P-1663

Modelling & Fabrication of Pneumatic Operated Automatic Loader/Unloader

A Project Report

Submitted by

G.Arun Kumar - 71202114007
K.R.D.Navin - 71202114025
T.Yokesh - 71202114060

in partial fulfillment for the award of the degree
of

Bachelor of Engineering
in
Mechanical Engineering

DEPARTMENT OF MECHANICAL ENGINEERING
KUMARAGURU COLLEGE OF TECHNOLOGY
COIMBATORE – 641 006

ANNA UNIVERSITY :: CHENNAI 600 025

APRIL– 2006

ANNA UNIVERSITY :: CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report entitled "**Modelling and Fabrication of Pneumatic Operated Automatic Loader/Unloader**" is the bonafide work of

Mr. G.Arun Kumar	-	Register No. 71202114007
Mr. K.R.D.Navin	-	Register No. 71202114025
Mr. T.Yokesh	-	Register No. 71202114060

Who carried out the project work under my supervision.

Signature of the Head of the Department
Dr.T.P.Mani PhD.
HEAD OF THE DEPARTMENT

Signature of the supervisor
Mr.V.R.Sivakumar M.E.
SUPERVISOR

28/04/06
Internal Examiner

Dr. T.P. Mani
B.E., M.E., Ph.D., DML., MIE, MNIQR, MISTE,
Dean & HoD / Dept. of Mech. Engg.
Kumaraguru College of Technology
Coimbatore - 641 006

External Examiner
28/4/06

DEPARTMENT OF MECHANICAL ENGINEERING
KUMARAGURU COLLEGE OF TECHNOLOGY
COIMBATORE 641 006

Integra Automation Pvt Ltd., Unit - II

Branch Office : 126/2, Sangothipalayam Road, (Opp) G.K.D. ITR, Arasur Village, Coimbatore - 641 407.
Phone : (0422) - 2361223, 2361221, 2361052, Fax : (0422) 2361053, E-mail : admin@integraautomation.net

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the following students,

Mr. K.R.D. NAVIN
Mr. T. YOKESH
Mr. G. ARUN KUMAR

Final year, B.E. Mechanical Engineering of KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE have done a project titled "MODELLING & FABRICATION OF PNEUMATIC OPERATED AUTOMATIC LOADER & UNLOADER" during the period Jan'2006 to Apr'2006. During this period their conduct was Good.

Managing Director
Integra Automation Pvt. Ltd

Date:18.04.2006
Place:Coimbatore

Registered Office : 11, M.T.H. Road, AMBATTUR SIDCO ESTATE, CHENNAI - 600 098.
Phone : (044) 26251303, 26258443, 26254832, Fax : (044) 26259164, E-mail : integra@md4.vsnl.net.in

ABSTRACT

In most of the industries the handling of materials is a very tedious and a sensitive process. Moreover, the loading of very heavy components in the machine and the unloading of them from the machine is a time consuming process.

Keeping this as the core, our project "Modelling and Fabrication of Pneumatic operated Automatic loader/unloader" was done in Integra Automation Private Limited to automate the loading and unloading of a flywheel component in a CNC machine.

Since the flywheel component under mass production in the company weighs 40 kg, it deteriorates the human working efficiency throughout the day for only loading and unloading resulting in reduction in productivity.

This was found by doing a time study for 16 hrs. To overcome the problem, the pneumatic operated automatic loader/unloader was proposed to the company and accepted by them. Along with the engineers in the company, a feasible machine drawing was prepared.

Using the software pro-Engineering (version wildfire), the modelling was done on computer which gave a clear view on how the components of the loader/unloader would be.

The final stage of the project was the fabrication of the equipment. The machine has many components such as pneumatic cylinders, main base, guide mounting brackets, FRL unit, gripper mounting bracket, gripper, cylinder connecting block, adjustment block and mechanical stoppers.

The time reduction in loading and unloading the work piece results in the increase of productivity by 40% by introducing the Pneumatic Operated Loader/Unloader.

ACKNOWLEDGEMENT

We express gratitude from the bottom of our heart to our guide and project coordinator Senior Lecturer **Mr.V.R.Sivakumar M.E.,** for his able guidance and suggestions during all stages of our project.

We are thankful to our Head of Department **Dr.T.P.Mani PhD** for his constructive criticism and constant encouragement.

We are grateful to our respected Principal **Dr.K.K.Padmanabhan PhD**, for his moral support in carrying out this project.

We are truly thankful to **Mr.Sokalingam,** Managing Director, **Integra Automation Private Ltd** for providing us this opportunity to do the project in their organization and for the valuable help and support during the project.

Our thanks must also to be mentioned to the operators and maintenance personnel at Integra Automation Private Limited who helped us during our project.

CONTENTS

LIST OF TABLES

LIST OF FIGURES/PHOTOS

LIST OF ABBREVIATIONS

CNC	Computer Numerical control
MH	Material Handling
MHS	Material Handling System
mm	millimetre
kg	Kilogram
Ltd	Limited
JIT	Just in Time
LM	Linear Motion
Rs	Rupees
ERP	Enterprise Resource Planning
%	Percentage

CHAPTER 1 INTRODUCTION

1.1 COMPANY PROFILE:

Integra Automation Pvt. Ltd. is a company with a goal to become a World Class Engineering Vendor / OE Supplier by focusing on quality, performance and capability, infrastructure and competitive price.

The company has two units, one of which is located at Chennai and the other at Coimbatore. A new unit of the company was under construction at Chennai.

The working unit at Chennai with a factory space of 7000sq. feet. is being operated with an annual turn over of Rs.250 lakhs and the unit at Coimbatore with a factory space of 17000sq.feet is operated with an annual turnover of Rs.650 lakhs. The third unit of the company has a factory space of 6500Sq. feet.

The major domestic customers are

1. Brakes India
2. ILJIN Automotive Private Limited.
3. Hyundai Motors India
4. Ford India Limited
5. Amalgamation valeo clutch Limited
6. Maruthi Udyog Limited.
7. TELCO
8. Ashok Leyland
9. Mahindra & Mahindra
10. Kerela Agro Machinery Corporation
11. ELGI Equipments Limited.

The major overseas customers are

1. Mitsubishi Corporation
2. Rhein Getribe GMBH
3. FMC – Germany thru' Craftsman
4. Ingersoll Rand thru' Craftsman
5. G.E. Transportation Systems thru' LMW.

The quality policy of the company is as follows,

"Integra Automation Private Limited is committed to meet and excel the customer requirements with regards to quality and delivery by adhering to proper systems and procedures and to continually improve the quality management systems"

1.2. BACKGROUND OF THE PROBLEM:

In the company,"Integra automation private ltd.", many types of components are machined. Flywheel covers are one of the components machined in large numbers for Ashok Leyland. The weight of a flywheel component is around 40kg.

When conducted a time study in company, we found that the manual loading and unloading of the components is time consuming and the worker loses his efficiency and develops back problems.

1.3 IMPORTANCE:

The workers are subjected to the above workloads due to heavy weight of the flywheel cover.

This results in

(1) Less profit due to less number of components being machined and

(2) The workers quit the job often due to back problems.

1.4 SCOPE OF THE PROJECT:

The scope of our project is to suggest some ideas and implement the best idea in order to improve the profit by ensuring more number of flywheel components are machined per day and thus resulting in increased productivity.

1.5 SEQUENCE OF THE PROJECT:

The sequence of the project is as follows:

(a) Time study

(b) Suggesting ideas

(c) Choosing the best idea

(d) Modelling the idea

(e) Implementation of the idea.

1.6 LITERATURE SURVEY:

Once we finalized on automating the loading and unloading of the flywheel component we made a study on automation, pneumatics, automation by robots and material handling.

1.7 SUMMARY:

The summary of the project is to improve the profit by reducing the machining time per component by using a pneumatic operated loading/unloading equipment for flywheel component and thereby ensuring more profit through increased productivity.

CHAPTER 2 TIME STUDY FOR FLYWHEEL COMPONENT

2.1 DEFINITION OF TIME STUDY:

Time study is the study of time required for machining a component and thereby finding where the consumption of time is more in order to increase the productivity.

2.2 COMPONENTS OF TIME STUDY:

2.2.1 Loading Time:

Loading time is the time taken to lift the component from the workplace and place it inside the machine.

2.2.2 Machining time:

Machining is the time for which the machine works on the component that is from the time when the tool touches the work to when the tool leaves the component after completion of operation.

The machining time depends on the type and extent of machining required, material being machined, speed, depth of cut, and number of cuts.

2.2.3 Checking Time:

Checking time is the time taken to check whether the component has been machined to the required dimensions using various instruments like screw gauge, vernier calipers etc.

2.2.4 Unloading Time:

Unloading time is the time taken to lift the component from the machine and place it in the workplace for finished components.

2.3 TIME STUDY OF FLYWHEEL COMPONENT:

We conducted a time study for flywheel component for a period of 8 hrs in the company. We noted down the various components of time such as loading time, machining time inside the machine, unloading time, checking time, allowances like personal allowance, fatigue allowance and disposal of scrap.

Then we calculated the average for each component of time and found out the average time required for machine a flywheel component. Using this study we concluded most of the time is wasted in loading and unloading.

The time study is shown in table number 2.1.

2.4. CYCLE TIME REDUCTION FOR GETTING MOST FROM CNC'S:

During any CNC machine's usage, there are really only two activities. Either machines are in setup or they are running production. Setup time is the total time the machine is down between production runs. Cycle time is the time it takes to complete a production run divided by the number of good work pieces produced.

During production runs, machines are supposed to be producing. Yet there may be activities occurring that are not very productive. There are many techniques that will help to keep machines in cycle for as great a percentage of time as possible.

Cycle time reduction will require an investment in time, effort, and/or money. There are two principles of cycle time reduction, including the two tasks types related to running production, the three ways to reduce cycle time, and the four steps to reducing cycle time. Finally, there are countless specific techniques that can be applied to reduce cycle time in the approximate order that production runs are completed.

Details should be known on preparation and organization, workpiece loading, program execution, workpiece unloading, other tasks that are done during every cycle, sizing adjustments, dull tool replacement, and other tasks done during a production run.

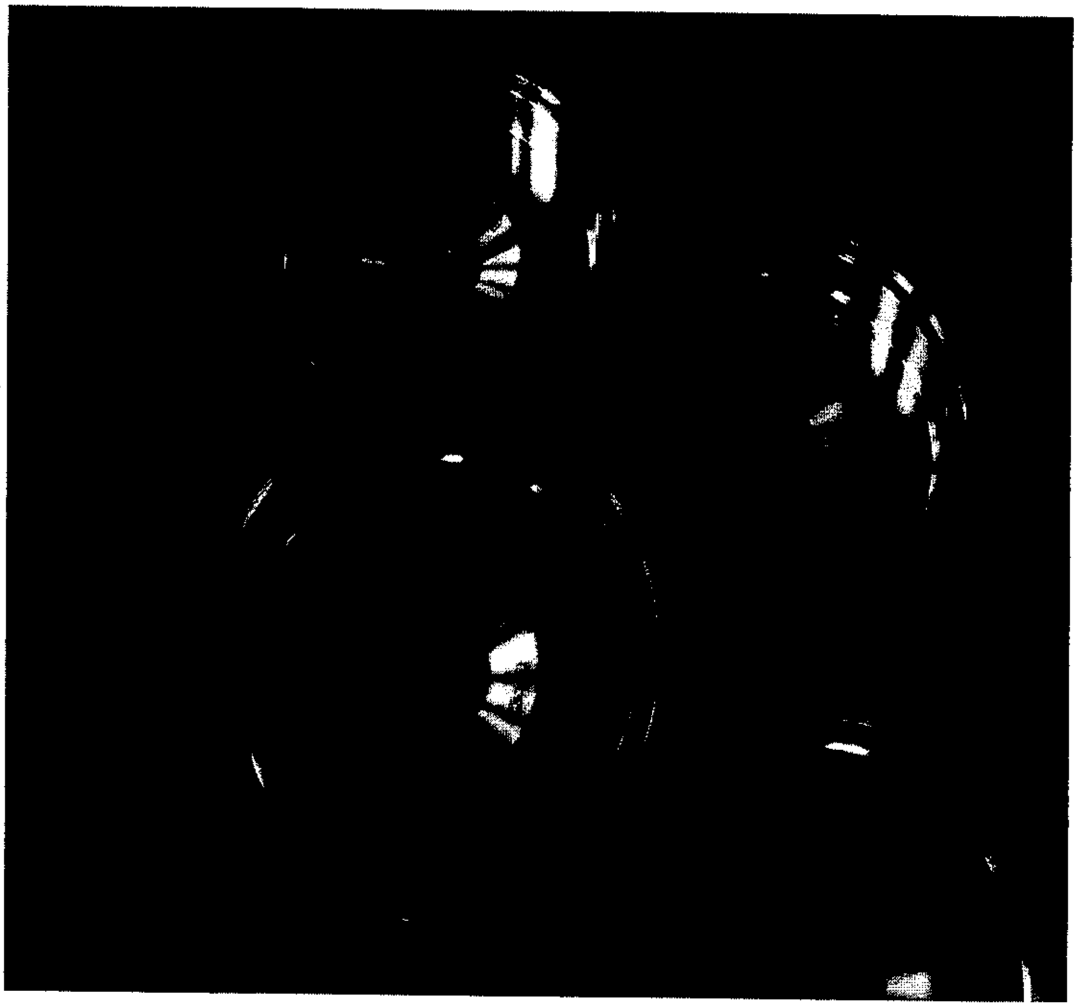

Figure 2.1 Flywheel Components

TABLE 2.1 TIME STUDY FOR FLYWHEEL COMPONENT

Trial No	Loading time(sec)	Machining time(sec)	Checking time(sec)	Unloading time(sec)	Total time for a component(sec)
1	98	240	38	96	472
2	95	240	38	97	470
3	102	240	39	98	479
4	100	239	40	98	477
5	100	241	40	98	479
6	99	238	40	98	475
7	97	240	40	98	475
8	98	240	40	100	478
9	99	240	38	100	477
10	99	240	37	100	476
11	100	240	38	102	480
12	100	240	36	102	478
13	103	240	36	102	481
14	102	240	37	101	480
15	100	240	38	100	478
16	98	240	39	101	478
17	97	239	39	101	476
18	99	240	40	98	477
19	99	240	38	98	475
20	99	240	39	97	475
21	99	240	38	95	472
22	95	240	38	95	468
23	105	240	38	98	481
24	102	240	38	99	479
25	101	240	38	100	479
26	101	240	37	100	478
27	100	240	37	101	478
28	101	240	40	102	483
29	101	240	40	103	484
30	101	240	38	103	482
31	99	240	39	102	480
32	98	240	39	101	478
33	97	240	40	101	478
34	95	240	40	100	475
35	96	240	40	99	475
36	97	240	40	99	476
37	98	239	40	99	476
38	99	239	40	98	476
39	99	240	40	97	476
40	100	240	40	97	477
41	101	240	40	97	478
42	102	240	41	97	480
43	102	241	38	97	478
44	103	240	38	95	476

45	104	239	40	98	481
46	105	240	40	100	485
47	100	240	40	100	480
48	102	240	40	100	482
49	103	240	40	100	483
50	101	240	40	100	481
51	101	240	40	100	481
52	100	240	38	100	478
53	98	240	39	100	477
54	97	240	38	100	475
55	95	242	39	98	474
56	95	240	37	99	471
57	98	240	40	100	478
58	99	240	40	100	479
59	102	240	40	99	481
60	105	242	42	103	492
Average	99.68	239.98	39	99.28	477.95

CHAPTER 3 PNEUMATICS – A STUDY

3.1 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.

