drive method used.

## 3.4 LOGISTICS VIEWS OF MATERIAL HANDLING IN MODERN FACILITIES

MH was primarily concerned with intra-facility logistics, or internal logistics within an organization. Due to the increasing significance of global logistics, it will be advantageous cover both production and distribution in the discussion, and does no incur any risk of being inconsistent.

Essentially, modern MH has been much influenced by the just-in-time philosophy that relentless attacks all forms of waste. The following "right Xs" elaborates on the definition of MH as a logistics function, and in the spirit of lean and quick response manufacturing.

### 3.4.1 Right amount

"Right amount" highlights the JIT philosophy in minimizing or eliminating in-process inventory in both manufacturing and distribution. Ideally, the supplier delivers the right amount of materials to the customers, or from the upstream process to the downstream process when the materials are really needed, no less and no more. To achieve this, the control of material flow must be accompanied by effective information flow.

For example, Kanban is used for authorizing material transportation and production. Modern MH or WH operations should embody the JIT concept to avoid inventories, which are used, inappropriately, as expensive insurance policies (or as buffer) against unlikely events or disruptions (e.g., upstream station or supplier incapable of delivering materials to the processing station when they are needed).

Alternatively, inventories are used to "bury" problems at the shop floor, e.g. to hide the problem of producing defective items. Apparently, all these malpractices make the company suffer due to the substantial cost incurred. Also, most of these "right Xs" are interrelated, some "right Xs" cannot be achieved without achieving the others. Of these, "right amount" is the most crucial objectives to achieve as it tries to remove the major obstacle to rationalizing a facility to achieve the "right Xs".

Yet, there is a problem associated with "right amount" in a JIT system, which concerns MH in both intra-facility and inter-facility logistics. Under normal circumstances, materials are delivered to a facility in lots by the suppliers, and an appropriate lot size is determined by the production controller for pulling material from suppliers just in time.

However, once the materials arrive, the lot will be disassembled or kitted and forwarded to the storage and fabrication activities in unit loads. Effort must therefore be made to co-ordinate issue quantities with stocking quantities. However, these two types of quantities do not always match. Production lot size determination is always the duty of production controller.

On the other hand, MHS designer is responsible for the load size problem. Load sizes have significant effect on the overall inventory level in the system. Sometimes they are the culprit. The difference in lot size and load size entails manual counting in the storeroom. Human mistakes will inevitably occur. Rather than relying entirely on the discipline of operators, the designer of MHS needs to consider such delicate matters, especially when the materials are expensive.

### 3.4.2 Right material

The "right material" objective addresses the problem of inaccurate picking in warehousing. The advancement of global logistics has put greater demand on good warehouse management systems that implement good part numbering system, labelling, and maintenance of status information, tracking of materials, and picking document system used by the order pickers.

Automatic identification system (e.g., using bar code or radio-frequency tags) will provide an effective support to material handling system to move, store, protect, and control the right material. While situations might exist where automatic identification cannot be justified, the speed, accuracy, and economics of automatic identification available today generally cannot be matched by manual approaches.

Other "process improvement" measures include: simplification of the part numbering system by reducing the number of part numbers by standardizing on parts and removing obsolete parts from the database. Part numbers often convey vast amount of information by using multiple data fields. *Experience shows that part numbers should be designed for people to use even when it is planned to do all part identification automatically. As noted by an order picker at a major catalogue distribution centre, locating "look alikes" together results in a man's medium-sized red knit short being picked instead of a man's large red knit short.

If more order picking systems were designed by people who had performed the function, perhaps we would find that providing the right material would occur quite naturally. (Experiences from front-line people are always a major source of rationalization.)

Finally, it is important to recognize that moving, storing, protecting, and controlling the right materials require a decision as to which material to move, store, protect, and control. (Materials are not created equal.) Infrequently used material of low value does not require the same degree of control as frequently used material of high value.

Similarly, not all material has to be stored, some can be shipped direct to the customer from the manufacturer and bypass the storage racks (cross docking). Appropriate and specific ways must be developed to handle specific materials.

### 3.4.3 Right condition

The primary focus of the "right condition" is about the MH effort in keeping the quality of materials and avoidance of damage. Since the MHS is frequently a major source of product damage (as it involves physical movements), it is imperative that total quality be embedded in the design and performance of the handling system.

"Right condition" also addresses the status of the material, which is presented to the point of use. Such status includes its location, the processing steps that have been performed, its physical characteristics, its availability for shipment, and the need for tests or inspection. This objective, therefore, is an embodiment of the JIT concept.

Processes (such as fabrication or packaging) performed too early may not actually add value to subsequent operations or processes, and should be deferred until there is an actual need to do so. For example, for a common part (with differentiator, say, some minor machining features, or colour) to various products, there is no need to pre-fabricate the differentiator because larger inventory will result. Alternatively, a late demand by customer to change product specification renders such an effort valueless. Therefore, such deferred commitment leaves some desired flexibility, too.

### 3.4.4 Right sequence

"Right sequence" is primarily concerned with handling of materials in following some efficient sequence to reduce cost and backtracking, etc. This does not present any difficulty for conventional system in which a definite material flow pattern exists and is recurrent; nor does this raise any confusion. The benefit of having the right sequence is self-evident. Also, when there is a well-established material flow pattern, some degree of automation may be applied.

However, in the modern context, "right sequence" addresses the discovery of regularity (manifested as sequences) in a flexible or versatile production environment which is characterized demand-based, mass customization, and JIT. Due to such an objective, different (small) jobs with similar processing and MH will be grouped together to follow the same sequence for fabrication. The benefits of being able to exploit such regularities are self-evident as manifested by the reduction of set-up and tool changing between jobs, avoidance of mistakes, reduced inventory, etc.

However, the ways to attaining "right sequence" are not entirely straightforward. Careful planning on the part of the production controller is therefore needed. The capability and motivation of the material handler, or the shop-floor personnel to exploit such opportunities (without violating the scheduling objectives, e.g., due dates) are also important. Also, productivity improvement can occur by combining steps and changing the sequence of steps performed.

The impact of the sequence of activities performed on the efficiency of an operation is very evident in MH. However, sometimes the minds set on "right sequence" will be distracted. For example, scheduling or sequencing of jobs to achieve minimum time span may give rise to a large number of moves between processes, and sizable storage buffers at each process. So, instead of minimizing time, minimizing material handling will yield better result.

### 3.4.5 Right orientation

The importance of "right orientation" is probably best demonstrated in automatic assembly systems, which employs orientation/feeding/transfer devices such as vibratory bowl feeders, escapements, etc. to attain correct orientations of parts for subsequent assembly/fabrication processes. Therefore, "right orientation" means reducing the uncertainty of part location and orientation. This is especially important with automated systems (e.g., flexible manufacturing system, automated assembly systems) that rely on software and sensing or mechanical means to ensure the "right orientation".

Often, such approaches are accompanied by product features designed specifically for attaining "right orientation", e.g., location hole, etc. Apparently, this comes with a cost, and efforts already spent in an earlier process should to retain for latter processes.

Arguments can be made against cases like: Precision machined parts are dumped into tote boxes; subsequently someone sorts out the parts and re-orients them for the next operation. This may be regarded as some kind of waste, although not generally regarded as a serious one in non-automated facilities.

The important point is that processes removed disorder, and disorder should not be re-introduced to the materials for no obvious reason. This is good manufacturing practice, though minor, and should not be overlooked.

**3.4.6 Right place**

"Right place" requires sending materials to the correct locations in storage/warehouse and manufacturing floor. The first issue is much concerned about warehousing operations, and will be discussed in greater details later.

Essentially, the materials entering the facility through the receiving dock have to be differentiated according to their activity levels (fast movers versus slow movers), weights and sizes; and sizes and values (small and valuable items must be handled with maximum security against pilferage). Some rules of thumb have been suggested for storing the various materials.

