KAUNAS UNIVERSITY OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING AND DESIGN

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"Automation of Conveyor System for Improving of Air Conditioner Components Production Line"

Master's Degree Final Project

Supervisor

Assoc. prof. Antanas Čiuplys

KAUNAS, 2016

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INDUSTRIAL ENGINEERING AND MANAGEMENT (621H77003)

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KAUNAS UNIVERSITY OF TECHNOLOGY

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(Title of study programme, code)

"Automation of Conveyor System for Improving of Air Conditioner Components Production Line"

Final project

DECLARATION OF ACADEMIC INTEGRITY

20 May 20 16

Kaunas

I confirm that the final project of mine, **Arivazhagan Sarala Velayutham**, on the subject "Automation of Conveyor System for Improving Air Conditioner Components Production Line" is written completely by myself; all the provided data and research results are correct and have been obtained honestly. None of the parts of this thesis have been plagiarized from any printed, Internet-based or otherwise recorded sources; all direct and indirect quotations from external resources are indicated in the list of references. No monetary funds (unless required by law) have been paid to anyone for any contribution to this thesis.

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Approved:

Head of ____________________ *(Signature, date)*

Production engineering Department

Kazimieras Juzėnas

____________________ *(Name, Surname)*

MASTER STUDIES FINAL PROJECT TASK ASSIGNMENT
Study programme INDUSTRIAL ENGINEERING AND MANAGEMENT

The final project of Master studies to gain the master qualification degree, is research or applied type project, for completion and defence of which 30 credits are assigned. The final project of the student must demonstrate the deepened and enlarged knowledge acquired in the main studies, also gained skills to formulate and solve an actual problem having limited and (or) contradictory information, independently conduct scientific or applied analysis and properly interpret data. By completing and defending the final project Master studies student must demonstrate the creativity, ability to apply fundamental knowledge, understanding of social and commercial environment, Legal Acts and financial possibilities, show the information search skills, ability to carry out the qualified analysis, use numerical methods, applied software, common information technologies and correct language, ability to formulate proper conclusions.

1. Title of the Project

Automation of Conveyor System for Improving of Air Conditioner Components Production Line

Approved by the Dean Order No.V25-11-7, 3 May 2016

2. Aim of the project

To improve the productivity and to make the production line to meet the market demand

3. Structure of the project

- To establish the importance of automated conveyor system over manual conveyor system
- To study the current production process and its importance i.e. study of productivity in real time environment
- To collect the required data for better understanding
- To analysis the data to plan for further improvements
- Implementing the idea generated for improvement
- Follow-up with the production to understand the stability and improvement in production and quality
- Compare and assess the data

4. Requirements and conditions

- The cost of idea should be as minimal as possible
- Current production system should not get disturbed or production volume should not get affected. In worst case scenario production units should be the same as before the implementation of the new idea
- No detrition allowed in the Quality front

5. This task assignment is an integral part of the final project

6. Project submission deadline: 2016 May 20th.

Given to the student Arivazhagan Sarala Velayutham

Task Assignment received ______________________________ _______________________

(*Name, Surname of the Student*) (*Signature, date*)

Supervisor ______________________________ _______________________

(*Position, Name, Surname*) (*Signature, date*)

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Study area and field: Production and Manufacturing Engineering, Technological Sciences.

Keywords: *productivity, automated conveyor system, manual conveyor system*

Kaunas, 2016. 49 p.

SUMMARY

The master thesis deals with the productivity improvement of Air Conditioner components assembly line. The current process is done by manual movement for moving Air Conditioner assembly which is holding fixture in assembly line. This results in using more man power and considerable amount of time consumption by means of pulling the fixture from one stage to another stage for the process. The main aim of the project is to improve the productivity by fixing an automated conveyor system which enables us to improve productivity. This will also help to plan the production line depending upon the availability of the resources and material as the conveyor is equipped with variable speed system which will help to meet the demand requirement. The worthiness of initial capital investment on redesigning the current conveyor system by providing an attachment of chain conveyor with the current roller type conveyor in the shop floor has been discussed. A case study close to reality has been presented by performing calculation with real time values. The overall productivity of the plant is affected by various factors like man power and inventory supply at various stages of production. The effect of such type of factors has been studied and discussed. On the whole it was found that productivity after the implementation of automated conveyor system was impacted with a 10% higher than the productivity achieved over manual conveyor system.