3.2 BASIC ELEMENTS IN A PNEUMATIC SYSTEM:

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

3.2.1 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.

3.2.2 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.

3.2.3 Control Valve:

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

3.2.4 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..

3.2.5 Auxillary Appliances:

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

3.3 TYPES OF AIR COMPRESSORS:

There 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.

3.3.1 Positive Displacement Compressor:

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

Positive displacement compressors are sub-divided into two groups. Reciprocating type and rotary type of compressors

3.3.2 Dynamic (Turbo) Compressor:

This type employs 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.

3.4 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 driven, gas/turbine drive.
4. By condition of compressed air, namely 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.

3.4.1 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.

3.4.1 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.

3.5 FRL UNIT:[FILTER-REGULATOR-LUBRICATOR]

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 whose 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.

3.5.1 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.

3.5.2 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.

3.5.3 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.

3.6 PNEUMATIC CYLINDER:

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.

3.6.1 Double Acting Cylinder:

The force exerted by the compressed air moves the piston in two directions in a double acting cylinders. 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.

3.6.2 Material for Pneumatic Actuators:

The important parts of a 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.

(1) Cylinder barrel or tubes:

Generally hard drawn seamless aluminium, 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.

(2) Piston:

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

(3)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.

(4) Mounting brackets:

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

(5) Tie rod:

High tensile steels are a good choice.

3.6.3 Cylinder Size:

Normal cylinder sizes are confined within economic cylinder- eg. From 6 mm diameter to 250 mm diameter for normal line pressures of 5 to 6 bar. Impact cylinders of high energy rate forming and similar applications are made in bronze 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.

3.6.4 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 and 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.

3.7 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

3.8 MODES 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

3.8.1 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.

3.8.2 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.

3.8.3 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.

3.8.4 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.

3.8.5 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.

3.9 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.

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 avery 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.

3.10 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.

3.11 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 4 AUTOMATION

4.1 ROBOTS IN MANUFACTURING:

The term "robot" readily evokes a mental image to most people, whether it be the metal friends of the Star Wars movies or a AIBO1 dog. Industrially, large multi-axis assembly robots are also fairly familiar. We see them regularly on television welding automobiles, or spray painting cars

With just over 800 units sold last year (up from 750 in the previous year) this is still one third down on the record year of 2000 when over 1200 robot units were sold into manufacturing.

Major applications are spot welding and materials handling, and automotive is the sector with the highest usage. What may not be quite so familiar is the success of the smaller bench top or desktop robot in industry.

Since the mid-1990's, when the sales began to take off, tens of thousands of these smaller machines have taken on assembly tasks and brought automation to even quite small manufacturing facilities all over the world. If bench top robots are taken into account in the above statistics, total robot usage might possibly be twice that reported.

4.2 BENCH TOP ROBOTS:

With a footprint not much larger than a piece of A4 paper and a working area of 200 x 200mm, the smallest machines still have all the functionality of their larger brethren. Bigger versions cover 800 x 600mm with a Zaxis of 200mm. They are often self-contained, controlled by internal computers.

Typically, programming is by means of a teach pendant, using simple step-by-step instructions. Program inputs are prompted. Programs are stored on the machine or, optionally, can be kept off the machine on a PC.

Software can be generic, allowing full control of all functionality by the programmer, or function specific (e.g. dispensing), where the software is customized and even more user-friendly. Point-to-point and continuous path motion are selectable. Whilst 2-axis machines are available, 3-axis are the most popular, with full interpolation of lines, arcs and circles through all three axes. A fourth, rotational axis is used for more complex, non-planar jobs.

Positional accuracy is within fractions of millimetres (0.01mm is typical), and movement speeds can reach one meter per second. There are inputs and outputs which allow an interface with external devices (e.g. pick and place pneumatics). They may be driven by servo or stepper motors, with belt or ball screw drives.

With a decade of installed units to reference, this category of machines have shown remarkable reliability. Maintenance is relatively simple, and they are built robustly and fit for shop floor use. They may incorporate self diagnostic procedures in case of malfunctions.

4.3 TYPES OF ROBOTS:

There are three major types of small robot:

4.3.1 Semi-Automatic, Batch type Cartesian Robot:

The work is placed on a moving plate on the bed of the machine, which provides x-axis movement. Overhead, a beam provides y-axis movement for the traveler which gives the z-axis movement.

4.3.2 SCARA Robot:

Invented in Japan in the 1960's, SCARA stands for Selectively Compliant Articulated Robot Arm, or sometimes Selective Compliant Assembly Robot Arm. With joints much like a human arm (shoulder, elbow and wrist axes), it performs pick & place or palletizing functions, and has useful dispensing opportunities. Bench top versions are available only 600 x 300mm in size, but with nearly 500mm reach.

4.3.3 Gantry Robot:

The overhead beam moves back and forth over the work, which is on a fixed base. A z-axis component slides on the gantry.

All types are suitable for semi-automatic batch operation, where the work is manually loaded/unloaded.

The SCARA and Gantry types will also work with automatic feed by, for example, being placed next to or over a conveyor.

4.4 ROBOT FUNCTIONING:

Robots consist of two parts: (a) a positioning system, which locates (b) the functional part, sometimes called an "end effector". It is this end effector which defines the robot function, and this is only limited by the engineer's imagination.

4.5 APPLICATIONS FOR BENCH TOP ROBOTS:

Typical applications for benchtop robots include:

1) Dispensing
2) Soldering, brazing and welding
3) Pick and place
4) Screwdriving
5) Engraving, cutting
6) Testing and calibration

4.5.1 Dispensing

This is one of the most popular applications. Adhesives, sealants, coatings, inks, paints, greases, oils, solder pastes and the like are accurately metered and positioned on the work.

The materials are either dispensed from barrels or cartridges mounted on the machine z-axis, or remotely located and fed through a robot mounted valve which controls the flow. Beads, coatings or micro-dots are common. Metering and mixing equipment can be interfaced to the robot to dispense two part systems like adhesives, encapsulants or potting compounds.

One very popular application is the dispensing of form-in-place (FIP) gaskets. A bead of adhesive is dispensed on the part, which is then cured to form a soft, sealing gasket. FIP gaskets offer some advantages over pre-cut gaskets: easier automated application, permanently positioned, much lower inventory and tooling costs and design flexibility.

However, it is difficult to dispense a FIP gasket manually. The bead needs to be the same diameter over its entire length, and to achieve this, the dispense needle travel speed must match the FIP gasket flow rate, even around corners or over a three dimensional surface. A robot can be programmed to do this, whereas a human would find it impossible.

4.5.2 Test & Calibration

Benchtop robots have been used in many test and calibration applications. A camera is sequentially positioned by the robot over each of a number of small parts, arranged in an array. At each part, the image is examined by a computer, which can detect a pass or fail state.

Reject parts can be identified, marked or even removed whilst on the robot. Alternatively, probes can be accurately positioned to measure electrical or thermal characteristics in a testing procedure.

One application used a benchtop robot to calibrate a thermostat, which was eventually to find its way into a fishtank water heater. The robot was interfaced to electrical testing equipment. The robot positioned a screwdriver onto a calibration screw on the thermostat, and turned the screw until the appropriate electrical output was detected by the testing equipment. The robot can be programmed to perform a task until it receives a signal through one of its I/O ports, and the proceed to the next task.

4.6 ADVANTAGES:

Whilst there are instances where the decision making capability of a person is needed, robots often take over a repetitive job from a human.

They do not mind if the job is boring or unpleasant. Justifications for using a robot include:

4.6.1 Quality:

Robots are more consistent and accurate than a human. They do not get distracted nor interrupted. Product integrity is enhanced.

4.6.2 Production Yield:

More often than not, reject rates go down when an automated process is installed.

4.6.3 Throughput:

Robots do not take tea breaks or holidays. They can be much faster than humans.

4.6.4 Necessity:

Sometimes the job just cannot be accomplished by a human (c.f. FIP gaskets).

4.6.5 Material Savings:

Due to more control and uninterrupted operation, there can be significant economic savings in material usage. Expensive materials like silver loaded conductive epoxies are dispensed accurately and without error or waste.

Systems which require mixing (e.g. two part potting compounds) may need purging or changes of mixing nozzles unless dispensed all day without interruption.

4.7 USAGE OF BENCHTOP ROBOTS:

Like the larger robots seen on television, automotive applications are popular for benchtop robots; they are often found in tier two or tier three manufacturers, making car subassemblies like radios, loudspeakers or fascia parts.

They have found many additional uses in all types of technology assembly companies making products like electronic components, optoelectronics, fibre optics and medical devices.

A myriad of simple tasks can benefit from the automation, such as the dome coating of small labels and badges.

Besides size, what differentiates the benchtop robot from their bigger compatriots. They are simpler, although they retain a high level of functionality. Software is user-friendly, and there is no need to understand complicated robot or machine language or PLC programming.

No previous experience or dedicated automation engineer is required, so they can be purchased "over the counter", and regularly represent the first piece of automation for the SME.

Moreover, prices start at about £5,000.00. This brings the technology into the budget range of almost all manufacturing concerns.

At this price level, cost justification by reasons of higher throughput and yields, fewer rejects, better quality or reduced labour content are relatively straightforward. Payback times can be as little as six months.

4.8 PROCESS AUTOMATION:

4.8.1 Process Automation:

Most business processes have already been automated. That's the good news. The bad news is that they tend to be loosely coupled and to exist on different systems.

For example, adding a customer to a packaged accounting application may establish the customer in one system, while it is necessary to use another system entirely to perform a credit check on the customer and still another to process an invoice. Clearly, not only do these systems need to share information, but they need to share that information in an orderly and efficient manner.

The goal of process automation, and of EAI as a whole, is to automate the data movement and process flow so that another layer of process automation will exist over and above the processes encapsulated in existing systems.

In other words, process automation completes EAI, allowing the integration of systems not only by readily sharing information, but also by managing the sharing of that information with easy-to-use tools.

Process automation is best defined as the passing of information from participating system to participating system and the application of appropriate rules in order to achieve a business objective. This is true whether or not the business processes are automated.

For example, the processing of an insurance claim or the verification of an expense report are business events that can be automated with process automation.

The process flow logic, generally, only has to do with process flow and is not a traditional programming logic (such as user interface processing, database updates, or the execution of transactions).

In most process automation scenarios, the process logic is separated from the application logic. It functions solely to coordinate or manage the information flow between many source and target applications.

For example, before process automation, in order for an expense report to be processed, an employee first had to enter it into the expense reporting system. The employee then printed the expense report and submitted it to his or her manager for approval.

After checking the report, the manager signed the report (when he or she found the time) and sent it to accounting for processing (with their packaged accounting system). If accounting discovered a problem, the report would be kicked back to the employee for correction. It is hard to imagine a more inefficient and time-consuming process.

Unfortunately, it is an equally credible process, one that many, many people would recognize. With process automation in place, the information in the expense report example could be moved directly from the employee's expense-reporting system to the manager (perhaps via intra enterprise e-mail), who could approve the expense.

Even better, the system may be built in such a way that the manager need not view the report at all. If the report passes a set of predetermined criteria (procedural rules), then it could be automatically approved by the process automation layer and sent along to the accounting system for processing.

The manager could receive automatic notice of the approval, and the employee could receive a notice that the check is on the way. Such a system operates on three levels of technology. At the uppermost layer is the process automation or workflow level. This is where the process automation-modeling tools and workflow engines exist, where the method of information movement is defined.

The next level down is the transformation, routing, and rules-processing layer. This is where the information movement and formatting actually occur. Typically, this layer is a message broker, but transaction-oriented middleware and distributed objects are applicable as well.

This layer also applies rules to information moving from one system to the next, reformatting the information as required and reading and writing from the source or target systems interfaces, either through direct calls or through adapters.

The messaging system exists at the lowest level. This is the system responsible for moving information between the various connected applications.

What this schema clearly shows is that the most primitive layers rest toward the bottom while the more sophisticated layers are at the top. Information moves up the layers from the source systems, where it is processed, and down the layers to the target system, where it is delivered.

Process automation saves steps and time. A process similar to the previous expense report example that could take days or weeks could, with a good process automation approach, take mere seconds.

Over the years, many business processes that have existed within organizations (on stovepipe systems) have been automated with fair success, but as we have seen with the EAI problem, there has not been a great deal of thought given to how all these systems will share information.

4.8.2 Implementing Process Automation:

Integrating business applications into a process automation solution means removing the flow dependency from the application. The routing feature found in most process automation solutions allows relevant information to be extracted from any source or target application or data store.

The benefit of this solution is that when a change in process flow or logic is required, only the model itself needs to be changed, not the applications that are a part of the process model. Moreover, using this type of approach, it is possible to reuse any source or target systems from model to model.

Like most things, implementing process automation solutions might seem relatively straightforward. It isn't. In many respects, it is similar in function to traditional Business Process Reengineering (BPR) solutions, only with a layer of automation.