For example, convenient storage locations should be reserved for fast moving items, and for bulky items (to minimize material handling costs, sometimes a trade-off with popularity). Ways to handle costly items and materials of high susceptibility should also be developed. Also, the facility should embody an effective warehousing system for easy storage and accurate retrieval. (The arguments for and against assigned (dedicated) or randomly (floating) storage locations will be presented later.) Prima facie, "right place" is not so such about JIT as it is about correct location of materials in storage and manufacturing floor.

Also, "right time" implicitly embodies "right place" as "wrong location" renders "right time" meaningless.

However, the achievement of "right place" requires good manufacturing practice and a good MHS. Without a good environment due to the lean production philosophy, materials tend to stack on the floor or placed in "buffers" awaiting further processing. Also, bad manufacturing practice will result in materials being put all over the places in the manufacturing floor, including aisles. MHS, in this connection, is about tracking the materials in storage or in transportation.

Kanban is probably the best known manual method. Automatic identification and tracking system are, however, essential for modern warehousing operations. In determining the right place for material to be stored, it is also important for decisions to be made as to whether central storage or distributed storage is best for a particular application.

Likewise, decisions must be made in manufacturing as to where in the process storage should occur (if at all); in continuous flow manufacturing, raw materials storage is preferred to storage of in-process material, which is preferred to finished goods storage, i.e., upstream, not downstream, is more likely the right place if storage occurs.

### 3.4.7 Right time

"Right time" would be more appropriately put under the domain of production control, with MH effects the physical handling operations to achieve the objectives. Lean production systems employ Kanbans to authorize MH and fabrications and pull materials from upstream processes to downstream processes when the materials are actually demanded by the final customers.

With the global logistics and quick response supply chain, however, a holistic view that treats MH as an important logistics operation should be adopted. In express mail and parcel forwarding companies (e.g., DHL, UPS, etc.), MH with advanced tracking systems has simply become the most significant logistics components to provide added value to customers. For example, many manufacturers now relying on express mail services to order electronics components (which depreciate very rapidly), and the electronics components must arrive on time.

Another aspect of "right time" in MH is due to time-based competition. Quick response manufacturing for leadtime reduction has now become an effective tool for achieving competitiveness.

However, quick response manufacturing depends on a number of factors: (i) rationalization of facility to achieve process orientation or to streamline production, e.g., formation of cell-based systems; (ii) determined effort to compress lead times in all stages of production, and (iii) carefully pull/push materials through production. So, "right time" is indeed a complex issue in inter-facility (or global) and intra-facility logistics. Design of MHS should place increasing emphasis on such a lean or quick response environment.

### 3.4.8 Right cost

Good MH comes with a cost. If it is not performed in the right ways, the cost will be even higher. Good MH practices require good MHS design and careful planning of MH operations. Toyota achieves lean and variety production through huge investment in production and MH facilities. Different sets of dies and tooling can be readily accessed by workers for fabricating different models of car.

Behind the scene, a group of planners resolves problems arising from the execution of production plans. In the example of printer manufacturer, human MH workers are employed, not just for physical handling, but also for ensuring proper information flow (collection and placement of Kanbans); foolproof procedures are devised to ensure individual customers' orders are fulfilled and products produced genuinely fulfilled customers' requirements.

All these point to the fact that MH is a critical element for enhancing a company's internal competitiveness. Maximizing the value provided to the shareholders does not imply minimum cost of MH.

MHS can be a revenue enhancer, rather than just a cost contributor; The important issue is that good MH enhances the competitive advantage of a company. Today, firms compete on the basis of product functionality, product quality, service quality, time, and cost. To do so, the MHS must be both effective (does the right things) and efficient (does things right). The next question concerns the determination of MH costs to justify the investments and operating costs.

The cost components include investments in MH devices and containers (degradable, perishable), IT/IS and production control (MH is regarded as a component of manufacturing execution system a computerized production management system); and operating costs include staff, consumables (bar code, materials for unitizing loads), among others.

Also, as MH is accident prone (MH contributes to 50% of industrial accidents), medical and insurance provisions, and on offering MH staff sufficient awareness on occupational health and safety. Good MH will reduce significantly some of the costs that used to be spent on inventories, space, inspectors, expediters, material losses due to damage and pilferage.

However, perhaps the most significant monetary impact of the system will be on the revenue side of the equation, because of the increased market share that will result from doing the right things right with the material handling system. To accurately identify and determine MH and related costs is beyond the scope of this discussion.

Accounting system should be designed to accurately capture the systems costs associated with MH devices (e.g., depreciation charges on the forklift truck fleet), labour, and other tangible or less tangible cost items. In sum, minimizing material handling costs is the wrong objective.

The right objective is maximizing overall shareholder value. For that reason, increased investments in handling technology might be needed. The bottom line for material handling: the right cost is not necessarily the lowest cost.

### 3.4.9 Right methods

Basically, MH can be accomplished in different ways as long as they are feasible. No facility will be able to sustain business with continuing materials mishandling resulting in continuing parts damage, customers' complaints, etc. However, MH should aim at finding the right methods that supports the overall optimum MH strategy.

In finding the MH method(s), the usual mistake committed is, on the part of the MHS designer, due to jumping to a "solution" flippantly without going through a fundamental approach that starts from the requirements of the MHS. Such "solutions" are usually common practices adopted by competitors, or assembled from knowledge about MH equipment or technologies.

However, MH best practices these solutions might be, they could not be directly transplanted to another facility without identifying the actual requirements of the facility. There are subtle differences.

A right method is not necessarily the most sophisticated method, nor the newest method, nor the least expensive method.

Simply stating, a method is right if it satisfies the requirements of providing the right amount of materials, in the right sequence, in the right orientation, at the right place, at the right time, and at the right cost. Clearly, MH is much more than simple handling material.

As described, material handling is an art and a science. It involves the movement, storage, control, and protection of material, with the objective of providing time and place utility.

# CHAPTER 4 PNEUMATICS

## 4.1 INTRODUCTION

In modern industries, pneumatic systems are used as a means of work place mechanization and automation where a major part of manual and tedious work may be supplemented by pneumatic controls for quick and economic production. Figure shows a simple bending device being pneumatically operated. The average investment in this field may be too high as the system components are not very costly and automation could be effected in stages too.

## 4.2 BASIC ELEMENTS IN A PNEUMATIC SYSTEM

The basic system requirements for introducing pneumatics in ones plant are listed below:

Compressor Plant

The production plant using pneumatic tools, etc.. should be equipped with the compressed air plant of appropriate capacity to meet the compressed air need of the systems.

Pipeline

A well-laid compressed air pipeline should be drawn from the compressor plant to the consumption point of pneumatic arrangement in various sections of the plant where the pneumatic gadgets and systems are to be introduced.

Control Valve

Various types of control valves are used to regulate, control, monitor the air energy, for control of direction, pressure, flow, etc.

Air Actuator

Various types of air cylinders or air motors are used to perform the usual work for which the pneumatic system is designed like using cylinders for linear movement of jigs, fixtures, raw material feeding, etc.

Auxiliary Appliances

Various types of auxiliary equipments may have to be used in pneumatic systems for effecting better performance, easy controllability and higher reliability.

## 4.3 TYPES OF AIR COMPRESSORS

There are two basic types of compressors (1) Positive displacement and (2) Turbo compressor. Their main distinction lies in their method of energy transfer and pressure generation.

### 4.3.1 Positive Displacement Compressors

Work on the principle of increasing the pressure of a definite volume of air by reducing that volume in an enclosed chamber.