Arivazhagan, Sarala Velayutham. Konvejerio sistemos automatizavimas siekiant pagerinti oro kondicionierių elementų gamybos liniją. Magistro baigiamasis projektas / vadovas doc. dr. Antanas Čiuplys; Mechanikos inžinerijos ir dizaino fakultetas, Kauno technologijos universitetas.

Studijų kryptis ir sritis: Gamybos inžinerija, Technologijos mokslai.

Raktiniai žodžiai: produktyvumas, automatizuota konvejerio sistema, rankinė konvejerinė sistema.

Kaunas, 2016. 49 p.

SANTRAUKA

Magistro tiriamajame darbe analizuojama oro kondicionierių komponenčių surinkimo linijos produktyvumo gerinimo galimybės. Dabartinis procesas yra atliekamas rankiniu judesiu judinant oro kondicionierių gamybos linijos konvejerio instaliaciją, kuri laiko surinkimo linijos pagrindą. To pasėkoje yra naudojama daugiau žmogiškųjų resursų ir ypatingai daugiau laiko, kuris sugaištamas judinant laikymo įrenginį nuo vienos pozicijos iki kitos. Pagrindinis darbo tikslas yra pagerinti produktyvumą adaptuojant automatizuotą konvejerio liniją dabartinei laikymo sistemai. Surinkimo linijos automatizavimo dėka konvejerio greitį bus galima konfigūruoti, tokiu būdu prisitaikyti prie rinkos paklausos bei planuoti gamybos apimtis. Norint sukurti naują konvejerinės linijos sistemos tipą priderinant grandininį konvejerinę konfigūraciją dabartiniam cilindrinio tipo konvejeriui gamybos patalpose reikalingas pradinis kapitalas, kurio atsiperkamumas taip pat buvo išanalizuotas. Buvo atlikta artima realybei atvejo analizė su realių duomenų ekonominio naudingumo įvertinimu. Bendram produktyvumui įtaką daro įvairūs faktoriai, tokie kaip žmonių resursų kiekis, inventoriaus pateikimas skirtinguose gamybos etapuose; šių faktorių įtaką buvo atsižvelgta ir įvertinta. Buvo ištirta, kad įdiegus naujo tipo konvejerinę liniją bendras produktyvumas bus pagerintas 10% palyginus su rankine konvejerine sistema.

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INTRODUCTION

The current project deals with the productivity improvement in Air Conditioner(AC) assembly process by introducing automated chain and roller type conveyor to maintain consistency, uniformity and to attain phased output in the production line/process. Presently, the process of AC assembly is being done by using roller conveyor which is manually controlled from one stage to another stage in the assembly line by stopping each and every stage for parts which is assembled in each stage for the process and then the same is being moved by hand to next stage for further assembly process. So, to reduce manual intervention, of one stage to another stage, automated conveyor lines should be incorporated to improve overall line productivity in AC assembly process. The main aim of the project is to improve the productivity by fixing an automated conveyor system which enables us to improve productivity. This will also help to plan the production line depending upon the availability of the resources and material as the conveyor is equipped with variable speed system which will help to meet the demand requirement. The worthiness of initial capital investment on redesigning the current conveyor system by providing an attachment of chain conveyor with the current roller type conveyor in the shop floor has been discussed. A case study close to reality has been presented by performing calculation with real time values. The overall productivity of the plant is affected by various factors like man power and inventory supply at various stages of production. The effect of such type of factors has been studied and discussed

Aim

To improve production and to make production line to meet market demand.