Here are a few steps to consider:

1. Business processes that exist within the organization must be documented. This means that you have to understand all processes as well as data contained within the source and target enterprise systems. This step has to be done regardless of the type of EAI solution you are considering applying.

2. The missing processes required to tie the existing processes together must be defined. This means understanding not only how each process works, but also how each must leverage the other to create a more efficient set of processes.

3. The processes using process automation technology to tie these processes together must be executed.

4.8.3 Process Modeling

Creating the model using the process automation tool generally means drawing a diagram that depicts the processes, resources (systems and people), logic, and the movement of information between the systems.

If the process becomes too complex, sub processes can be defined and even reused from model to model.

For example, a credit check may be a complex sub process that is included within many separate processes. This is analogous to traditional structured programming, where subprograms or subroutines can be reused. Drawing a process using a process automation — modeling tool is just a matter of selecting items (e.g., resource, process, and data) from a palette and pasting them on a diagram.

Once the graphic diagram is in place, it is simply a question of defining the processes' connections and sequence. Using this model, it is possible to further define the process automation logic or the process logic that is being layered on top of the existing process logic.

Not surprisingly, each process automation tool approaches this generic description of activities in very different ways. However, as time goes on, de facto approaches will emerge, and each tool will align itself behind a commonly accepted approach.

CHAPTER 5 MATERIAL HANDLING

5.1 INTRODUCTION:

This describes the material handling (MH) functions in modern manufacturing or service facilities. Prima facie, in manufacturing facilities whose primary objective is to manufacture products for sales, these functions do not contribute value to the products directly.

In some service facilities, however, these functions do actually provide value to customers. Examples can be drawn from DHL, Fedex or similar express parcel/mailing/forwarding and e-retailing companies, whose customers especially demand on-time delivery of goods to the right destination.

To achieve this objective, an effective Material Handling infrastructure is crucial to effective performance of such logistics undertaking. Also, in the manufacturing sectors, the "winds of change" due to the just-in-time (JIT) and quick response manufacturing concepts have caused people to see Material Handling in a new light. Particularly, for a manufacturing system to respond quickly and appropriately to demands, material handling must be treated as a logistic function, and new concepts and methodologies are required to design to fulfill the roles of material handling in the modern era.

5.1.1 Material Handling:

MH is essentially concerned with "realizing, actuating, and energizing material flow activities"; and is also manifested by the traditional view that it "provides the final link in layout planning by realizing material flow".

This is a view that has been come across in plant layout design. Particularly, when establishing gross material flow within a facility, focus is often placed on minimizing the amount/cost of MH, since MH is a nonproductive activity that does not add any value to the final product(s). Apparently, there are certain truths in this view, as is exemplified by the following example.

A major manufacturer of white goods (i.e., refrigerators and air conditioners) has an assembly plant fed by a number of suppliers on numerous components and subassemblies. The plant used to occupy a multi-storey industrial building -- a common phenomenon in China. Due to the production manager's recent study mission in the U.S., he has decided that it is simply too costly and ineffective to move incoming materials from the ground level to another storey for processing or storage, and so forth.

Also, in a large assembly plant in which the amount of input is huge, a non-JIT approach to the problem will cause necessary materials storage and retrieval, and resulting in wastes in space and resources. The above example highlights the benefit of minimizing Material Handling in a mass production environment.

Actually, the issue of material flow and its minimization has been well established in the field of work study. For example, the process chart and flow diagram have been applied to record the various process elements including operation, transport, inspection, delay, storage in some details.

Techniques of work design is then applied achieve a more efficient flow. Apparently, there is some considerable truth embodied in this view. However, simply treating MH as non-value added passes moral judgment on MH, and minimizing such activities as the only objective becomes inappropriate, especially in contemporary facility design.

While minimizing gross material flow is an important objective to achieve, it is not *the* only objective to consider. Particularly, this view must be complimented by the logistics view of MH. Also, the question is posed on: how these two views can be embodied in an MH system design framework so that they could become consistent with each other? While there is not a simple answer to the MHS design problem, a systematic and holistic approach must be considered.

5.1.2 Material Handling in Competitive Manufacturing:

Due to global competition, companies must develop capabilities to react to fast changing market demands. One of the major competitive weapons of a company is on its ability to quickly customize its products according to various customers' specifications, and to produce these customized products in the efficiency close to that of mass production.

This manufacturing strategy and practice is known as mass customization, which is made possible due to the characteristics of the product that allow various product variants (i.e., of different configurations) to be manufactured, without significantly changing the set-up of the entire production line. Different product variants are then produced according to customers' demand, usually in very small batches or in batch of one. Examples of such demand-based production in a mass customization environment can be drawn from Dell Computer or Lexmark (a printer manufacturer), amongst many others.

Therefore, a study on MH must consider the spectrum of manufacturing facilities from mass production, to just in time system (with steady demand), to demand-based system operating in mass customization environment, to quick response manufacturing [Suri 1998]. While MH in mass production has been adequately addressed, the issues of MH in demand-driven and quick-response manufacturing environments have not been adequately dealt with.

The issue of MH in such systems is more than minimizing amount and cost of MH. (It is assumed activities been placed in an optimum manner, and materials arrive to the right activities in a timely manner.) On the other hand, MH is more appropriately seen as supporting the many aspects of factory operations (i.e., production, change of mould bases, etc. etc.) to achieve the very objectives of competitive manufacturing.

In other words, MH adds value to these systems. Also, from an operational level, MH goes deeper than gross material flow as it concerns the functions of physical material flow including moving, storing, protecting, and controlling materials.

MH actually addresses the system, methods and technologies (including software and hardware) involved. So, these are the characteristics of MH that make it an important issue to study in facility design. Also, modern MH places significant emphasis on the flow of information for physical MH to be effected.

For example, information systems for warehouse management have been development for storage and accurate retrieval of materials; Kanbans are used in JIT or demand-based systems to authorize production and transportation of materials at the right time and right junction. The significance and complexion of MH have grown in modern manufacturing.

To find the right treatments of MH, it is more appropriately to regard MH as an internal logistics component of a facility. To use the words of Tompkins et al. (1996), MH is "providing the right amount of the right material, in the right condition, at the right place, at the right time, in the right position, in the right sequence, and for the right cost, by using the right method(s)."

The materials include not just materials for production, but also ancillary equipment (e.g., cutting tools, moulds and dies, and fixtures, etc.) These "right Xs" are the also objectives to be accomplished modern logistics systems that operate spanning a wide geographical area.

To discuss the internal logistics of a facility, one must not ignore the "mastermind" that plan ahead to achieve the "right Xs". Such a "mastermind" is some kind of information system manifested in the form of enterprise resources planning system (ERP).

MH differentiates itself from such logistics information systems in that it operates at some lower levels. In the context of enterprise resources planning (ERP), this aspect of MH overlaps with the functions of the manufacturing execution system (MES), and operates until the lowest levels that execute physical actions and collect information from processes.

It is pointed out that good MH can only be built on a good system that has been sufficiently rationalized and optimized, e.g., lean and quick response systems. The following discussion has made such an assumption.

Finally, the significance of MH is found out. It involves 25% of all employees for its performance, occupies 55% of all factory space; and amounts to 87% of production time (i.e., 13% of time is spent on actual production). Also, MH takes up 15-70% of the total cost of a manufactured product; 3-5% product damaged due to mishandling; and alarmingly, there are more than 50% industrial accidents arising from MH.

5.2 THE BASIC DEFINITION OF MATERIAL HANDLING:

MH is the art and science of moving, storing, protecting, and controlling materials. MH is an art because the MHS is a complex system that it is naive to conceive that problems related to "MHS can be solved/ designed" using scientific formula or mathematical model.

MH requires considerable judgment that can only be acquired through experience in the field. (There is no substitute for experience in order to come up with solutions for the problem.) As the related problems to MH attain some considerable complexity, any attempt to solve such a problem must be approached systematically manifested by suitable methodologies.

Such a methodology includes problem specification, data collection and analysis, syntheses of solutions, evaluation of alternatives, and selection of the most appropriate solution. For the analysis of the problem, there always exist some analytical models and/or quantitative techniques that can be wisely applied to solve the problem.

Further, as is apparent in the section on MH equipment, the design of MHS will benefit most from a knowledge-based approach: systematic organization of knowledge about MH equipment and MH best practices. Now, the meanings of these four MH actions are described as follows:

5.2.1 Moving:

Moving materials create time and place utility. Any movement of materials requires that the size, shape, weight, and condition of the material, as well as the path and frequency of the move be analyzed.

5.2.2 Storing:

Storing materials provides a buffer between operations, facilitates the efficient use of people and machines, and provides for efficient organization of material. Material storage considerations include the size, weight, condition, and stackability of the materials; the required throughput; and building constraints such as floor loading, floor condition, column spacing, and clear height.

5.2.3 Protecting:

The protection of material include both the packaging, packing, and utilizing done to protect against damage and theft of material, as well as the use of safeguards on the information system to include protection against the material being mishandled, misplaced, misappropriated, and processed in the wrong sequence. Continuous improvement programmes strive to eliminate "inspecting quality into a product, by designing quality into the product".

In a similar fashion, the MH system should be designed to minimize the need for inspections and costly methods of protecting the material. Controlling: Truly controlling material requires physical and status material control. Physical control is the orientation of, sequence of, and space between material movements. Status control is the real-time awareness of the location, amount, destination, origin, ownership, and schedule of material. Care must be taken to ensure that too much control is not exerted over the MHS. Maintaining the correct degree of control is a challenge, because the right amount of control depends upon the culture of the organization and the people who manage and perform the MH functions.

5.3 LOGISTICS VIEWS OF MH 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:

5.3.1 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.

5.3.2 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.

5.3.3 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.

5.3.4 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.

5.3.5 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.

5.3.6 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.

5.3.7 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.

5.3.8 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.

5.3.9 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.

5.4 MATERIAL HANDLING PRINCIPLES:

The MH principles provide concise statements of the fundamentals of MH practices. Condensed from decades of expert MH experience, not unlike the MH equation, they provide guidance and perspective to MH system designers.

As with all design tools, the applicability of a MH principle depends on the conditions that exist; due to the many different conditions that might exist, it is unlikely that any principle will always be applicable.

Rather than being design axioms, the principles serve as rough guides or rules of thumb for MH systems design; hence, the principles should not be considered substitutes for sound judgment.

Based on the principles, a number of checklists have been developed to facilitate the identification of improvement opportunities for existing systems.

Checklists can serve a useful purpose in designing new and improved systems. Namely, they can be used to ensure that nothing will be overlooked by checking, one by one, all the issues (important or not) involved.

1. Orientation:

Study the problem thoroughly prior to preliminary planning in order to identify existing methods and problems, physical and economic constraints, and to establish future requirements and goals.

2. Planning:

Establish a plan to include basic requirements, desirable options, and the consideration of contingencies for all MH and storage activities.

3. System:

Integrate those handling and storage activities that are economically viable into a coordinated system of operations, including receiving, inspection, storage, production, assembly, packaging, warehousing, shipping, and transportation.

4. Unit Load:

Handle product in as large a unit load as practical.

5. Space utilization:

Make effective use of cubic space.

6. Standardization:

Standardizing handling methods and equipment wherever possible.

7. Ergonomic:

Recognizing human capabilities and limitations by designing MH equipment and procedures for effective interaction with the people using the system.

8. Energy:

Consideration of energy consumption for evaluating different MH system design alternatives.

9. Ecology:

Use MH equipment and procedures that minimize adverse effects on the environment.

10. Mechanization/automation:

For increase of operating efficiency and accuracy.

11. Flexibility:

Use methods and equipment that can perform a variety of tasks under a variety of operating conditions. (For example, a robot is more flexible than dedicated pick/place arm. However, when consider the pros and cons of using robot, the idea of flexibility may lose its attraction.)

12. Simplification:

Simplify handling by eliminating, reducing, or combining unnecessary movements and/or equipment.

13. Gravity:

Utilize gravity to move material wherever possible, while respecting limitations concerning safety, product damage and loss.

14. Safety:

Provide safe MH equipment and methods that follow existing safety codes and regulations in addition to accrued experience.

15. Computerization/information technology:

Consider computerization in MH and storage systems, when circumstances allow, for improved material and information control.

16. System flow:

Integrating the data flow with physical material flow in handling and storage.

17. Layout:

Prepare an operation sequence and equipment layout for all viable system solutions, then select the alternative system which best integrate

18. Cost:

Compare the economic justification of alternate solutions in equipment and methods on the basis of economic effectiveness as measured by expense per unit handled.

19. Maintenance:

Prepare a plan for preventive maintenance and scheduled repairs on all MH equipment.

20. Obsolescence:

Prepare a long-range and economically sound policy for replacement of obsolete equipment and methods with special considerations to after-tax life-cycle costs.

5.5 EQUIPMENT FOR MH OPERATIONS:

Selection of material handling equipment is one of the most significant design decisions made in the design of material handling or warehousing systems. Also, the problem constitutes one of the major obstacles of the material handling system design process. This is mainly due to the huge variety of material handling equipment available, and matching the characteristics of materials, method, and move (analysis due to the MH equation) to the appropriate equipment becomes a demanding task. It is used to say that people tend to turn to specific equipment and "duplicating or imitating best practices" as the simple way out. This will help to avoid the difficult questions.

Unfortunately, it also undermines the object of genuinely understanding the actual requirements of a particular material handling system, thus forfeiting the opportunity of offering the best solutions to the problems.

Another pressure facing a MHS/WHS designer is the increased capital investment for the equipment that makes up the system. The complexity and sophistication of the system depends more and more on increased automation and specific design of material handling equipment, and the integration of various material handling devices and IT/IS elements.

The consequences of making a poor design will incur loss of businesses and heavy financial losses, which are serious. Apparently, a knowledgeable material handling designer who is able to suggest the appropriate MH equipment for a particular MHS design is much desired. This has not been easy, mainly because having, or acquiring such expertise does not usually contribute to the competitiveness of a company.

Normally, especially for repetitive manufacturing with low-value added operations, the choices are rather obvious. However, when competitive manufacturing strategies are to be embodied in the plant layout and MH design at some quicker tempo, and with the degree of automation increases, the knowledge of MH/WH equipment must become part of the a company's competence.