### 4.3.2 Dynamic (Turbo) Compressors

Employ rotating vanes or impellers to impart velocity and pressure to the flow of air being handled. The pressure comes from the dynamic effects such as centrifugal force. Positive displacement compressors are sub-divided into two groups. Reciprocating type and rotary type of compressors.

## 4.4 COMPRESSOR CLASSIFICATIONS

There are many geometrical and operational features of air compressor resulting in various types of compressor classification. Depending on the various features, classification can be done in number of ways:

1. As a single or double acting compressor, by no of stage of compressor, eg. Single, two or three or multiple stages.
2. As per disposition of cylinders related to crankshaft (cylinders in vertical, inline, horizontal, radial, vee positions.etc
3. By compressor drive or prime mover such as diesel engine driven, electrical motor drove gas/turbine drive.
4. By condition of compressed air, viz lubricating oil, contaminated air, or oil air free..

5. By mounting and portability conditions,viz portable compressor, stationary compressor or skid mounted compressor.
6. By cooling medium applied,viz air cooled, water cooled, liquid injected compressor,etc.

Air compressors air invariably specified in terms of their capacity to deliver free air and pressure of the compressed air at the final discharge point. At this point it would be relevant to define single acting and double acting compressor.

#### 4.4.1 Single Acting type

Compression takes place in the space on one side of the piston with one compression stroke per stage for each revolutions of the crank shaft.

#### 4.4.2 Double Acting type

Here the compression takes place on both the faces of the piston giving two compression strokes for each rotation of the crank and the crankshaft. Here with this type of arrangement, individual cylinders could be used as a multi stage compressor of the compressed air from one side is fed to the other side of the piston. The figure shows a schematic view of the double acting cylinder.

## 4.5 FRL UNIT

The air that is sucked by the air compressor is evidently not clean because of presence of various types of contaminants in the atmosphere. Moreover the air that is supplied to the system from compressor is further contaminated by the virtue of generation of contaminants downstream. It is also a fact that the pressure of the air does seldom remain stable due to possibility of line fluctuations. Hence to enable supply of clean, pure and contamination free compressed air, the air requires to be filtered. The system performance and accuracy depends on the pressure stability of the air supply. An airline filter and a pressure regulator therefore, find an important place in the pneumatic systems along with the third component-airline lubricator .The main functions of the lubricator is to provide the air with lubricating oil or a film. These three units together are called service unit or FRL unit.

Hence the three main units of the FRL unit are:

1. Air filter
2. Pressure regulator
3. Lubricator.

### 4.5.1 Air Filter

The air filters are used in pneumatic system to perform the following main functions:

1. To prevent entrance of solid contaminants to the system.
2. To condense and remove the water vapour that is present in the air passing through it.
3. To arrest any sub micron particles that may pose a problem in the system components.

### 4.5.2 Pressure Regulator

The main function of this valve is to regulate the pressure of the system so that the desired air pressure is flowing at a steady condition.

### 4.5.3 Lubricator

In most pneumatic systems that compressed air is first filtered and then regulated to the specific pressure. Then it passes through a lubricator in order to form a mist of oil and air from the sole purpose of providing lubrications to the mating components of valves, cylinders etc.. To form the mist a lubricator unit is used.

As already mentioned, the three units are termed as FRL unit or service unit. These are commonly fitted to each and every pneumatic workstations. In certain cases, the filter and the regulator form a single unit referred to as combination filter regulator. After it is determined whether it is fog or mist type lubrication is best suited for the application, lubricators are selected according to the pipe size. For critical applications minimum and maximum flow rates and the pressure requirements should be considered before one selects the lubricator.

## 4.6 TYPES OF CYLINDERS

The pneumatic power is converted to straight line reciprocating motion by pneumatic cylinders. The various industrial applications for which air cylinders are used can be divided duty wise into three groups- Light duty, Medium duty and heavy duty. But according to the operating principle, air cylinders are subdivided as single acting and double acting cylinders.

Single Acting Cylinder:

With single-acting cylinders compressed air is applied on only one side of the piston face. The other side is open to atmosphere. The cylinder can produce work in only one direction. The return movement of the piston is effected by a built-in spring or by the application of an external force. The spring force of the built-in spring is designed to return the piston to its starting position with a reasonably high speed under no load conditions.

The construction and simplicity of operation of the single-acting cylinder makes it particular suitable for compact, short stroke length. The single-acting cylinder has a single piston seal which is fitted on the supply side. Sealing is by a flexible material that is embedded in a metal piston. During motion, the sealing edges slide over the cylinder bearing surface.

Double Acting Cylinder:

The force exerted by the compressed air moves the piston in two directions in a double acting cylinder. They are used particularly when the piston is required to perform work not only on the advanced movement but also on the return. In principle, the stroke length is unlimited, although buckling and ending must be selected before we select a particular size of piston diameter, rod length and stroke length.

## 4.7 MATERIALS FOR PNEUMATIC ACTUATORS

The important parts of pneumatic cylinders have been discussed. Various types of materials are needed to construct a cylinder. The main parts which may need special mention are cylinder body, end covers, piston and piston rod, seals, etc. materials selection of the pneumatic cylinder is most important. The most common materials that are used for cylinder parts are given below.

Cylinder barrel or tubes:

Generally hard drawn seamless aluminum, brass, steel are used. For low pressure applications nylon or plastic may also be used. For high pressure or heavy duty application seamless steel tubes are mostly used.

Piston:

The universal choice is castings of aluminum, bronze, etc. cast iron is also widely used.

Piston rod:

As it is highly stressed part, the piston rod is made up of grounded polished, or chrome plated medium carbon steel. The rod is hardened to ensure its strength and provide its scratch free characteristics.

The most common material for cylinder end covers is aluminium, brass, bronze and cast iron.

Mounting brackets:

Aluminium alloy, brass, cast iron, or high tensile castings are most common.

Tie rod:

High tensile steels are a good choice.

## 4.8 CYLINDER SIZE

Normal cylinder sizes are confined within economic cylinder- eg. From 6 mm dia to 250 mm dia for normal line pressures of 5 to 6 bar. Impact cylinders of high energy rate forming and similar applications are made in broze sizes upto 200 mm diameter. The stroke length should be greater than 2000 mm. With the large cylinder diameter and larger stroke, the high consumption makes pneumatics uneconomical due to heavy investment in compressor plant.

With large piston stroke, the mechanical stress on the piston rod, the pilot bearing is too great. To avoid the danger of buckling, a large stroke, the piston rod support length must also be increased.

## 4.9 SENSOR MOUNTED CYLINDERS

In case of automatic sequential control, the position of the piston and the piston rod is very important. This helps the control system to initiate the next sequence of action. Various methods are used to sense the cylinder positioning. Uses of sensors are common for position, direction and signal transmission in pneumatic system. The sensors after sensing the piston position will provide appropriate commands for the next phase of work. The sensors are classified as below:

1. Mechanical or Electro-mechanical sensors
2. Pressure sensors.
3. Electronic sensors.

Roller operated direction control valves and electrical limit switches are widely used for Mechanical or Electro-mechanical sensors. Mostly they are fitted to the machine base or table on the path of the piston rod travel.

Pressure sensors are purely pneumatic sensing elements, which may fitted on the cylinder body. This type of sensor senses the fall in exhaust back perjure at the end of the cylinder travel and transmits signal to the next pneumatic valve in the form of pneumatic, electrical or electronic output.

The other type of sensors, which are used, are electronic sensors with magnetic detection. They are directly mounted on a magnetic cylinder tube. A permanent magnet is embedded in the system. This creates a magnetic field when the piston moves the magnet actuates the electronic system of the sensor provides the desired signal. These electronic position sensors works at 10 to 24 V. The maximum current is around 150mA. The leakage current is around 10mA at 24V and the internal voltage drop is less than 0.5V for 199mA. They are capable of working between 10°C and +60°C.