Objectives of the work

The objective of the thesis work is to improve an existing assembly line in the conveyor system. The research is based on the study which analysis an existing assembly line and redesigns it for productivity improvement

1. LITERATURE REVIEW

The productivity of assembly line is described as the volume of work completed per unit time by using the available materials. Assembly process is done by joining of different components to form an end user product in the production line, and it is done by using automated and mechanized device to achieve various function in the assembly process. The main purpose of using assembly line is so important because of the mass production, which acquiesce us to produce more products continuously. In, manufacturing companies the assembly line is more productive since it helps in operating of difficult machines into a repeated step. Mostly, a globalized companies depend upon the manufactures who makes them to complete the product with speed and efficiency to meet the market demand. Correspondingly, Conveyor system will help in boosting the productivity and so that the labour cost and the consumption of energy can be reduced [1].

Throughout the 20th century, comprehensive steps were taken for developing automated process which is used by manufacturing industries for increasing efficiency and to continue an immense quality of production. The expanding demands for productivity, proper distribution of resources and reducing cost have continuous research and analysis in manufacturing systems. Automated assembly operations play a crucial aspect in manufacturing industries [2].

The use of mechanized and automations emerge to be growing as it plays an important role in production system. By introducing automated conveyor system, it will decrease the physical work demand.

1.1 Automation of Assembly Line

Assembly line is one of the most efficient and convenient method being used in assembly production line/system. The assembly line explains as, how well a production system uses its assets to reach production goals at optimal costs. By using the conventional productivity metrics, such as utilization rate and throughput gives us the measure of performance of the assembly line. Assembly line perform a series of operations to combine at different stages to get a final product. (i.e., AC assembly as a completed product which is ready to move to market for sale) [3]

This technology is considered for the following conditions:

- High product demand
- Steady product design
- The assembly which consists of more number of components to get it assembled

- The product is created for automated assembly
- High production rate
- High product quality and precision to get more or less zero defects

1.1.1 Types of Automated Assembly Line Systems

Based on the physical configuration the automated assembly systems are classified as [4]:

1. Dial or Circular type assembly method
2. In-line or Straight line assembly method
3. Carousel or Closed loop assembly method
4. Single-station or One-point assembly method

1.1.2 Dial or Circular type assembly Method

In this system, the work parts are placed in a circular table or dial table. The work parts are added at various workstations which is located around the edge of the dial. As, the work stations are usually located outside the periphery of the dial table, when the dial table turns the parts are assembled consecutively.

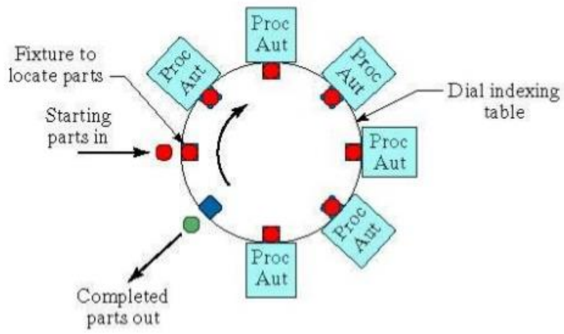

Fig. 1.1. Workflow process of Dial-Type Machine

Figure 1.1[5] shows the workflow of how parts are loaded which are attached to the rounded dial.

1.1.3 In-Line or Straight Line Assembly Method

In this system, the structure of assembly systems consists of continuous workstations in a more or less straight -line arrangement. The workstations are located in the straight line of transfer system which helps in transferring work parts from one workstation to another work station.
The workflow of the in-line system is illustrated in the ***Figure 1.2***[5]:

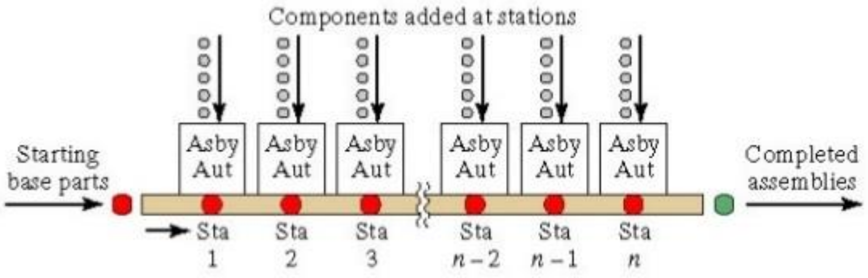

Fig. 1.2. Workflow process of In-line Machine

1.1.4 Carousal or Closed Loop Assembly Method

The carousal assembly systems perform a circular flow combination of work furnished by dial type assembly machine and the straight work flow of the in-line assembly type. The carousal system configuration is used partially in the automated assembly systems. The system configuration is shown in the ***Figure1.3*** [5]:

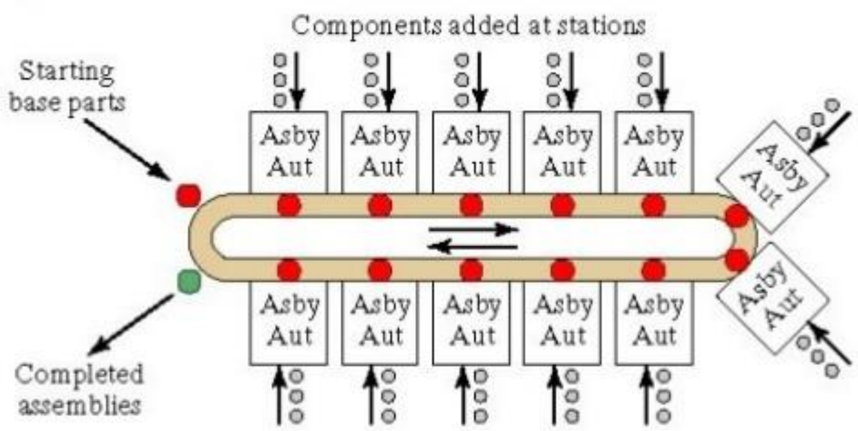

Fig. 1.3. Workflow process of Carousel Assembly System

1.1.5 Single-station or One-point Assembly Method

In single station assembly machine system, the assembly operations are executed at a single work station. The operations involve the arrangement of base part of the workstation where different components are added to the base. The work parts are forwarded to the workstation by feeding mechanisms, and one or more work heads operates the various assembly and fasten the operation.

Basically the single-station is sometimes configured for robotic assembly functions. The parts are fed to single station which are added to the base parts and perform the operations.

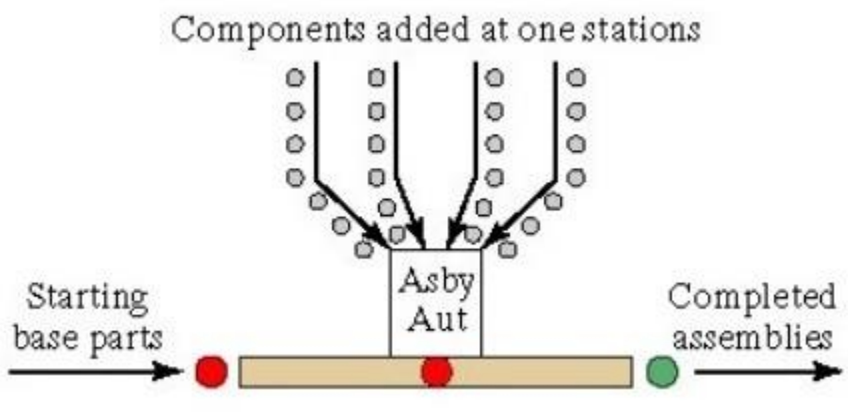

Fig. 1.4. Workflow process of Single-Station Assembly Method

Figure 1.4[5] illustrates the possible combination of work transfer and assembly of system configuration.

1.2 Various Elements Involved in an Assembly Process

In order to create the understanding of the dynamics in a continuous assembly process, it is important to be get it familiar with the various elements, which is involved in assembly process and the relevant details are explained below:

1. **Work station**

A ***work station*** is the part/section of assembly line where a certain volume of assembly work is executed. Each station of the assembly line is fixed up with materials, machine, method of working, required tools, and the workers who are required to complete the work/task assigned to them in the operation line [6].