In the design of other non-manufacturing facilities, for example, the Super Terminal of HACTL, industrial engineers must be competent enough on MH/WH in order to clearly define the requirements, to work with consulting companies, to negotiate with vendors, and to implement and maintain the facilities. Due to the proliferation of MH/WH equipment (especially automated equipment), a well-structured presentation of such the information, from introductory level to technical specification, is desired.

Recently, numerous websites have been set up by commercial or professional organizations to provide useful information on MH/WH equipment. Some of them provide useful educational and technical information on MH equipment.

When designing a MHS, the designer will be facing a host of feasible solutions. The most crucial issue is whether a particular solution will satisfy the requirements. Often, cost constitutes a major consideration. It consists of the cost of the equipment itself, cost of hiring operators who will use it, safety aspects, and power to drive the equipment.

Apart from these considerations, the material handling principles should always be on the mind of the designer. However, it must be born in mind that the selection of MH equipment forms part of a complete MHS design process, which should be driven by requirements, and not by solutions.

The major types of MH/WH and supporting equipment can be divided into:

1. Conveyors
2. Cranes
3. Storage and retrieval equipment
4. Industrial trucks
5. Containers or unit load formation equipment
6. Automatic identification and recognition, and information system

5.5.1 Conveyors

Conveyor is used when there is frequent material movement between specific points. Also, the path between points is fixed. Conveyors can be categorized by the type of product being handled (bulk or unit); the location of the conveyor (overhead or on floor); and the allowance of loads to be accumulated on the conveyor.

Traditionally, conveyors are generally inexpensive to install and to operate. The rule of thumb of using conveyor is that (same) materials to be handled must possess sufficient volume to justify its use. However, innovative applications of conveyors have evolved over time as highlighted by the flow systems and conveyor systems. Such systems have found widespread uses in the modern distribution industries.

These systems, which combined with modern identification and recognition systems (highlighted by the bar coding technologies), have played a significant role in the transportation and sorting of a large variety of products in modern warehouses.

Some of the most common types of conveyors include chute conveyor, flat belt conveyor, trough-belt conveyor, skate wheel conveyor, roller conveyor, etc.

A chute is "a sloping channel or slide for conveying things to a lower level". Chute conveyors are the most inexpensive type of conveyor. It can be used for the transportation of both bulk and unit load. Chute conveyors are often used to link two powered conveyor lines, and can be used to provide accumulation in shipping areas.

5.5.2 Cranes

Cranes are normally used for the transfer of materials with some considerable size and weight, and the flow of material is intermittent. Compared with conveyors, cranes are used for material transfer in the same general area. In general, loads handled by cranes are more varied with respect to their shape and weight than those handled by a conveyor. Compared with industrial trucks, they are less flexible and maneuverable.

However, in most cases, the applications of these different classes of MH equipment do not normally overlap. For example, in a toys manufacturing plant, such lifting devices are used for the transportation, installation or dislodging of moulds, etc. Apparently, it is difficult to conceive how such lifting devices could be replaced by, say, industrial trucks. Hoists are frequently attached to cranes for vertical translation (i.e., lifting and lowering) of loads. They can be operated manually, electrically, or pneumatically.

5.5.3 Storage And Retrieval (R/S) Equipment

The primary objective for storing a product is to provide buffer for production or distribution so that disruption or non-delivery can be avoided. This is not the place to discuss the downside of having inventory (something of a necessary evil), but a modern facility must employ a lean philosophy to minimize the inventory levels, and employs appropriate equipment for efficient storage and retrieval.

Another aspect of R/S concerns the unit load principle, which encourages handling as a large unit load as possible and the use of standard approaches. The simplest method of storing must be block stacking, which is, rather paradoxically, not quite a kind of equipment. Block stacking refers to unit loads that are stacked on top of each other and stored on the floor in storage lanes (blocks) 2 to 10 loads deep.

Depending on the weight and stability of the loads, the stacks may range from 2 loads high to a height determined by the acceptable safe limits or by the building clear height. Block stacking is particular effective when there are multiple pallets per SKU (stock-keeping unit), and when inventory is turned in large increments, i.e., several loads of the same SKU are received or withdrawn at one time. Despite block stacking is not a type of equipment, its significance lies in the fact that it is the benchmark for evaluating all other types of unit load storage equipment. Storage equipment can be in the form of racks, shelves, bins and drawer. Among these, storage rack is probably the most common form of storage equipment.

There are numerous variants and configurations of storage racks, which include single-deep, double-deep rack, cantilever rack, etc.; and configurations that are designed to facilitate specific storage and retrieval operations drive through, flow-through, etc. More sophisticated R/S systems combine the use of storage equipment, storage and retrieval machines, and control that are manifested in the modern automated storage/retrieval systems (AS/RS).

A single-deep selective rack is a simple construction of metal uprights and cross-members, and pallets/loads are supported between horizontal members. Such a storage rack provides immediate access to each load stored.

Unlike block stacking, when a pallet space is created by the removal of a load, the loads are immediately available. Loads do not need to be stackable and have varying heights and widths. In instances where the load depth is highly variable, it may be necessary to provide load supports or decking.

5.5.4 Industrial Trucks:

Industrial trucks are used to move materials over variable (horizontal) paths with no restrictions on the area covered (i.e., unrestricted area). Generally, industrial truck is preferred to conveyor when there is insufficient (or intermittent) flow volume between given points, or when a high maneuverability is required.

Many types of trucks are equipped with the lifting capabilities to provide vertical movements. Important applications of industrial trucks can be found in cases involving the storage/retrieval of materials in unit loads. In spite of their large variety, the following descriptions essentially introduce the most common types of industrial trucks in use today.

The simplest types of industrial trucks are operated manually, have no palletizing and no stacking capabilities. These include the two-wheeled hand truck dolly, and hand truck. The two-wheeled hand truck will be tilted when loaded and during travel (to keep the load from falling off the truck).

Dolly is a highly portable type of "truck". It has three or more wheeled hand truck with a flat platform. Since it has no handles, the load is used for pushing, and its use therefore requires some skills and care.

Floor hand truck has four or more wheeled hand truck with handles for pushing or hitches for pulling, sometimes referred to as a "cart" or "(manual) platform truck". These kind of trucks are for small loads and short distances. Industrial truck with palletizing capability probably forms one of the most significant method to handle unit loads in pallets.

The simplest of these is the pallet jack .A pallet jack has a pair of fork for inserting into the pallet for the lifting and depositing of pallets. Its front wheels are mounted inside the end of the forks and extend to the floor as the pallet is only lifted enough to clear the floor for subsequent travel. Therefore, when using pallet jack for lifting pallets, there are certain restrictions on the design of the pallets. Basically, reversible pallets (pallets with deckboards on both sides) cannot be used as such pallets do not provide room for the front wheels to extend to the floor.

Lifting can be performed manually or assisted with power. The use of pallet jacks for transporting pallet loads mainly confines to short distance travel. Common types of pallet jacks can only lift a load a few inches to clear the floor for subsequent travel, and are said to possess no stacking capability.

A special type of pallet jack, called the walkie stacker (powered or non-powered), allows stacking of load, and has counterbalance or straddle load support. The possession of stacking capability is required of industrial trucks to handle loads that are put to differing heights, on top of one another or on shelves for space saving.

The following types of trucks can essentially perform stacking. The counterbalanced (CB) lift truck or fork truck is known as the workhorse of a facility. The truck derives its name from it design in that its weight plus the operator behind the front wheels of the truck provide the counterbalances weight of the load (and weight of vehicle beyond front wheels) to avoid overturning. The rated capacity is reduced for load centres greater than 24 in. and lift heights greater than 13 ft. This kind of truck is called the workhorse of the facility because of its versatility. It can operate indoor/outdoor operation over a variety of different surfaces. It ability to turn in small radius gives rise to its high maneuverability.

Further, it can be equipped with a variety of attachments in addition to the standard fork attachments (e.g., carton clamps, and blades for slip-sheets) for enhancing its handling capabilities.

5.6 MATERIAL HANDLING SYSTEM DESIGN:

MHS design is a complex process. The effective performance of such a process requires tremendous amount of expert knowledge and in-depth understanding of the specific problem by the designer. Paradoxically, and indeed like facility design, such a design problem used to be non-recurrent. People performing MHS design do not usually have such capabilities and knowledge to start with.

The design process therefore becomes both a design and a learning process. Very often, especially for less sophisticated systems, and for situations in which the availability of expertise and resources are limited, the MHS designers would find an easy way out by adopting similar "design templates" or “standard solutions” used by his counterparts.

However, without a proper and penetrating consideration of one’s own specific situations, it would be difficulty to achieve an optimum solution. Although such an approach would give acceptable performance for the timing being, the long-term benefits will be undermined.

In designing an MHS, the fundamental aspects of the MH problems must be clearly identified and understood. To achieve this goal, the material handling equation is applied to motivate the designer to answer the 5 "Why's" 1 "How" questions to obtain full knowledge of the materials to be handled, the move to be installed, the methods and the equipment to use.

Secondly, as emphasized by Tompkins et al., the design process must be driven by the design requirements. A designer should try to resist the appeal of certain MHS design templates and lose sight on the actual requirements of the MHS. Attempts are made to resolve the problems associated with issues concerning contemporary MH. Notice that, however, the purpose of this framework is to motivate readers to consider the various issues and new developments of MH. It should not be treated as an MHS design methodology.

Such an ambition will require substantial development and elaboration of the present framework.

5.6.1 MH is to be fulfilled as a Logistics Function:

MH has been identified as the logistics function of a facility, which is highlighted by the facility's ability to achieve the various "right Xs". These "right Xs" (which embody the competitive manufacturing aspects), should therefore form the major requirements of the MHS.

Traditionally, MHS design mainly concerns the physical system configuration (i.e., equipment) as the deliverable. The operational aspects and the IT/IS that support the MHS to achieve the "right Xs" are not normally addressed. In the modern context of MH, the deliverables of the MHS design process should include these important aspects.

5.6.2 Knowledge-based Approach to MHS:

Knowledge is the most important ingredient and resource for MHS design. Knowledge about MH equipment, best MH practices, best manufacturing practices (lean and quick response manufacturing embodied in MHS design), system analysis techniques, and the methods to realize the MH principles form the components of an MHS designer's knowledge base.

Apparently, MHS design is a knowledge intensive process. For our purpose, we distinguish two types of knowledge. The first type is highlighted by the vast amount of explicit knowledge that supports the creative understanding of MHS design.

Examples include MH equipment, best practices, etc. Such knowledge essentially exists in explicit forms such as in documents, in websites, and in different media, although we consider its "implicit form" is of equal importance. Roughly speaking, the latter is concerned with one's experience and insight, and can only be elicited after considerable deliberation by the expert MHS designer.

The second type of knowledge related to MHS design is the computer processable knowledge that is for the modelling and analysis of MHS highlighted by simulation models. This knowledge problem presents some considerable difficulty to the performance of MHS design.

First, the knowledge related to modern MH highlighted above is proliferating. On the other hand, knowledge sources of these types, whether they are critical or not, are not readily available. Apparently, an effective way to organize and manage knowledge to support MHS design is much desired.

With respect to the types of knowledge mentioned above, it is proposed that some forms of computerized "knowledge-based systems" should be developed to capture the first type of knowledge for ready and convenient access by users.

It is generally agreed that public domain resources do not normally provide complete knowledge to specific subjects. However, conscientious effort should be made to gradually establish and to maintain one's own knowledge base.

The available knowledge in the public domain provides a good starting point. As for the second type of knowledge, the e-manufacturing solution has suggested an effective means of representing and maintaining the knowledge of the system model that supports recurrent analysis and design activities.

5.6.3 Life-Cycle Engineering (LCE) view:

MHS design used to be considered as one-off process. This is still true in many cases, especially in applications (manufacturing or non-manufacturing) in which the system is not required to be redesigned or reconfigured to respond to various customer demands. This is especially the case when the MHS is specially designed for the application.

For example, an MHS used for automatic and complex warehousing operations is custom designed. The major concern for such systems will be more appropriately placed on the operational, reliability and maintenance aspects. On the other hand, MHS used in today's agile and competitive manufacturing environment must be sufficiently re-configurable to suitably fulfill its logistics functions for different demands. Also, fine tuning of operations and MHS re-configuration and enhancement are part of the evolution processes.

Evidently, the design and re-design of MHS is more appropriately treated as a recurrent rather than one-off process, whose effective performance must be underpinned by "readies" including knowledge, reusable models and resources; and analysis and design techniques.

The life-cycle engineering (LCE) view is also motivated by such a need. Ideally, LCE of MHS would be best performed in a suitably customized e-manufacturing environment, which provides the necessary integration, coherency, and knowledge maintenance.

As is mentioned above, knowledge is the most crucial resources for performing MHS design, the availability of knowledge will effectively removes the obstacles, for example, in collecting data in performing an analysis (using simulation) of the dynamic behaviour of the system, in the identification of bottlenecks and deadlocks, and in the evaluation of certain quick response strategies, etc.

The implementation of the LCE requires: i) a well-established knowledge base; ii) a closer integration of system analysis and design tools that consume knowledge; and iii) a conscientious effort to continuously elaborate and refine such a LCE system.

5.6.4 Consistency with Layout Design:

MHS is always regarded as a subset of facility layout design problem. This view, despite the simple truth it embodies, cannot be taken as grant without further deliberation. Especially, MH is now treated as a logistics function. Both the richness in content and the new complexion of MH demand a more elaborated treatment.

Also, the "MHS design work" developed in plant layout design will need to be revisited when the MHS proper has been performed. A facility plan *is* an optimum configuration (or space plan) of production equipment, MH equipment, ancillary devices, workplaces, and in-process inventory, etc. Ideally, therefore, the design of layout and MHS should be performed as one single activity. For practical reasons, they are separately performed.

As fully illustrated in Lee's FacPlan, layout planning serves to establish the basis for product and process rationalisation. This is achieved through information acquisition, strategy development, and layout configuration arrangement. It can be said that, layout planning addresses the formative phases of facilities design, and inevitably, its approaches are devised for problems at higher levels of granularity and of a more static nature. Also, the overall complexity of the problem has to be suitably contained so that the design tasks would not be inhibited by the need to overcome such complexities.