## 4.10 PNEUMATIC CONTROLS

To control the to and fro motions of a pneumatic cylinder, the air energy has to be regulated, controlled and reversed with the pre-determined sequence in a pneumatic system. Similarly, one may have to control the pressure and the flow rate to generate the desired level of force and speed of actuators. To achieve these functions, valves are used. The valves are fluid power elements used for controlling and regulating the working medium that is the compressed air in the case of a pneumatic system. Broadly valves are used to (1) Start and stop pneumatic energy (2) Control the direction of flow of the compressed air (3) Control the flow rate of the compressed air (4) Control the pressure rating of the compressed air.

These are the various types of valves available in the family of compressed air systems but according to their main functions they may be divided into three broad groups:

1. Direction control valve
2. Direction control check valve
3. Flow control valve.

According to their constructions, valves may be classified into two groups.

1. Seal type
2. Spool type

## 4.11 MODE OF CONTROL

In direct controlled direction controlled valve, the controlling force is directly applied on the working piston or spool. The following control methods used are

1. Electro-magnetic control
2. Pneumatic
3. Mechanical
4. Manual
5. Electro-pneumatic

#### 4.11.1 Electro-Magnetic Control

Electromagnet is very commonly used for actuation of pneumatic valves. It consists of a plunger in 'C' frame structure. The armature presses on the valve spool when the electromagnet is excited. The plunger gets attracted due to magnetic force of the valve. In an AC magnet the ferromagnetic system is composed of stacked iron laminations. Laminations are not needed in case of DC solenoids.

#### 4.11.2 Pneumatic Control

The pneumatic method acts on a spool or piston with a large effective area, which in turn transfers the actuating force to the spool. The pilot control element used in pneumatic actuation is mostly 3/2 or 2/2 direction control valve.

#### 4.11.3 Mechanical Control

Here rollers, springs or similar mechanical elements are used. The roller tappet is pushed in by cam or similar devices and presses the spool. The spool moves and actuates the valve plunger. Roller operated valves are most common examples.

#### 4.11.4 Manual Control

The angular movement of the pedal or lever is transmitted to a tappet from there to the spool. The detents in the lever-operated valves in the individual positions are achieved with the use of balls, which are pressed into angular grooves in the tappet by springs. Push button is operated.

#### 4.11.5 Electro-Pneumatic Control

This is a combination of electric and pneumatic control methods. The 3/2 way valve (pneumatic) is actuated by a solenoid and in turn controls the main direction control valve.

## 4.12 APPLICATION OF PNEUMATICS

The technology of pneumatics deals with the study of the behavior and application of the compressed air. Though the science of air was known to man for centuries, it was not much used till the beginning of the second world war (1939-44).During the war, many industries all over the developed western countries started switching over more and more to automatic equipment. Many of these were operated and retrofitted with pneumatics operated gadgets and accessories for the purpose manufacturing and other activities, to meet the sudden need of the enhanced production of war commodities under the tremendous shortage of technical man power.

This was the age present day concept of automation started provoking man to use compressed air in production plants. Today air operated tools and accessories are a common sight in each and every industry, not only in the technologically advanced countries but even in the countries where industrial activities are still at the age sheer infancy. With the introduction of pneumatics in the manufacturing process, the industry is benefited with a cheaper medium of industrial automation which if judiciously used, may bring down the cost of production to much lower level. A few years ago maximum application of the pneumatics was probably in the field of construction where the main source of power for tools like power hammers, drills, nut runner, riveting hammers etc. was compressed air only. Today the list is endless. Now the compressed air is used in every walk of the life starting with pneumatic cranes, to the use of air in the brake systems of automobiles, railway coaches, railway wagons, printing pressed and what not. In fact today we find that it is extensively used in all fields.

## 4.13 SALIENT FEATURES OF PNEUMATIC SYSTEMS

It is because of the following basic feature that make the application of pneumatics in industries more advantageous and exceptionally suitable in handling. The following features are notable:

1. Wide availability of air
2. Compressibility of air
3. Easy transportation of compressed air in pressure vessels, containers, and in long pipes.

4. Fire proof characteristics of the medium
5. Simple in construction of pneumatic elements and easy handling
6. High degree of compatibility of pressure, force and speed
7. Possibility of easy but reliable remote controlling
8. Easy maintenance
9. Explosion proof characteristics of the medium
10. Comparatively cheaper in cost

Compared to the hydraulic systems, pneumatic systems have operational advantages but it cannot replace hydraulic system so far as power requirements and accuracy of the operations are concerned. In areas of hazards, probably air will be a better medium of power than electrical system, hydraulic system and steam power system. It may not be necessary at this stage to dwell further on the multitude of advantages that may be derived from applying pneumatic energy on production plants and systems except what has been already mentioned earlier.

## 4.14 MAINTENANCE NEED OF THE PNEUMATIC SYSTEMS

In comparison to other types of mechanical systems, pneumatic systems are found to be less problematic and hence offer more trouble free life. However, industrial experience shows even the best of the systems fails and hence to take necessary care against such failures. It is very important that pneumatic system is subjected to regular and adequate preventive maintenance checks and sound foolproof routine inspection should be carried out in order to keep running at their optimum efficiency. From the experiences of various engineers and technicians engaged in maintenance and repairing work in different plans and factories, where a large number of pneumatic attachments, accessories and hand tools are employed in production machines and other systems, it has been seen that a well maintained pneumatic system encounters minimum problems and probably minimizes the downtime to a greater extent with more fruitful work cycles.

While designing a pneumatic system specific care should be taken to make the system simpler and easy to handle. The following guidelines may also help both the designer and service personnel if followed properly:

1. It should be easy to handle, operate, reliable, light in weight and simple.
2. For each system the circuit diagram and the functional diagram must be available.
3. The control elements must be as small as possible.
4. The impulse valves should be guarded against dirt, cooling water and mechanical shocks.
5. Before assembly of each unit care must be taken such that it is free of dust.
6. The imprints on the units and the elements should be easily visible.
7. Use valve openings provided by the manufacturers. No new openings are to be drilled on the elements.
8. All the elements must be given proper identification number from the diagram.
9. The service unit should be easily visible, serviceable and be placed at a higher level.
10. The valve with spools should not be buckled when assembling in the unit.
11. Throttles must be connected as nearer to the air passages.
12. When dismantling and assembling valves and the cylinders takes care of the sealing materials.
13. Silencer should be used as they decrease the noise of the air.
14. Lies should be short, tension free and bend free. Plastic hoses should be also connected that they do not get too bent and they block the air passages.
15. Cut the plastic hoses straight. If they are many bind them together.
16. If hot chips or mechanical shocks are likely to occur on the plastic hose cover the hose by a sheet metal or used plastic pipes.
17. Lines and working units should be numbered according to the circuit and functional diagrams. Connections of plastic hoses to the elements must be screwed properly.

# CHAPTER 5 DESIGN OF AUTOMATIC ENAMEL REMOVAL

## 5.1 EXISTING SYSTEM

The current method of enamel removal is done manually. In the coil winding section, the coil is wounded on to the spool. The operators will cut the coil after its desired turns and they put in the stock box. The number of turns is controlled by the control unit which is pre-programmed based on the type of the horn to be winded. This spool is transported to cottage industries where the enamel is removed by manual process.

In the manual process they grip the coil in to the slot. They require extra length of coil for easy handling which they lock in corresponding groove. They remove the enamel with the knife, by stripping the enamel coating from the coil and they cut off the remaining coil. The method and the type of removing will vary from person to person this leads to various factors.

### 5.1.1 The factors which affect the manufacturing of the horn

1. Improper removal of enamel which won't allow current to pass through. This leads to the rejection of the spool in the assembly section.
2. Varying manual loads will leave depression on the removed surface which will reduce the life of the spool which in turn the horn.
3. Due to over loading there may be a chance of coil breakage during this manual removal process.