2. Operation

The assembly process of a product consists of a series of sequenced action which moves on the assembly line. These indivisible actions are called as ***operation*** [6]**.**

3. Operator

The work of an operator is to perform an operation in the assembly line which is assigned to them. The operator executes their work either manually by using hand tools or by using automatic tools depending upon the requirement at that particular assembly stage. Based on the total number of work station the operators are utilized on the assembly line process [7].

4. Material Flow

A ***material flow*** is defined as the continuous transportation of raw material, parts and components etc., which is used in the production system. It is very critical in production line since, whole production will be affected if there is any shortage or problem, which may stop the whole system until the required item is received or corrected [7].

According to Scholl [8], he emphasizes the main advantages of flow line related to production system which are:

- High capacity utilization
- Regular and simple material flow
- Less space is required for material movement
- Ability to use less skilled operators
- Easy training of less skilled labors for allotment in shop floor

On the contrary, he points out the disadvantages of these system as:

- High investment required for installation
- Maintenance and repairs may become critical
- Machine break-down may stop the system completely
- Rigidity of the system will be pf high specialization which may result in shortening of product life cycles

By considering these factors, consistent products, bulk production and the material must be supplied continuously for the successful work in the assembly line system.

1.3 Advantages of Automation Process

It is very well, known that manual methods used for production, pose many difficulties such as requirement of increase in labour force, hence larger investment of production capital. To reduce these lacunas, we use automation process, which has the following advantages:

1. Increase productivity
2. Improve quality of the product
3. Improve consistency of process or the product
4. Increase the consistency of the output
5. The operationtime and work handling time can be reduced
6. The workers can be freed up and used in other roles
7. Reduces the direct human labor cost

1.4 Disadvantages of Automation Process

Although automation is constantly setting up standards for the industry, there is also some disadvantages aspects which are as follows:

1. Initial investments
2. Skilled people is needed for maintenance
3. Development costs
4. Technology limits

1.5 Benefits of Assembly Line

Basically, assembly line benefits are classified as two types, such as [9],

Technical Benefits

1) It can lessen the number of workstations for given cycle
2) Cycle time for each work station can be decreased
3) Idle time could be shortened
4) Minimizing the overall facility length
5) Throughput time might be decreased

Economic benefits

1) Labor cost can be cut down as per unit
2) Net profit might be expanded
3) Overall cost of labor, workstations and product defects can be diminished
4) Inventory, setup and idle time cost can be decreased
5) Overall inventory process costs will be reduced

2. PRODUCTION SYSTEM

A ***production system*** indicates to a system, which transforms a function of an input to get a desired output by using the required process and the resources. The production system depends on utilizing the facilities, equipment's and processing the method to satisfy the customer and to produce the goods depending on the demand. Basically the production system is characterised as [10]:

1. **Job shop production**
   - This process is suitable for manufactures who has a small batches with different products, which requires a unique and custom designed of processing steps on production process
   - More time is consumed in preparing access to equipment
   - In this system different sequences are followed over different shops for various type of products
   - It is famous for rapid value addition
   - It is mostly suitable for producing less volume with variety of custom designed products
   - Less investment and easy to start
   - Management problem will be less since workforce will be small
   - Because of the flexibility, the failure won't affect reduction of demand in factory
   - The utilization equipment will be low

2. **Batch Production**
   - In batch production mixture of products can be made in different volumes
   - With vast range of products, different products are repeated in large volume
   - Batch production is more often preferred when there is variety of volumes and products which are to be produced
   - Generally, the plant capacity is higher than the demand
   - It is smaller than mass production progress and colossal in scale than that of job production
   - The production rate will be high since it is used for general purpose