On the other hand, MH concerns the realisation and optimisation of the physical movement of materials to supply and activate the production processes. It goes into finer details of the design of an enterprise logistics system, which includes the physical aspects manifested by MH equipment. Also, MH addresses problems related to production planning and control requirements after the facility has been deployed. MH serves to provide a more refined and refined facility design plan. Further, space requirements for MH and WH equipment will be determined more accurately; capacity requirements due to detailed system analysis would suggest revision of earlier layout plans, etc. Therefore, facility design describing the appropriate flow of design activities is desired to ensure consistency between layout planning and MHS design.

5.6.5 IT/IS aspects

There are two related issues on this aspect. First, many of the "right X" objectives have to be backed up by the provision of accurate information, e.g., the next destination, the amount of materials to transfer in a JIT environment, etc. For manufacturing facilities producing a small variety of products, the use of Kanbans will probably be sufficient.

For complex manufacturing and distribution systems, it is difficult to imagine how the control of material movement will be performed effectively, without the use of a powerful information system. Specifically, in the manufacturing context, the aspect of material control is known as production activity control to be performed through the manufacturing execution system (MES) in an ERP environment.

MES includes an integrated suite of methods and tools to accomplish production activity control, including material control and the necessary automatic identification function. While MES helps to resolve the problem concerning information capturing for production activity control within a facility (intra-facility), the significance of the IT/IS in the inter-facility context has been greatly increased highlighted by the recent re-emergence of ERP. This phenomenon has reinforced the role of MH and the related IT/IS which are crucial to the effective operation of modern day global supply network.

Basically, it is not possible to devise any design procedure that is powerful enough to deal with the spectrum of MHSs engaging in different facilities. In some facilities, for example, car manufacturing, MH involves sophisticated, expensive, and special purpose MH equipment. In light manufacturing, on the other hand, the goal of MH is set more on agile and competitive manufacturing, whose emphasis is placed more on logistics, rather than exotic MH equipment. Also, in some facilities, MH forms the major value-added operations.

Examples can be founded in modern warehouses for internet retailing, etc. The actual approaches for the vastly different cases are different. It is futile to devise any MHS design methodology that tries to encompass the issues that will be dealt with in different cases.

The proposed framework attempts to achieve: 1. To motivate MHS designer to look at the problem from a fundamental viewpoint (through MH equation). 2. To introduce the modern view of MH as a logistics function in the facility. 3. To emphasise the important of knowledge, and propose ways of managing such knowledge for effective MHS design. 4. To introduce the concepts of life-cycle engineering, and the significance of IT/IS in MHS design.

However, specific efforts must be spent on specific issues to specific details for specific cases. Finally, a word on the possibility of computerisation is raised.

The proposed framework for MHS design has considered the possibility of computerizing certain aspects of the design process. We take the view that such computerization, if to be considered, will result in some form of system software highlighted by an e-manufacturing solution. That means, the analysis tools will allow the study of the system performance in various aspects which relate to JIT and quick response.

The commercially available MH software like FactoryFlow, which only serve to focus on the analysis of gross material flow, only addresses the initial design stages. Apparently, computerisation will remain a difficult issue for further research.

CHAPTER 6 COMPONENTS OF PNEUMATIC OPERATED LOADER/UNLOADER

6.1 MAIN BASE:

The main base is one of the most important parts of pneumatic operated automated loading unloading equipment. As the name indicated it is the backbone of the equipment.

The main base is placed on and attached to a stand. In the main base the other parts of the equipment are mounted and attached.

The pneumatic cylinder for the x-axis movement is attached to the main base by means of bolts and nuts. The main base is shown in figure 6.1.

The length of the main base is 1550mm. The lower part of the main base is used for attaching it to the stand. The height of the main base is 405mm. The side of the main base consists of triangular plates attached to it. The width of the main base is 380mm. Large number of holes are present on top and bottom of front side of the main base for easy attachment of other parts.

6.2 PNEUMATIC CYLINDER FOR X-AXIS MOVEMENT:

This cylinder is used for movement of parts along x-axis. This cylinder is attached to the main base by means of bolts and nuts. The z-axis LM guide mounting bracket is attached to the cylinder.

The bracket is attached such that the position of the bracket is same as the position of piston inside the cylinder.

The length of the cylinder is 1350mm. The bore of the cylinder is 140mm. This pneumatic cylinder is of double acting type.

The force exerted by the compressed air moves the piston in two directions in double acting cylinders. 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. The cylinder is shown in figure 6.2.

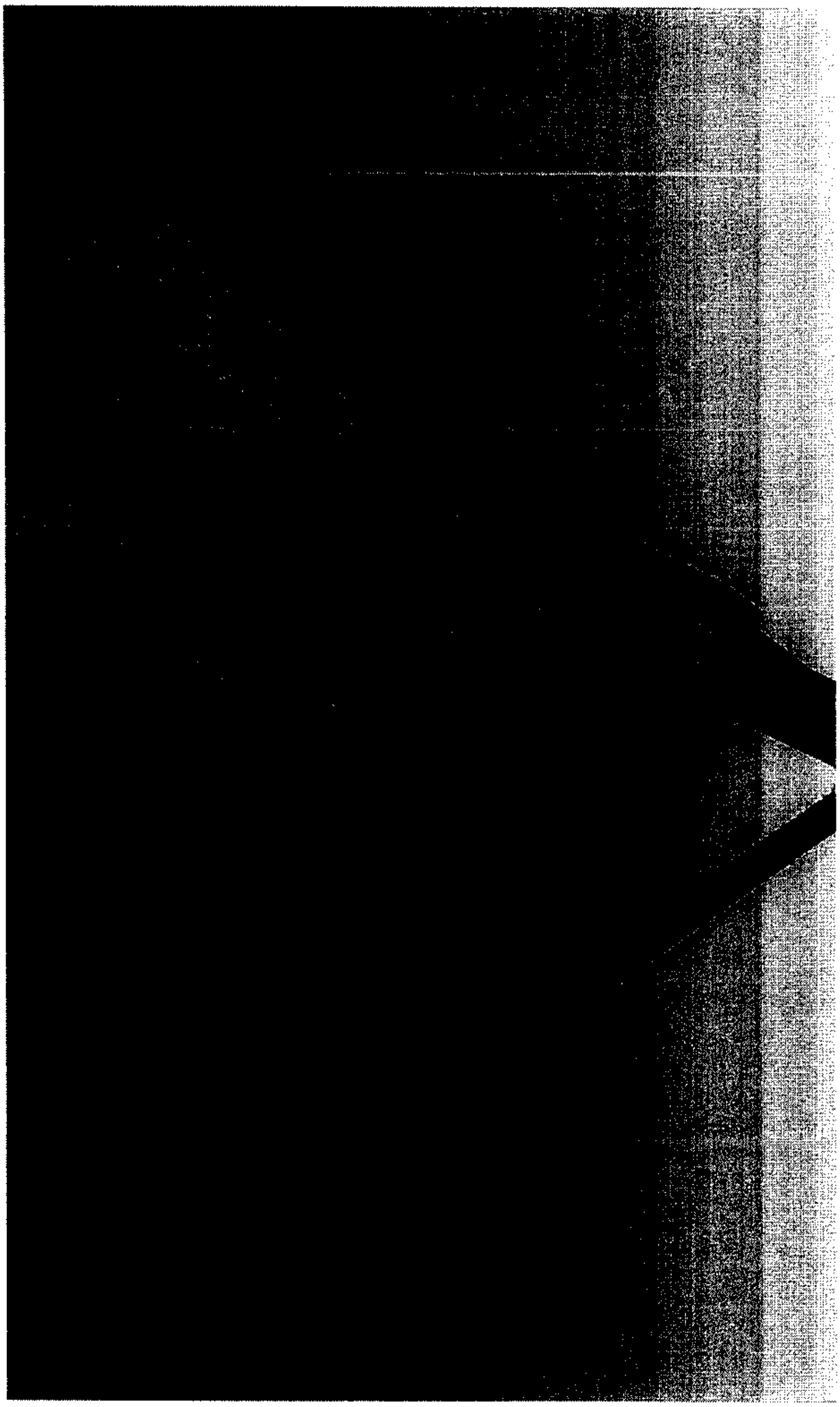

Figure 6.1 Main Base

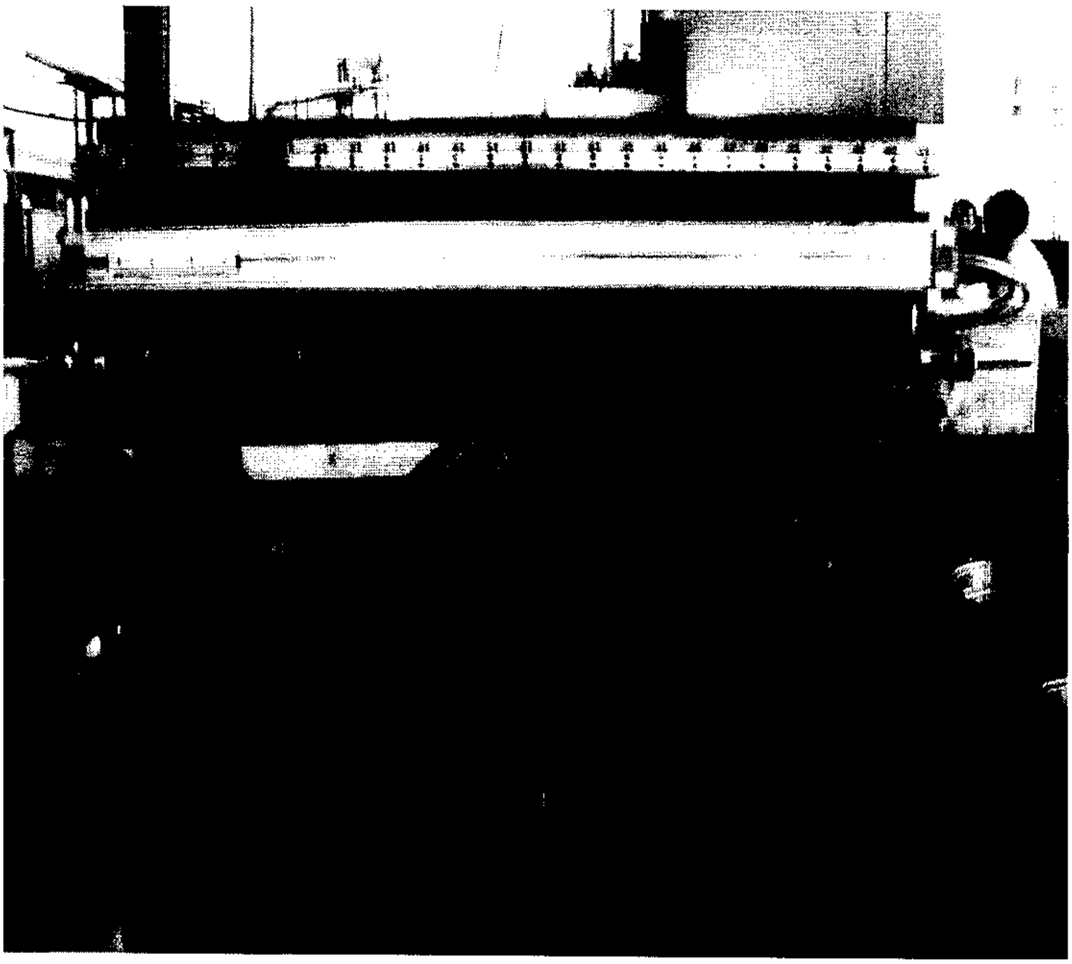

Figure 6.2 Pneumatic Cylinder for X-Axis Movement

6.3 Z-AXIS LM GUIDE MOUNTING BRACKET:

The z-axis LM guide mounting bracket is used for guiding the linear motion along the z-axis. This z-axis LM guide mounting bracket is attached to the pneumatic cylinder used for the x-axis movement.

This bracket will move in the horizontal direction as the piston in the x-axis pneumatic cylinder attached to the main base moves due to the intake and outtake of air. The pneumatic cylinder for the z-axis movement i.e. the vertical movement is mounted on the z-axis LM guide mounting bracket.

The height of the z-axis LM guide mounting bracket is 470mm. The width of the z-axis LM guide mounting bracket is 334mm. The face thickness of the z-axis LM guide mounting bracket is 144mm.

There are two projections on this bracket for easy mounting and attachment of pneumatic cylinder for z-axis i.e. vertical movement. In this part also there are a large number of holes for easy attachment purposes.

The z-axis LM guide mounting bracket is shown in figure 6.3

6.4 PNEUMATIC CYLINDER FOR X-AXIS MOVEMENT:

This cylinder is used for movement of parts along z-axis. This cylinder is attached to the z-axis LM guide mounting bracket by means of bolts and nuts.

The gripper mounting bracket is attached such that the position of the bracket is same as the position of piston inside the cylinder.

The length of the pneumatic cylinder for z-axis movement is 450mm. The bore of the pneumatic cylinder for z-axis movement is 140mm. This pneumatic cylinder is of double acting type.

The force exerted by the compressed air moves the piston in two directions in double acting cylinders.

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.