### 5.1.2 Defects of existing system:

Wastage of Material

1. Excess amount of coil is left in the spool for easy handling, which is cut down at the end of the removal. About 20mm of the coil is lost due to this cutting for each spool in process.
2. In the assembly section the spool is checked before assembling it into the horn. It will be placed into the circuit section for the passage of current; if the enamel is not properly removed then current won't pass

properly. The whole spool is rejected as a result of this, so the entire coil winded is also waste.

Wastage of Time

The spool has to be transported from the coil winding section to the enamel removal section and vice versa after the completion.

## 5.2 PROPOSED SYSTEM

Our proposal deals with grinding the enamel in the desired portion, which is done with the rotating arm, guiding post, grinding box and with the back up plate.

Initially the grinding wheel will be in the original position. The grinding wheel in the box is made to rotate continuously with the help of a low power motor. A backup plate will be provided in the coil guiding post. The grinding wheel is mounted in the grinding wheel box, which in turn is fixed in the rotating arm. The set up is shown in figure 5. The grinding wheel which is mounted in the rotating arm is free to rotate about 360 degree.

The Length of the rotating arm is designed in such a way that it is equal to the distance between the wheel holding post and the coil guiding post. The purpose is discussed in detail in the following chapters.

To automate the grinding process various mechanisms are discussed and pneumatic cylinder actuation is selected as a suitable process. A slot is provided in the rotating arm. The slot in the rotating arm is for the piston end which will locked in the slot. The pneumatic cylinder actuation moves the rod and it slides over the slot. The position of the cylinder is in such a way that piston rod traces the hypotenuse of a triangle as to ensure the circular path.

Break Turn:

While winding the coil, the spindle will run at a desired speed. When the speed of the spindle is reduced suddenly to halt, it will get damage. To prevent the spindle from sudden stoppage, break turn of about 2 turns is given to the control unit which will reduce the spindle speed at the final turns of the coil. This break turns is increased to 4 turns so that the spindle slows earlier than the current process, and signal from the control unit is given to pneumatic cylinder actuator.

This will bring the grinding wheel into the coil and will remove the enamel. Another concept in this grinding is enamel removal is done for the end coil and as well as for the start of the next coil.

## 5.3 DESCRIPTION AND DESIGN OF PROPOSED SYSTEM

The components which involve in the design of our proposal are,

1. Rotating arm
2. Guide post
3. Grinding box
4. Back-up plate.

### 5.3.1 Rotating Arm

The purpose of the rotating arm is as follows,

1. To hold the grinding wheel with the box.
2. To move the wheel in the circular manner.

The arm is mounted over the guide post. The length of the arm is set to be the length of space between the guiding post and the coil guiding post. A Slot is provided in the rotating arm the purpose of the slot is,

1. To move the grinding wheel in the forward direction.
2. To hold it in position during grinding.
3. To retract it the wheel from the coil.

### 5.3.2 Guide Post

The guide post is bolted and held in the table. Top of the post is of the circular manner and it will help the rotating post to rotate. The guide post serves for two purposes

1. To support the rotating arm.
2. To guide rotating arm in rotation.

It is fixed in-line with the coil guiding post so as to ensure the correct engagement of the wheel with the coil during winding.

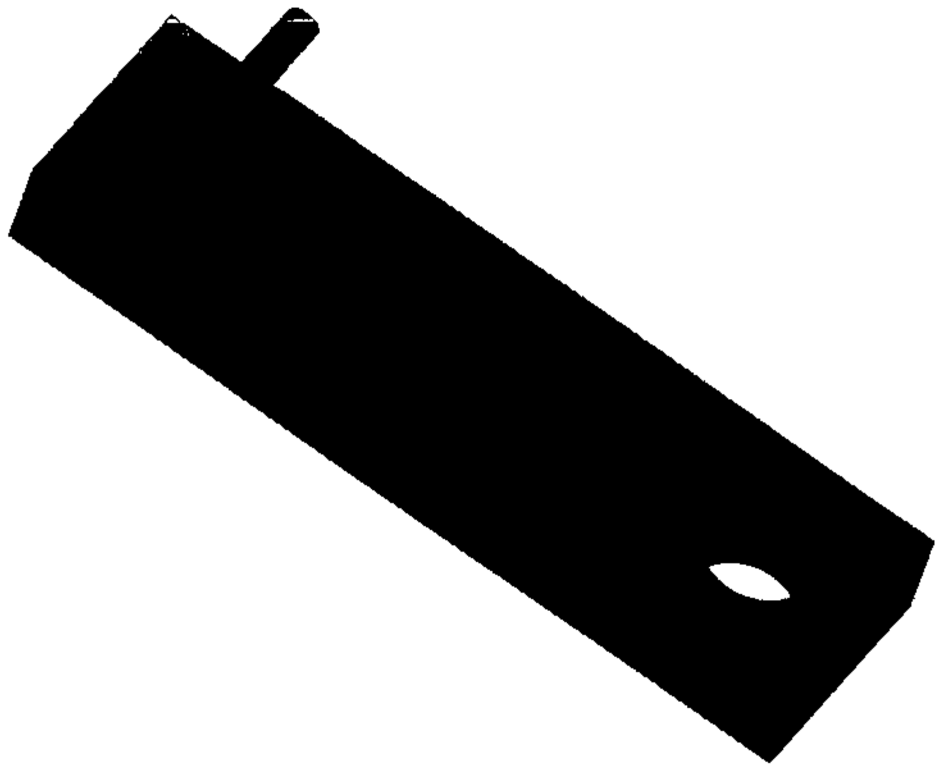

FIGURE 5.1 ROTATING ARM.

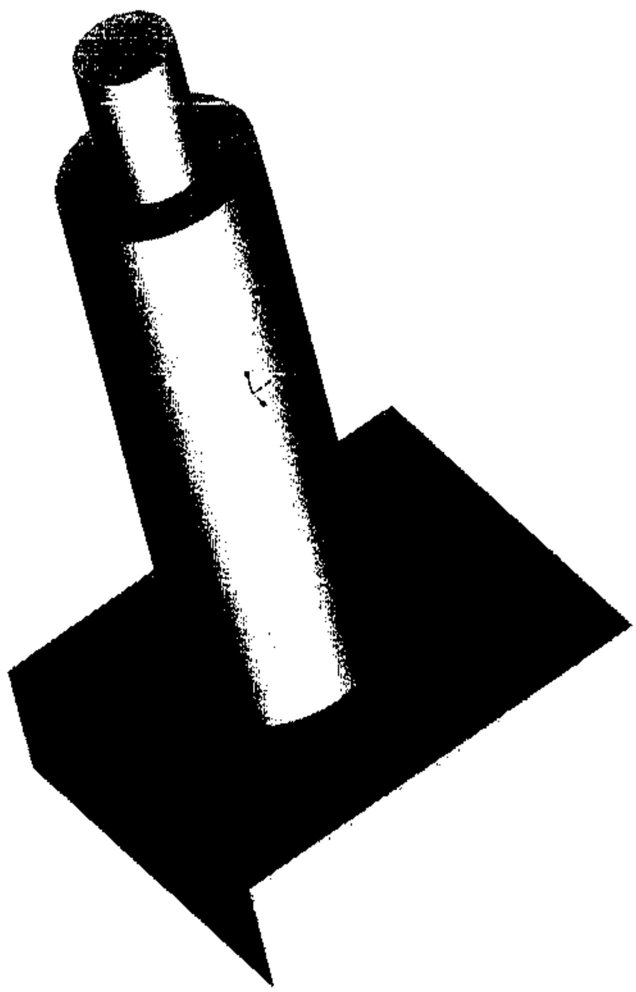

**FIGURE 5.2 GUIDE POST.**

### 5.3.3 Grinding Box

It is mounted in the small projection in the rotating arm. It has the wheel in continuous rotation with the rod provided in the box holding it. Grinding wheel is of suitable diameter chosen accordingly. There will be a slot provided in the box at the top as well as the bottom, the purpose of it is

1. To prevent the slipping of the coil while grinding is in progress.
2. To ensure that no accidents happens.

### 5.3.4 Backup Plate

A rough back up plate is mounted in the guide post at the position where the wheel will grind the coil. The purpose of the backup plate is to

1. Avoid slipping of the coil while grinding is in progress.
2. Grind the back side of the coil while grinding.

The purpose of grinding the back side of the coil is to ensure that coil after winding only the grinded surface is exposed to the contact points. The plate is mounted in a lever like arrangement so that it can be moved in length wise so that new rough surface is exposed. This need not be done often, once when the fresh surface is needed.