The cylinder is shown in the figure 6.4

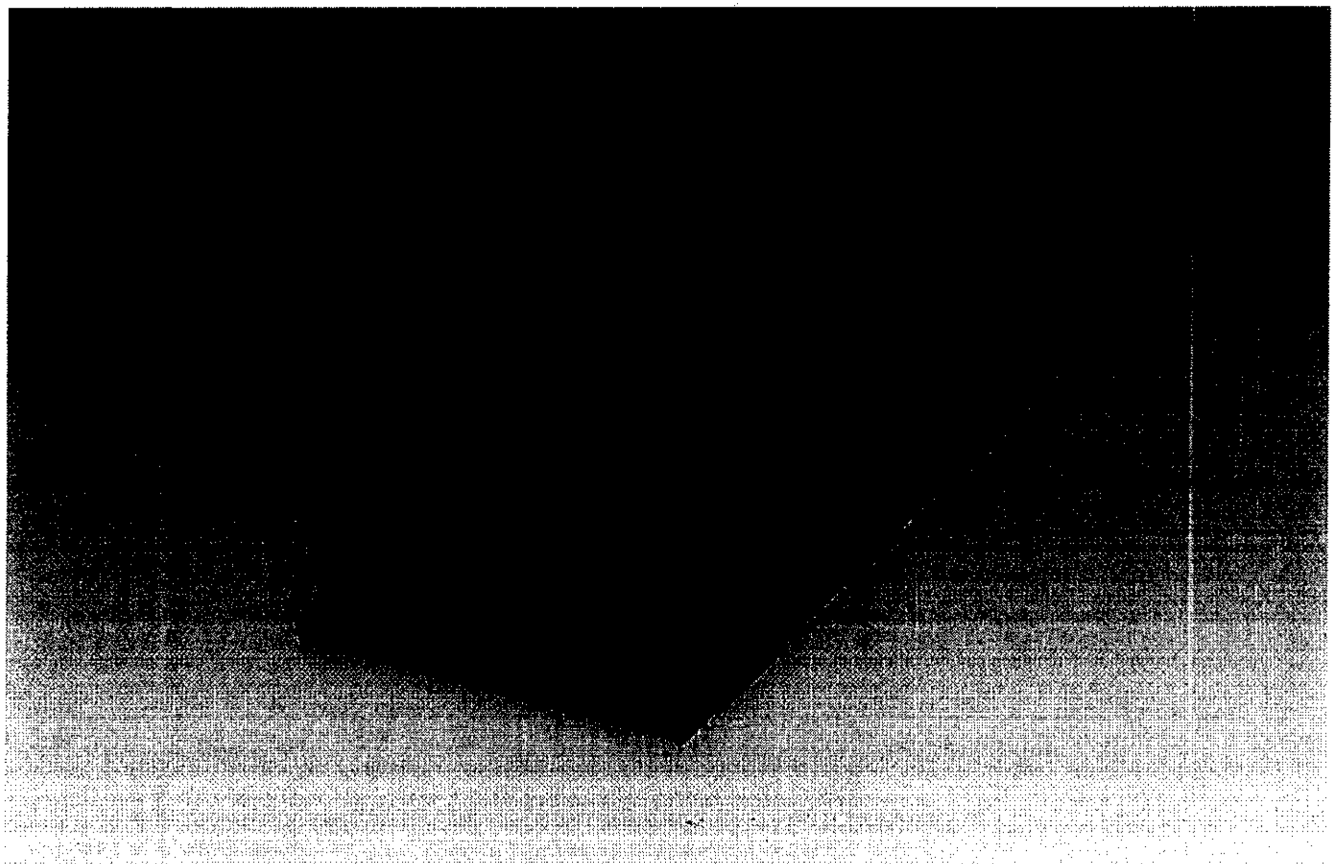

Figure 6.3 Z-Axis LM Guide Mounting Bracket

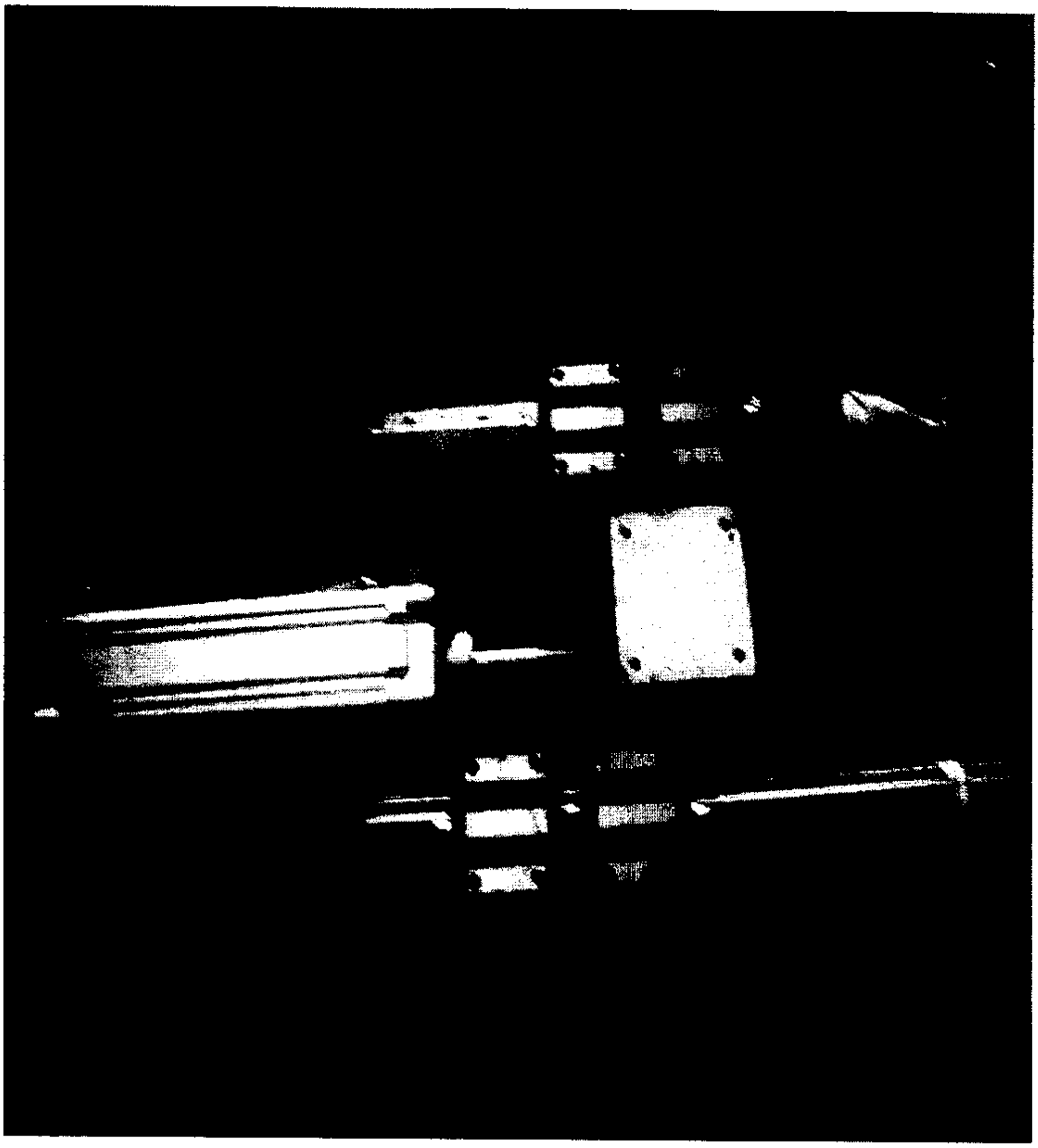

Figure 6.4 Pneumatic Cylinder for X-Axis Movement

6.5 GRIPPER MOUNTING BRACKET:

The gripper mounting bracket is one of the essential components of the pneumatic automated loader unloader. The gripper mounting bracket is attached to the pneumatic cylinder for z-axis movement and the LM guide mounting bracket.

This is almost similar to L shape with a square plate at one end for easy mounting of the bracket on the pneumatic cylinder for z-axis movement.

The gripper which is used for gripping the component is connected to this part. A set of triangular plates made of steel are used for reinforcement purposes. The gripper mounting bracket is as shown in the figure 6.5.

The cylinder for actuating the gripper is also mounted on this gripper mounting bracket. The cylinder connecting block is used for connecting the cylinder to the gripper mounting bracket.

6.6 GRIPPER:

The main function of the gripper is used for gripping the work piece during the loading and unloading of the work piece. Gripper is attached to the gripper mounting bracket as shown in the figure. The gripper is actuated by means of a pneumatic cylinder. The gripper is of magnetic type. The gripper is placed below the pneumatic cylinder for gripper. This is shown in figure 6.6.

6.7 PNEUMATIC CYLINDER FOR GRIPPER ACTUATION:

This pneumatic cylinder is attached to the gripper mounting bracket. This pneumatic cylinder is of double acting type. This cylinder is used for actuating and de-actuating the gripper i.e. for gripping and un-gripping the work piece. This is the smallest of the three pneumatic cylinders present.

The force exerted by the compressed air moves the piston in two directions in a double acting cylinders. 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.

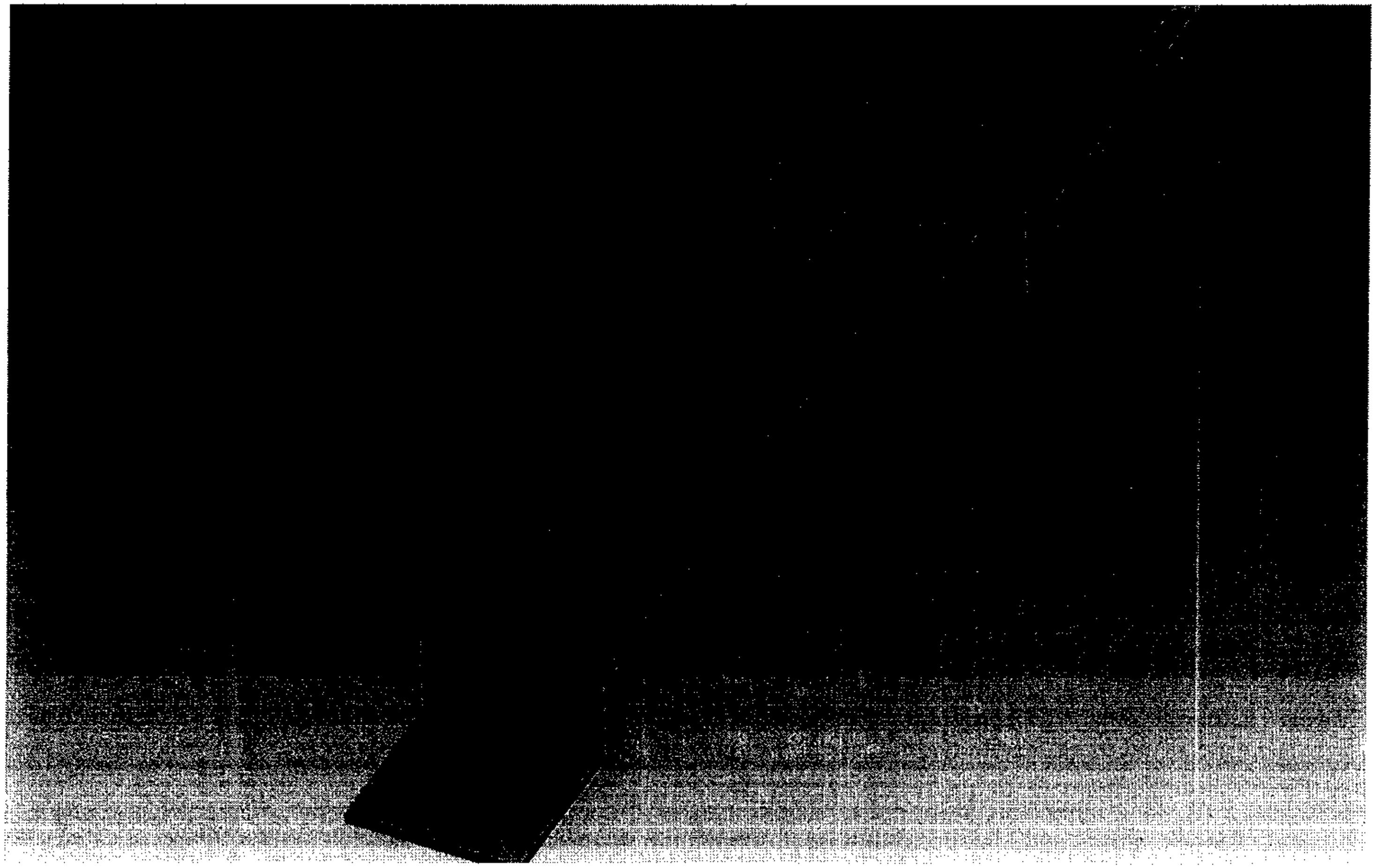

Figure 6.5 Gripper Mounting Bracket

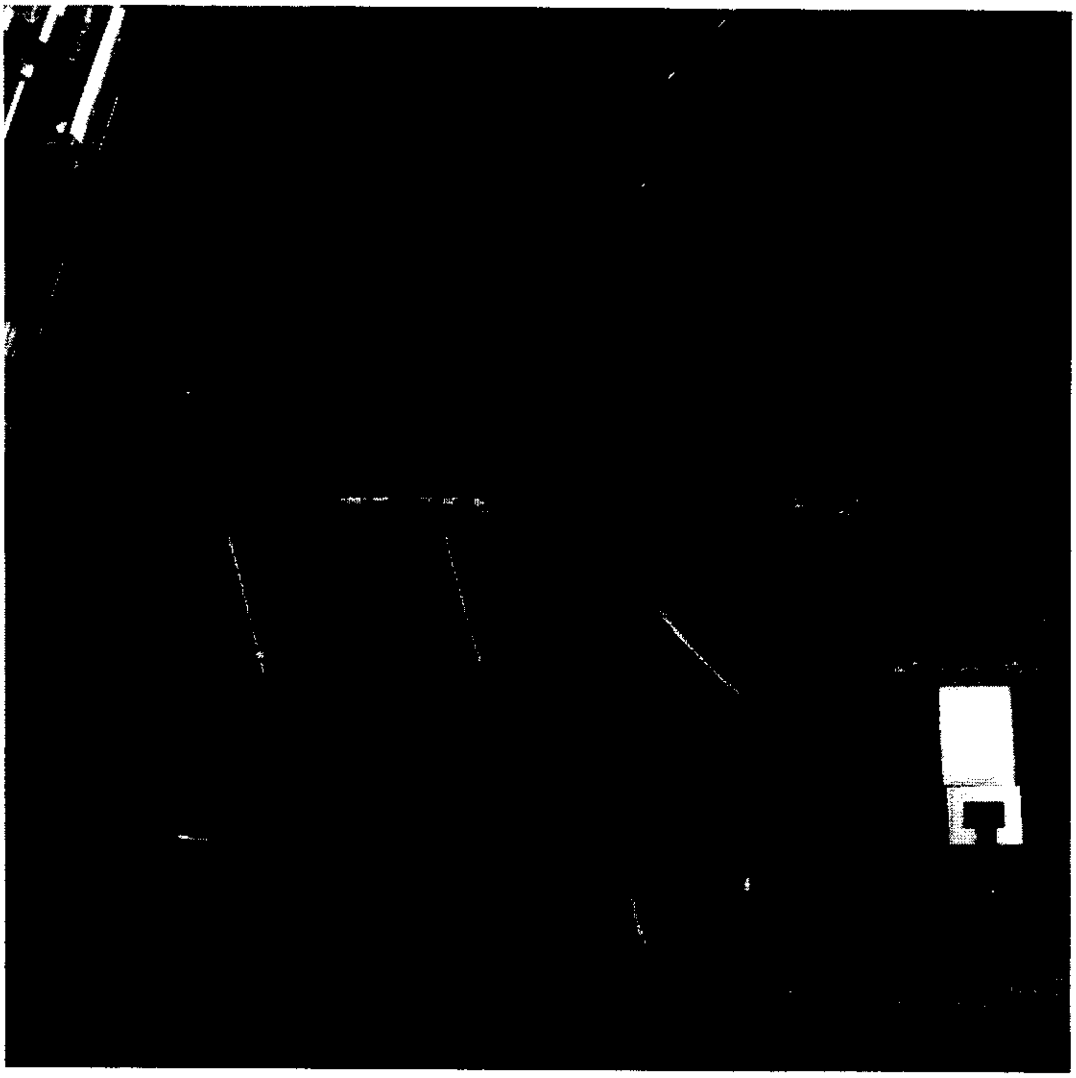

Figure 6.6 Gripper Mounting Bracket with Gripper and Pneumatic Cylinder for Gripper Actuation

6.8 LM GUIDE FOR Y-AXIS:

As the name indicates it is used for guiding the paths in a linear motion along the y-axis. The LM guide for y-axis is shown I the figure. The length of the LM guide for y-axis is 470mm. The diameter of LM guide for y-axis is 22mm. This is used for guiding purposes. This is shown in figure 6.7.

6.9 ADJUSTMENT BLOCK:

The adjustment block is a rectangular shaped block with four holes on various faces for mounting purposes. As the name indicates the function of this block is for adjustment purposes. The dimensions of the adjustment block are 100x60x30mm. The adjustment block is shown is figure 6.8

6.10 CYLINDER CONNECTING BLOCK:

The cylinder consists of a square plate and a rectangular block connected at right angles to each other. Dimensions of the square plate are 100x100x12mm and consists of four holes of diameter 8mm at each corner. Dimensions of the rectangular block are 81.5x50x20mm. The rectangular block consists of a hole of diameter 16mm for attachment purposes. As the name indicates, the cylinder connecting block is used for connecting the cylinder with various parts of the equipment.

6.11 MECHANICAL STOPPER-1:

The main function of the stopper is used for stopping the movement of the part upto a certain limit. The mechanical stopper 1 is a stepped shaft type with diameters 25mm, 20mm and 16mm respectively. It is made of mild steel. The total length of the mechanical stopper 1 is 123mm. This is shown in figure 6.9

6.12 MECHANICAL STOPPER-2:

The main function of the stopper is used for stopping the movement of the part upto a certain limit. The mechanical stopper 2 is a rectangular shaped block of dimensions of 110x40x15mm. There are two hole of diameter 9mm.

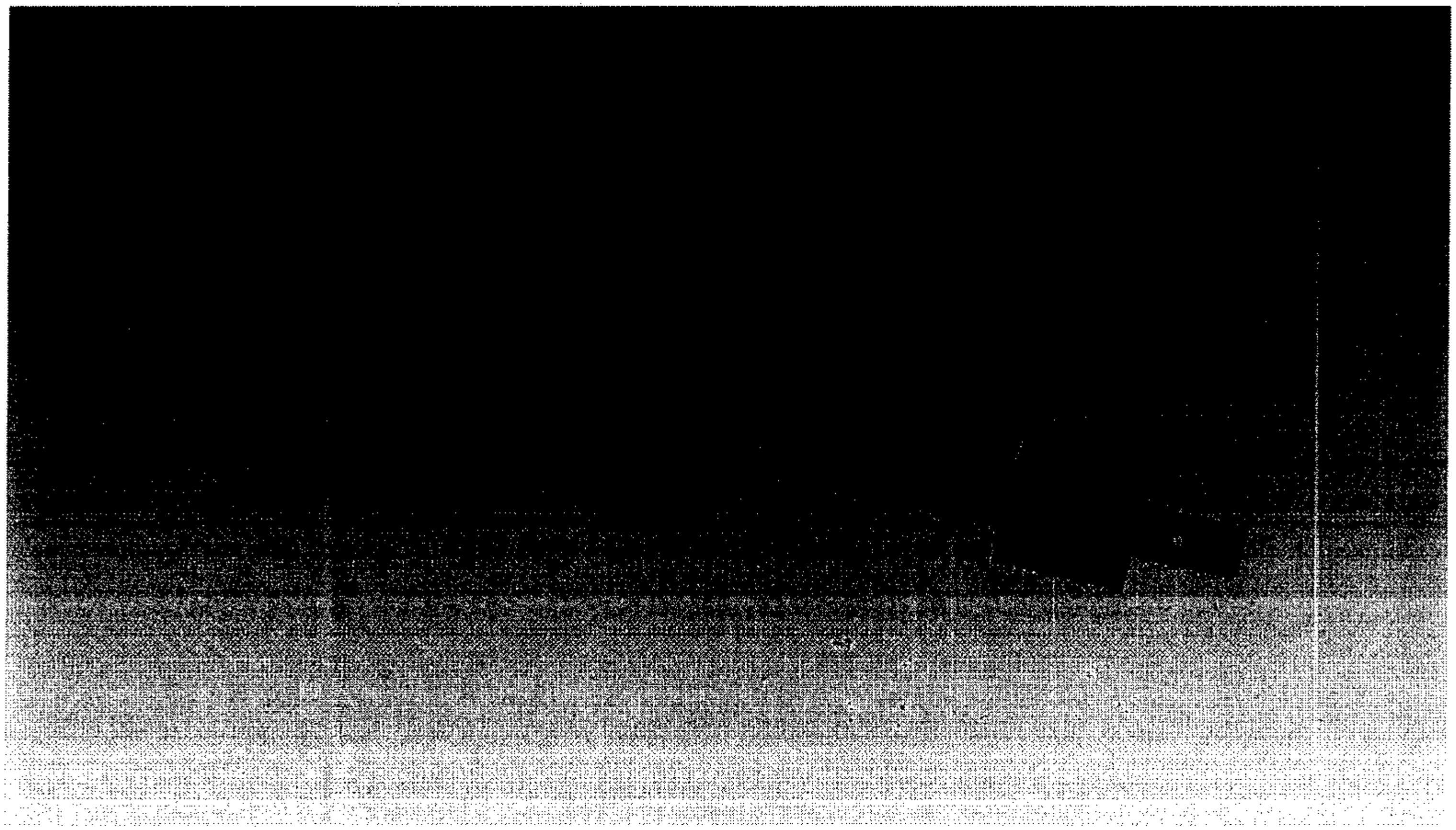

Figure 6.7 LM Guide for Y-Axis

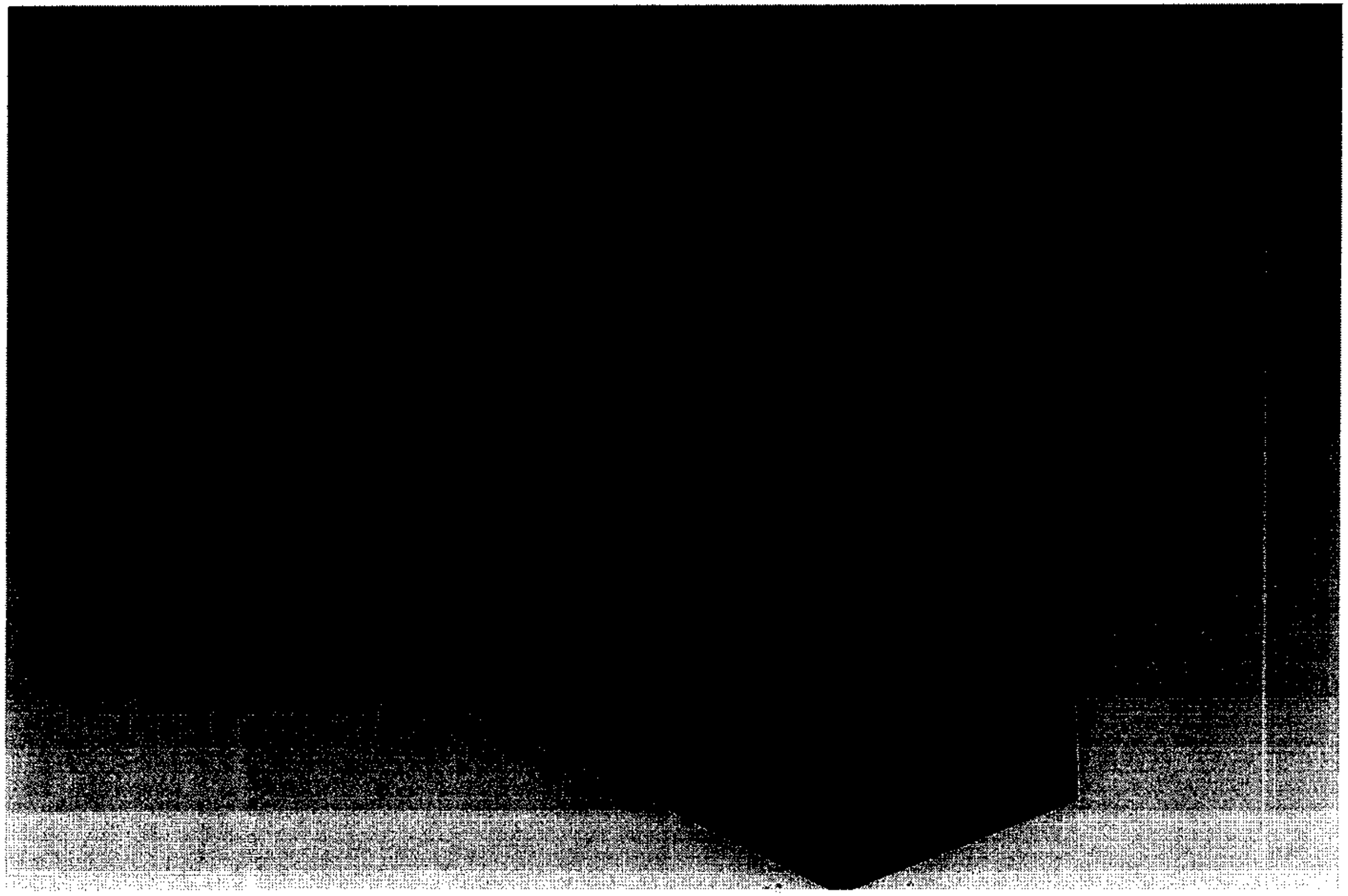

Figure 6.8 Adjustment Block

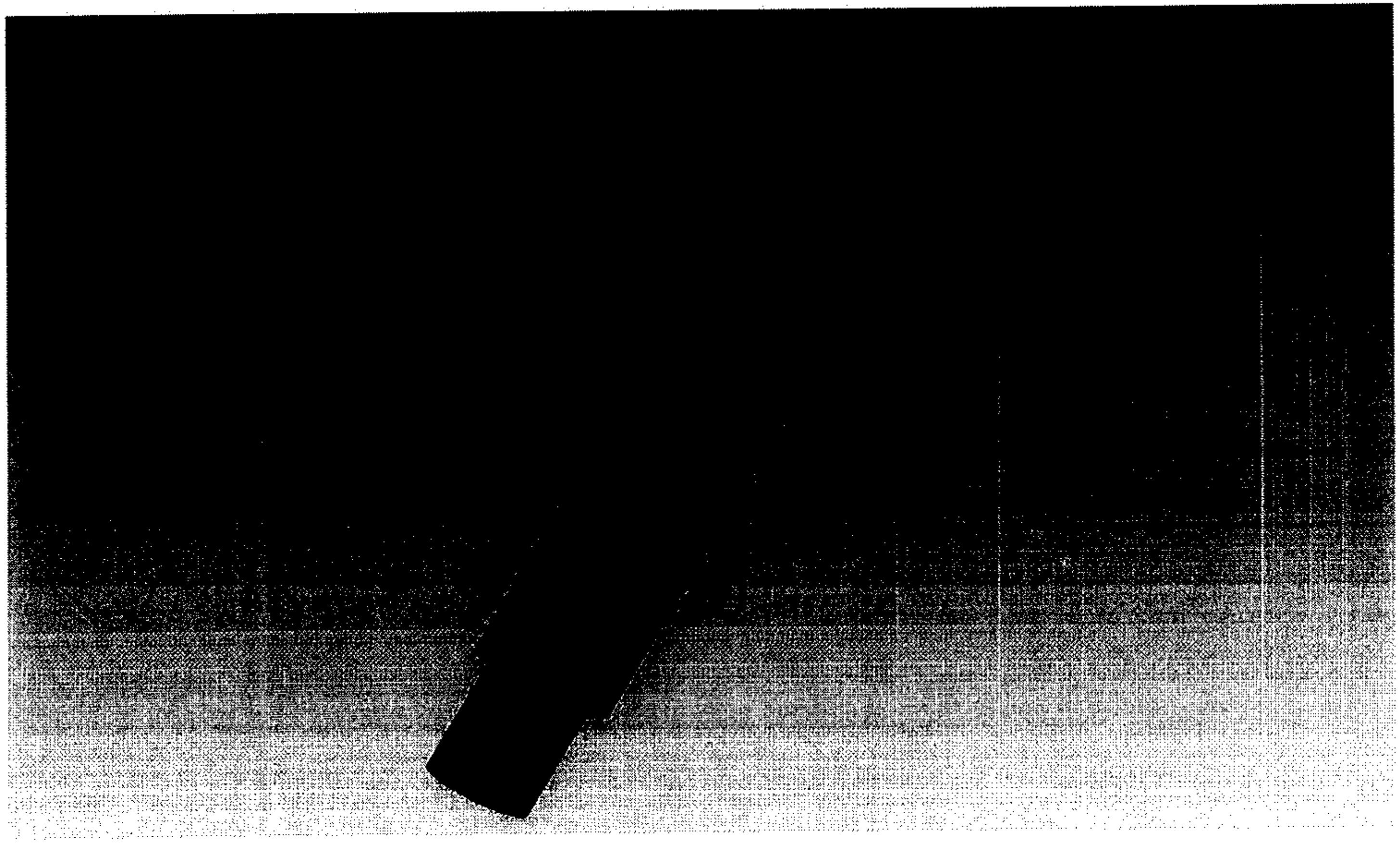

Figure 6.9 Mechanical Stopper-1

6.13 MECHANICAL STOPPER-3:

The main function of the stopper is used for stopping the movement of the part upto a certain limit. The mechanical stopper 3 is a rectangular shaped block of dimensions of 110x40x15mm. There are two hole of diameter 9mm.