The designs of the components are shown in their corresponding section.

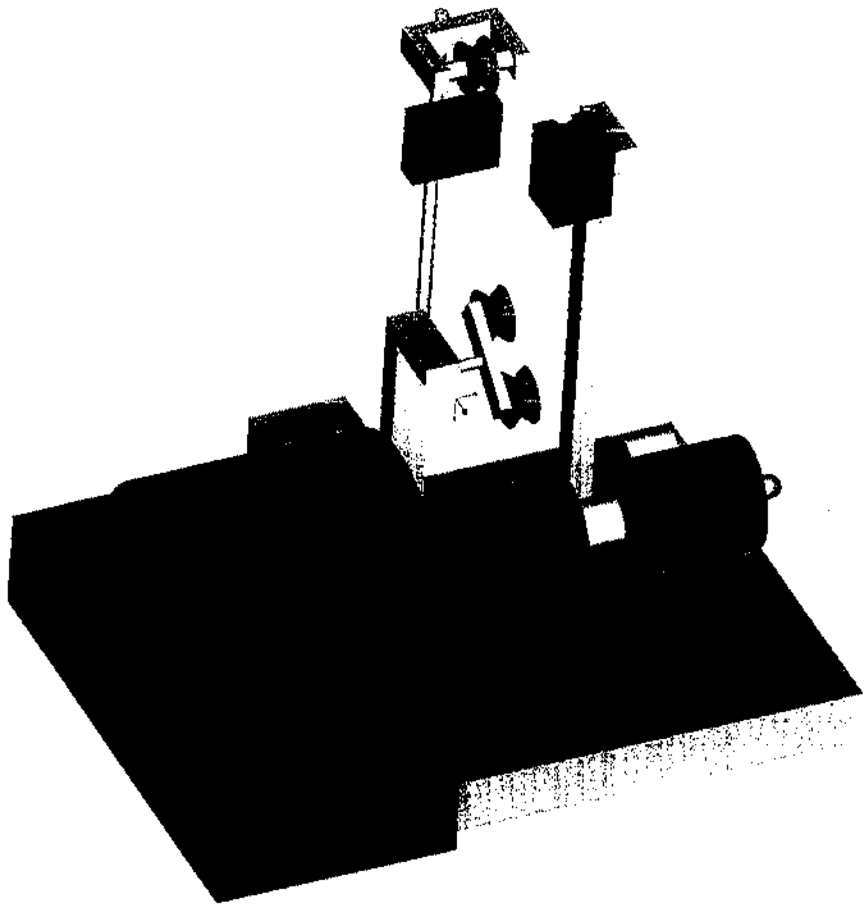

**FIGURE 5.3 MACHINE SET UP WITH THE REMOVER.**

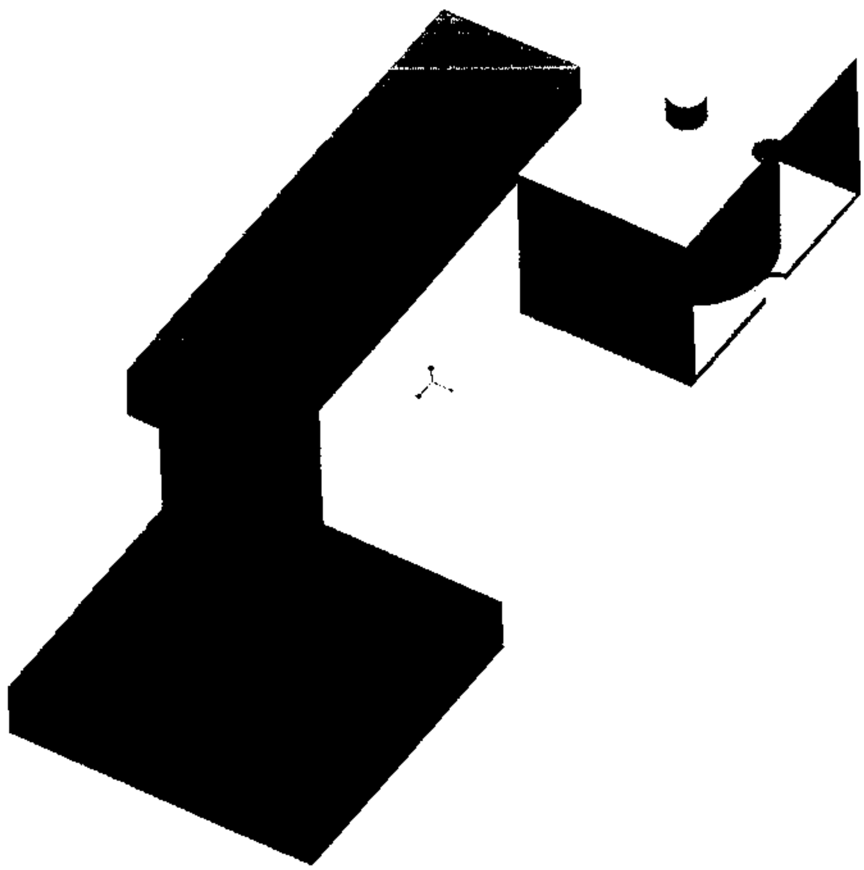

**FIGURE 5.4 ENAMEL REMOVAL ATTACHMENT**

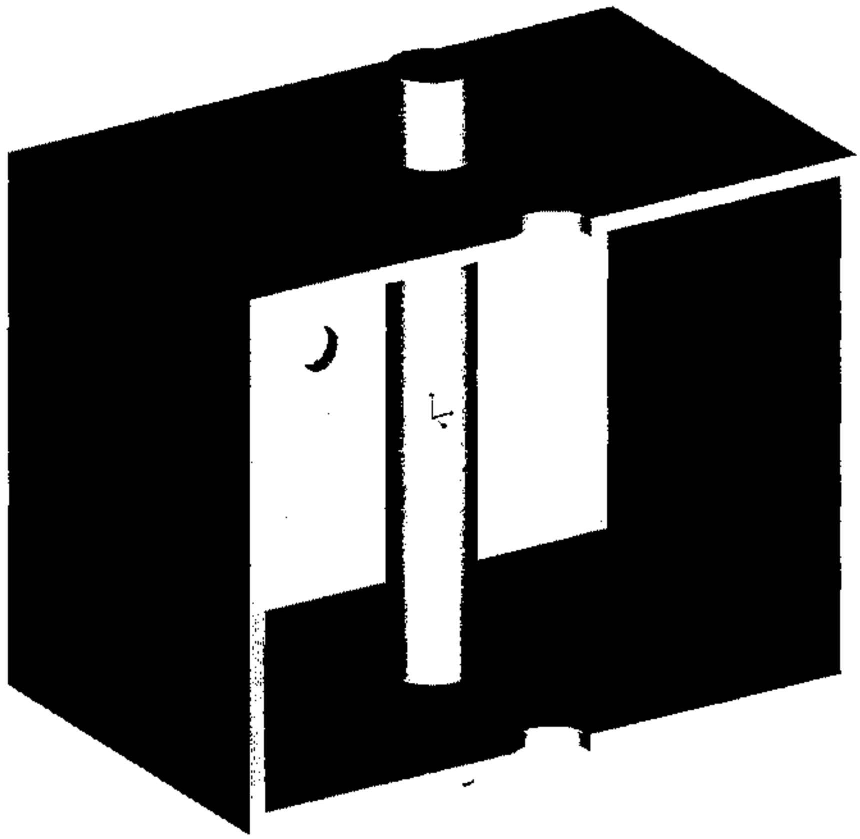

**FIGURE 5.5 GRINDING BOX.**

## 5.4 SELECTION OF THE AUTOMATING PROCESS

In order to automate the rotating arm the process considered are

1. Hydraulic process.
2. Pneumatic process.

### 5.4.1 Hydraulic Process

In this method of actuation fluid storage tank is required, normally oil will be the fluid used. This method ensures great précised movements but the amount of oil has to be constantly stored in the container.

One more problem with this system is that the oil has to be replaced frequently, in order to ensure the proper working of the process.

The system has to as near as possible because if the distance is more then more amount of oil has to be stored, so to avoid this it has to be as near which is a major problem with shortage of space.

The oil which is the source is costlier than what we use in pneumatic. Some of the drawbacks are,

1. Space required is large.
2. Oil is costlier when compared with air.
3. Difficult to maintain and repair
4. Retrieval is not fast enough.
5. Cleaner environment is not possible.

Even though it may provide good vibration damping characteristics the above draw backs will overdue it.

### 5.4.2 Pneumatic Process

In this process air is used as the source for the movement of the piston rod. This method is compact in nature. The various other factors which influence the selection of this process are discussed.

The main aim of choosing pneumatic process to automate the rotating arm is the fast retrieval of the arm after grinding, this is to ensure that time is not wasted by the operator till the arm gets retrieved. The fast retrieval can be achieved by using valves on the flow regions where the volume of flow plays the retrieval rate.

**Advantages of Pneumatic System**

The various advantages of pneumatic process over the hydraulic process are,

1. Air is available in plenty.
2. Compressed air can be stored and transported easily through pipes over long distances.
3. Leads to a cleanlier environment.
4. For small output forces it is cheaper and simple and achieve high working speeds.
5. Simple in construction.
6. Easy to maintain and repair.
7. The used air is exhausted, so no return lines as in hydraulic system.
8. Considering all this benefits we propose pneumatic system for automating the rotating arm with the grinding wheel.

## 5.5 DESIGN AND SELECTION OF PNUEMATIC CIRCUIT COMPONENT

### 5.5.1 Cylinder Selection

The double acting cylinder is chosen since single acting spring return cylinders have very short stroke lengths which are not suitable for our intended purpose. We have to assume a loss factor Lf to compensate for frictional losses, pressure drop. The total estimated load on piston,

F1 = (load due to rotating arm)
+ (load due to grinding box)
+ (load due to guide post)
+ (load due to grinding wheel)
+ (load due to stoppers)
+ (load due to rod coupler)

$= 2.25 + 0.52 + 2.95 + 0.3 + 0.13 + 0.25$

$F1 = 6.4Kgf$

| | | |
|---|---|---|
| D | = | Diameter of cylinder (cm) |
| L | = | Stroke length (cm) |
| P | = | Operating pressure = 5 $Kgf/cm^2$ |
| F1 | = | Total estimated load on piston Kgf |
| Lf | = | Loss factor |
| F | = | F1 x Lf |
| A | = | Cross sectional area of cylinder bore |

We shall have a loss factor,

| | | |
|---|---|---|
| Lf | = | 4 |
| F | = | Total estimated load on piston x 4 |
| | = | 6.4 x 4 |
| | = | 25.6 Kgf |
| | = | 26Kgf |
| we know, force | = | Pressure x area |
| F | = | P x A |
| 26Kgf | = | $5Kgf/cm^2 \times \pi (D)^2 /4$ |
| D | = | 2.6 cm |

From the FESTO catalogue

The next available cylinder size is of bore 32mm. For our application we need to sense the position of the piston when it is at the end of extension stroke.

For this we have to go for cylinder with provision for proximity sensing i.e. a cylinder whose piston contains a permanent magnet whose magnetic field can be sensed from the outside of the cylinder by a reed switch and the signal is sent to the timer.

It is found that a stroke length of 100mm is sufficient for satisfactory operation.

Cylinder specification is: DGS – 32 – 100 – PPV – A

Mountings : Flange type

### 5.5.2 Calculation of Flow Rate

Normally speed range available in cylinder is from 0.5- 2.5 m/sec. attempting to operate at lower or higher speeds can produce difficulties. So we select our optimum value of 1 m/sec

Ql = Flow rate

V = Forward stroke velocity (m/sec)

D = Diameter of cylinder (m)

L = Stroke length (m)

$$Q1 = V \times \pi D^2 L / 4$$

$$= 1 \times \pi (0.032)^2 (0.100) / 4$$

$$= 8.04 \times 10^{-5} \, m^3/sec$$

### 5.5.3 Selection of Proximity Switches and Controls

The DNU series cylinder which we have selected is manufactured for mountings proximity sensors of type SME and SMP mounted using kit type SMBU on profiled barrel.

On approaching a magnetic field the permanent magnet on piston, the proximity switch emits an electrical signal. The electrical connections are cast into the switch. Since the cylinder operates 12 times a minute, we have to go for heat resistant design proximity which is SMEO- 1- B. In order to mount this proximity switch on to the external surface of the cylinder we use a mounting kit (SMBU-1-B) which is a clamp that holds the proximity switch and is clamped on to the cylinder.

#### 5.5.4 Selection of Rod Coupler

If the piston rod is directly connected to moving plates slight misalignment may deform the piston rod which leads to the cylinder being jammed. So we use a rod coupler between the piston rod and the top plate to compensate for manufacturing and alignment in accuracies. The rod coupler has a maximum angular compensation of 2mm.

Since piston rod has M10 x 1.25 thread we have to select a rod coupler having internal threads M10

Make : FESTO
Specification: FK- M10

#### 5.5.5 Selection of Service Unit (FRL UNIT)

The air which enters into the system must be pure in all respects and free from impurities. If the impurities are present, then over a period of time the dirt affects smooth functioning of various parts of a pneumatics system. Also the air must be dry, i.e. the presence of humid air corrodes the components and affects the performance of the system in the long run. In order to overcome these problems we have to use a Filter – Regulator – Lubricator. We know that the only component which consumes maximum air in this system is the double acting cylinder. So we can use a compact FRL unit.

Make : FESTO
Specification: LFR- ¼- D- M

In this unit, filter and regulator are combined into a single unit. The filter with water removes dirt, pipe scale, rust and condensate from compressed air.

It has a 40µm filter [i.e. the smallest size of impurity that can be filtered is 40µm].

This 40µm filter can be easily replaced by 5µm filter element.

The pressure regulating valve holds the working pressure largely constant, irrespective of pressure fluctuations in the supply.

### 5.5.6 Selection of Silencer

Silencers are used to reduce noise at exhaust valve ports. This is achieved by reducing the velocity. The silencer greatly reduces noise of exhaust air with out significantly affecting speed of the piston.

Since the solenoid valve has G 1/8 threads in its exhaust ports we have to select silencer having compatible external threads.