6.14 CYLINDER MOUNTING BRACKETS:

There are two cylinder mounting brackets one for rodless and one for z-axis. It has two square plates with holes at right angles to each other. These brackets are used for mounting the pneumatic cylinders as the name indicates. The two cylinder mounting brackets are shown in the figures 6.10, 6.11 and 6.12.

6.15 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 whose 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.

Figure 6.10 Cylinder Mounting Bracket for Z-Axis

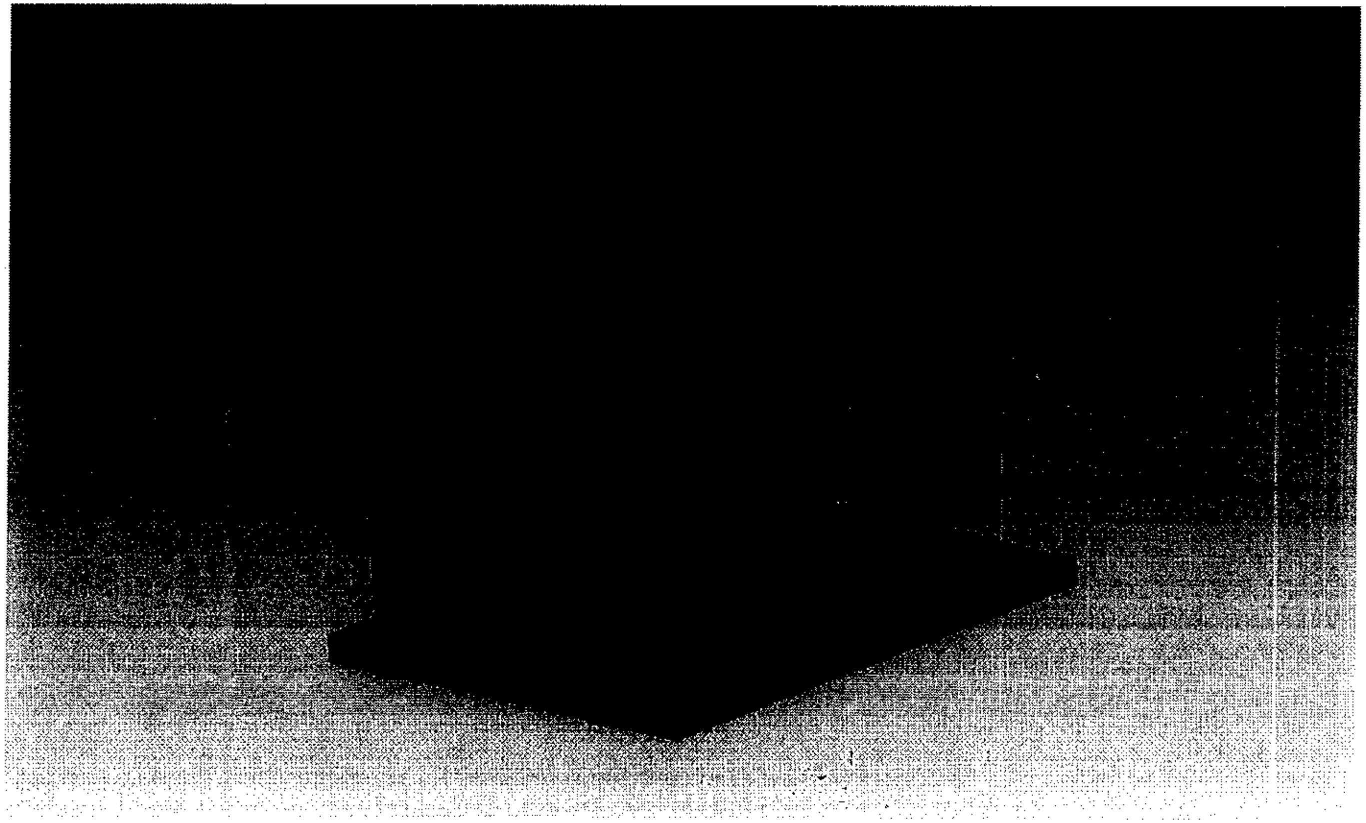

Figure 6.11 Cylinder Mounting Bracket for Rodless

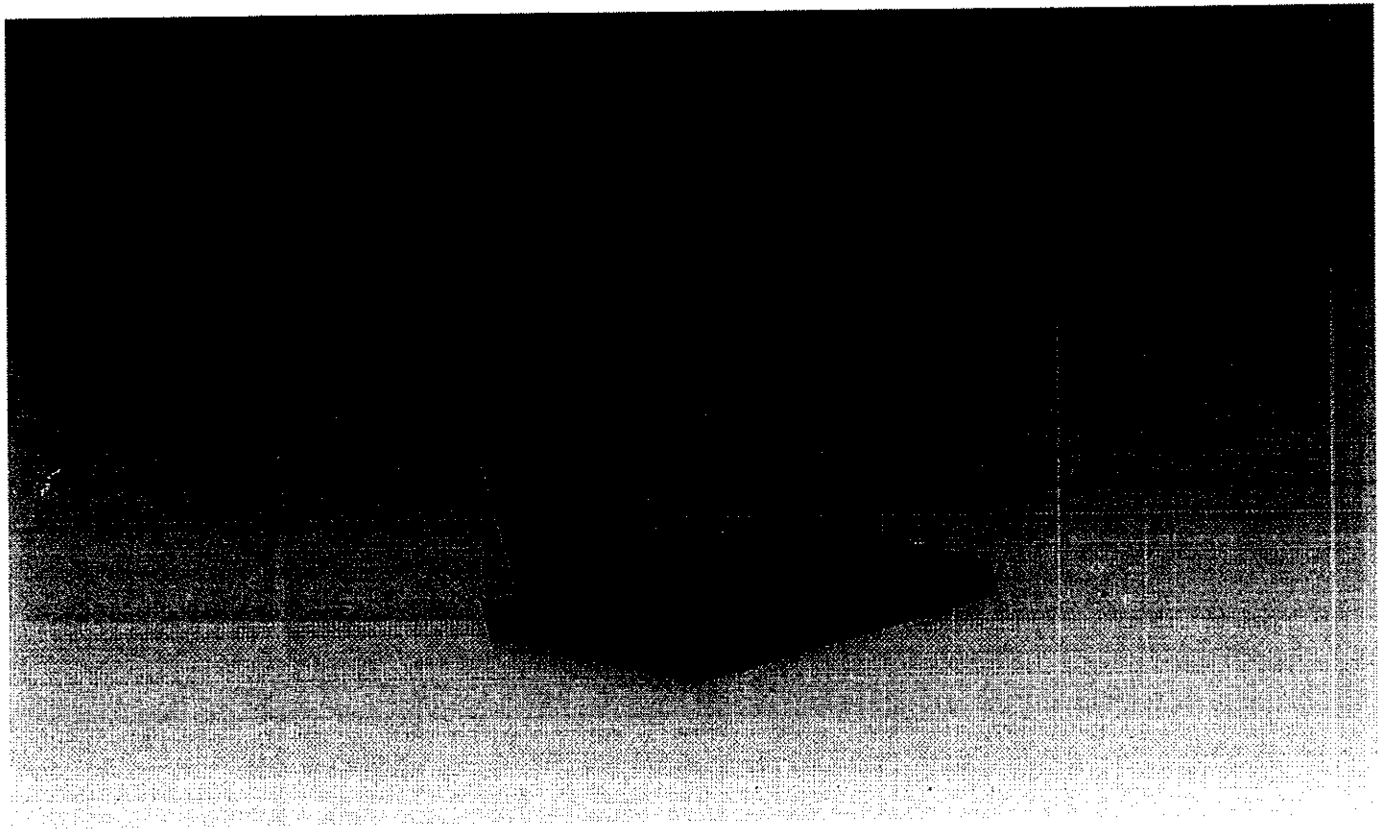

Figure 6.12 Bracket for Z-Axis Cylinder

CHAPTER 7 COST ESTIMATION OF LOADER/UNLOADER

7.1 DEFINITION:

Cost estimation is the estimation of the expected cost of producing a job or manufacturing order before the actual production is taken up or predicting what things will cost, before they are made.

Costing means classifying, recording and allocating the appropriate expenditure for determining the cost of production and is achieved by keeping a continuous record of all the costs involved in manufacturing.

7.2 ELEMENTS OF COST:

7.2.1 Direct Cost:

Direct costs are costs which directly contribute to the final product and can be directly allocated to the manufacture of a specific product. It includes the cost of raw materials, labour processing the materials and cost of equipment and special tooling.

7.2.2 Material Cost:

Material cost consists of the cost of materials which are used in the manufacture of the product. It is divided into direst material cost and indirect material cost. Direct material cost is the cost of materials which are directly used for the manufacture of product and become a part of finished product. In addition to direct materials a number of other materials are necessary to help in the conversion of direct materials into final shape.

7.2.3 Labour Cost:

It is the expenditure made on salaries, wages, overtime, bonuses, etc., of the employees of the enterprise. It is classified as direct labour cost and indirect labour cost. Direct labourer is one who actually works and processes the materials to convert it into final shape. Indirect labour is one who is not directly employed in the manufacturing of the product but his services are used in some indirect manner.

7.2.4 Machining Cost:

Machining cost is the cost for performing various machining operations on the desired part. It also includes the cost for carrying out the finishing operations on the component.

7.3 COSTS FOR VARIOUS PARTS OF THE PNEUMATIC LOADER/UNLOADER:

Part 1: Main Base

Material cost for the part	:	Rs. 1500
Labour cost for the part	:	Rs. 600
Machining cost for the part	:	Rs. 1400
Total cost for the part	:	Rs. 3500

Part 2: Pneumatic cylinder for x-axis: Rs. 2500

Part 3: Z-axis LM guide mounting bracket

Material cost for the part	:	Rs. 750
Labour cost for the part	:	Rs. 500
Machining cost for the part	:	Rs. 750
Total cost for the part	:	Rs. 2500

Part 4: Pneumatic cylinder for z-axis: Rs. 2500

Part 5: Gripper mounting bracket

Material cost for the part	:	Rs. 1200
Labour cost for the part	:	Rs. 600
Machining cost for the part	:	Rs. 1200

Total cost for the part	:	Rs. 3000

Part 6: Gripper component

Material and labour cost for the part	:	Rs. 1200
Machining cost for the part	:	Rs. 600
Total cost for the part	:	Rs. 1800
Part 7: Pneumatic cylinder for gripper:		Rs. 1500

Part 8: LM guide y-axis

Material cost for the part	:	Rs. 500
Labour cost for the part	:	Rs. 250
Machining cost for the part	:	Rs. 500
Total cost for the part	:	Rs. 1250

Part 9: Cylinder connecting block

Material cost for the part	:	Rs. 430
Labour cost for the part	:	Rs. 325
Machining cost for the part	:	Rs. 350
Total cost for the part	:	Rs. 1105

Part 10: Adjustment block

Material cost for the part	:	Rs. 335
Labour cost for the part	:	Rs. 175
Machining cost for the part	:	Rs. 315
Total cost for the part	:	Rs. 825

Part 11: Cylinder mounting bracket for rod less

Material cost for the part	:	Rs. 285
Labour cost for the part	:	Rs. 215
Machining cost for the part	:	Rs. 225
Total cost for the part	:	Rs. 725

Part 12: Cylinder mounting bracket for Z-axis

Material cost for the part	:	Rs. 250

Labour cost for the part	:	Rs. 150
Machining cost for the part	:	Rs. 225
Total cost for the part	:	Rs. 625

Part 13: Mechanical stopper 1

Material cost for the part	:	Rs. 125
Labour cost for the part	:	Rs. 75
Machining cost for the part	:	Rs. 100
Total cost for the part	:	Rs. 300

Part 14: Mechanical stopper 2

Material cost for the part	:	Rs. 125
Labour cost for the part	:	Rs. 75
Machining cost for the part	:	Rs. 110
Total cost for the part	:	Rs. 310

Part 15: Mechanical stopper 3

Material cost for the part	:	Rs. 125
Labour cost for the part	:	Rs. 80
Machining cost for the part	:	Rs. 125
Total cost for the part	:	Rs. 330

Total cost of the Loader/Unloader	:	Rs. 22,770

CHAPTER 8 CONCLUSION

This project dealt with the modelling and fabrication of pneumatic operated loader and unloader.

In this, we have automated the loading and unloading process of the flywheel component in a CNC machine, which resulted in reducing the overall time required for completing a component.

This reduction in time resulted in the increase of productivity by 40% (24 components per day.

The cost of machining a flywheel component is Rs: 60. Therefore, it increases the profit for the components by Rs: 900 per day.

The cost of the pneumatic loader/unloader is Rs: 22770. Therefore the cost of the machine will be recovered in just a month.

Therefore after a month, the company will get a profit of Rs: 27,000 per month. The automation also saves the human workload put for loading /unloading the component.

If the gripper mounting bracket is replaced by some other arm, the pneumatic loader/unloader can be suitable for some other workpiece.

REFERENCES

1. Anthony Esposito (2004), *Fluid Power with applications,* Pearson Education, Patparganj, New Delhi.
2. Benjamin C. Kuo, Farid Golnaraghi (2002), *Automatic Control Systems,* MgGraw-Hill, New York.
3. Bolton.W (1997), *Pneumatic and Hydraulic Systems,* Butterworth-Heinemann, Washigton.
4. Igor Lazar Krivts, German V.Krejnin (2004), *Pneumatic Actuating Systems for Automatic Equipment: Structure And Design,* Butterworth-Heinemann, Washington.
5. Joe Jones, Daniel Roth (2003), *Robot Programming : A Practical Guide to Behavior-Based Robotics* ,PaperBack, New Jersey.
6. Majumdar.S.R. (1995), *Pneumatic Systems: Principles and Maintenance* McGraw-Hill, New York.