Silencers also improve working conditions due to reduction in noise which may otherwise distract the worker. Considering the type of usage we select a silencer whose specifications is

Make : FESTO

Specification: U -1/8

### 5.5.7 Selection of Pressure Of Regulating Valve

Pressure regulating valve is used to maintain a separate pressure range for the syringes. It is to be noted that if the entire line pressure is transmitted to the syringes, all the adhesive will be forced out through the syringes leading to wastage. In order to avoid this we have to use a pressure regulating valve.

Make : FESTO

Specification : LR – 1/8 – D – M

### 5.5.8 Selection of Flow Control Valves

There are two flow control valves. One flow control valve the flow rate when the syringes are connected to the pressure port and the other flow control valve controls the amount then the adhesive may get sucked into the system due to excess vacuum.

The flow control valves are important in order to control the amount of adhesive being applied and also to reduce wastage.

Make : FESTO

Specification: GR – 1/8 – B

### 5.5.9 Selection of Direction Control Valves

The directional control valve used to control the cylinder which is of double acting type has to be solenoid type because the signal sent by the proximity switch is an electrical signal.

For this purpose we select a 5/2 way solenoid actuated spring return D.C. valve. This valve has one pressure port, two supply port (A and B) and two exhaust port(R and S).

The pressure port P is connected to the air supply from the FRL unit. In the normal position the pressure port is connected to rod end of the cylinder and when the solenoid signal valve receives signal from the timer B, the pressure port is connected to the piston end of the cylinder. The valves remain in this position as long as the timer B is in ON position. When the timer B reverts to OFF position the solenoid is de-energized and it returns to the normal position by spring action the piston retracts.

| | | |
|---|---|---|
| Make | : | FESTO |
| Specification | : | MFH – 5 – 1/8 |
| Representation: | | 5/2 way DCVB |

We need to control the pressure or vacuum that is being given to the syringes. In the normal condition the syringes are connected to the vacuum generator but when the timer is ON the pressure port has to be connected to the syringes. In order to achieve this co-ordination we need 2 D.C valves – one for the vacuum generator circuit and other for pressure circuit. It also has integrated quick exhaust and silencer.

| | | |
|---|---|---|
| Make | : | FESTO |
| Specification | : | MFH – 3- 1/8 – SEU |
| Representation | : | 3/2 way DCV A1, DCV A2 |

### 5.5.10 Selection of Vacuum Generator

There are two very important practical reasons for using vacuum in the system.

1. Vacuum is to prevent the adhesive from flowing out of the syringes when the system is not working. If the vacuum were absent all the adhesives will flow out of the syringes due to gravity.
2. Vacuum also prevents the adhesive from hardening when it comes into contact with air. If vacuum are absent then the adhesives would slowly solidify in due course. We can therefore use a vacuum generator which is a common source of vacuum.

| | | |
|---|---|---|
| Make | : | FESTO |
| Specification | : | VAD – 1/8 |

### 5.5.11 The Control Panel

In order to effectively control the application of adhesive, we need a control panel. The control panel is made of sheet metal. It consists of two parts - the base and the cover. The sheet metal is 1.2mm thick and is made out of CR CA (cold rolled carbon alloy). The base and top are held by means of screws

The front portion of the control panel is drilled in order to accumulate the pressure gauge, the pressure regulator knob and the two flow control valves – one each to control the vacuum circuit and pressure circuit.

The base is drilled to the required diameter and centre distance so that the pneumatic components can be held together by fasteners on to the base are the 3/2 way solenoid activated D.C. valves and the vacuum generator.

The rear portion of the control panel consists of four holes. The first opening carries the supply line into the control panel. The second opening is provided for electrical connections.

The vacuum line and the pressure line emerging from the two D.C valves are taken out from the other two openings and connected to the syringes.

All the components of the pneumatic circuit are connected by means of flexible polyurethane tubing.

## 5. 6 OPERATION SEQUENCE

1. Power supply is given
2. Spindle starts winding.
3. Signal is given to pneumatics actuator at break turn time.
4. Actuator moves the piston in linear motion.
5. The rotating arm moves in the circular direction.
6. Grinding wheel removes enamel.
7. Signal is given to cylinders for retrieval at the end of break turn.
8. Retrieve the rotating arm.
9. Spool is removed.

## 5.7 COMPARISON OF MANUAL PROCESS AND NEW SYSTEM

As stated earlier that our method of enamel removal will increase the rate of production and reduce the material wastage.

In the manual process the extra coil length will be provided for flexibility in usage which will lead to the loss of coil. Around 20mm of coil is wasted which is avoided in the current system.

Another advantage of the current system, is that the improper removal and the unnecessarily depression are avoided which if not leads to the rejection of the entire spool at the assembly section which is checked there for proper current conduction. Wastage of time is also reduced since the spools are not transferred to the enamel removal section and vice versa. The completely finished spool with enamel removed at desired part.

## 5.8 COST ANALYSIS

In the American auto service coil winding section there are about seven single spindle coil winding machines are in function, producing around 14,000 spool assemblies every day. These spools assemblies have to be transported to the enamel removal section where it has to be removed. The cost details involved in it are, the transportation cost, material handling cost, operation cost.

### 5.8.1 Savings in Transportation.

The spool assembly from the coil winding section has to be moved to the enamel removal section. Each day it has to taken to the enamel removal section and ahs to be brought back, which results in the transportation cost. This cost is saved by this project.

| | |
|---|---|
| Fuel and vehicle cost (to & fro) | = Rs 118 / trip |
| No of trips | = 1/day. |
| Total transportation cost/month | = Rs 3540/month. |

### 5.8.2 Savings in Material handling.

In order to transport the spool assemblies safely it has to be packed well. The package cost is avoided by this project since it is not transported.

| | |
|---|---|
| Package cost | = Rs 5/1000 spools. |
| Total package cost/ day | = Rs 70/day. |
| Package cost /month | = Rs 2100/month. |

### 5.8.3 Savings in Operation Cost

In the enamel section the charge for removing enamel per piece is about 10paise, which is completely saved by this project.

| | |
|---|---|
| Removal cost / piece | =10 paise/piece |
| Total cost/day | =Rs 1400/day. |
| Total cost/ month | =Rs 42000/month. |

### 5.8.4 Savings from Wastage

Usually 20 mm of the coil will be left in excess before removing the enamel to facilitate easy handling for the workers. In the removal section it will be cut down after removing the enamel, which is completely a waste for the company. This project saves the wastage which is an asset for the company.

| | |
|---|---|
| Coil wasted /day/spool | = 20 mm |
| Coil wasted / day | = 280 m. |
| Coil wastage per month | =8400 m. |
| Cost of coil | =Rs 300/1000 mm. |
| Cost saved | = Rs 2520 / month. |

Overall Savings/ month = Transportation + Material Handling + Operation cost + Wastage cost.

= 3540 + 2100 + 42000 + 2520

= Rs 50160/ month.

Project cost involving the enamel removal assembly is around 12000 Rs, which we get it back within the course of 15 days.

# CHAPTER 6 CONCLUSION

Automation is a continuous evolutionary that began many decades ago. Industry depends on the automation to increase the productivity. In modifying the coil winding machine we mainly dealt with the enamel removal which was successfully designed and accepted by the company. It removes the enamel without affecting the quality of the coil and leaves no depression on the coil.

The automation of the enamel removal is done by the pneumatic system. The actuation of the system is made by the signal, which is obtained from the control unit.

This method of removal increases the life of the horn and about 20 mm of coil is saved per spool assembly. It also reduces the time wasted during the transportation. Since present manual work is reduced in this project, it is more advantageous than the current method.

It leads to Zero rejection at the next stage and provides 100% mistake proofing system. It improves the quality of the horn and reduces the cost, which is an asset for the company.

For future improvement our method of enamel removal can be adopted to the Multi spindle coil winding machine which increases the overall productivity and then the profit.

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