3. **Assembly line (Mass) Production**
    - It is suitable for a precise range of regulated products in high quantity
    - In this unit, the same sequence of operation is carried out which is positioned along a production line for successive output
    - The assortment of product is fixed here. Ex. Assembly of AC, television etc

4. **Continuous Production**
    - It is used for producing a repeated flow of products
    - Since, the process are automated the capital investment will be high
    - Large volume of products could be made and also the quality will be better
    - The product output is highly standardized
    - When the process is continuous, high volume of products can be produced
    - The production process will be continuous instead of batches or various units
    - Labor cost will be reduced since, only few skilled workers are required

2.1 Factors for Productivity Improvements

There are variety of factors which affect productivity, both affirmative and dissentingly. Some factors can be under controlled some cannot be under control and these are listed below:

Table 2.1. Factors of Productivity Improvement [11]

Sr. No	Factors
1	Capital investment in production
2	Capital investment for equipment
3	Capital investment in facilities
4	Technological changes
5	Work methods
6	Procedures

7	Quality of products
8	Quality of processes
9	Skill and knowledge for training and experience
10	Social environment

2.2 Productivity Improvement Indices

Productivity is a regular measure the ability of production. It can be declared as the ratio of output to inputs used in the production process. i.e., output per unit of input. When all inputs and outputs are comprehended in the productivity measure, then it is called as ***total productivity*** [12].

An increase in productivity measures an increase in output which is proportionally greater than increase in input. The basic rules/principles for the development of improving methods which helps in productivity indices are of following types [13]:

i. Principles concerning the use of Human Body
ii. Principles concerning the plan of the workplace
iii. Principles concerning the design of tools and equipment

Basically, these rules provide a suitable way of doing work which maintain us how to use human body, how to place the equipment and tools and also how to design the work place. The various principles are listed below:

i) Principles concerning the use of Human Body

1. The workers should not be rambling and should begin and finish their progression at same time
2. Work should be organized so that eye confirmed to a comfortable area, without the need for frequent changes of focus
3. Continuous flow are to be adopted to straight-line ambulation associated with changes in control
4. Gesture of the arms should be symmetrical and in opposite direction simultaneously

ii) Principles concerning the plan of the workplace

1. Fixed stations must be implemented for tools and materials regular habit formation
2. Tools and material should be relocated in the same place to cut down searching
3. Tools, materials and controls should be positioned within the maximal working area to avoid wastage of time
4. The color of the workplace should be contract with that of the work, thus reducing eye fatigue

iii) Principles concerning design of tools and equipment’s

1. Two or more tools should be connected wherever possible
2. The hands should be consoled of all work of holding the workpiece where this can be changed by fixture or foot-operated device
3. Handles such as cranks and large screw drivers should be arranged that as much of surface of hand as feasible so that it can come into contact with the handle. This is especially necessary when considerable forces have to be used on the handle
4. Levers, crossbars and hand wheels should be located that the operators can use them with the least change in body position and with the greatest “mechanical advantage”

2.3 Performance Indexes and workstation Sequencing

Various factors are essential for studying and integrating the assembly line design and depending upon the production approaches, objectives and pressure. And to collect the assembly line data, the following different performance indexes and workstation are required.

Table 2.2. Performance Indexes and sequencing of workstation [14]

Performance Indexes	**Workstation Indexes**
Variance of time along product versions	Operator skills, motivation
Cycle time	Tools required
Number of stations	Setup time
Transportation network	Average station time
Reliability	Worker absenteeism during operations

2.4 Parameters Involved in Production System

The following part represent the different time parameters that involved in production system.

- Operation Time
- Cycle time
- Idle time
- Tolerance time
- Throughput time
- Labor productivity

2.5 Methods of Work Part Transport

The transfer mechanism of automated assembly line is not only to carry the moderately completed products or the assembles in the station, it should also locate the parts in the perfect position for processing each station. The most applicable transport system hinge on the pursuing aspects:

- The type of operations to be performed
- Total stations on the line
- The weight and size of the work parts
- Production rate demand
- Balancing the various process of time on the line

The general methods of transporting of work parts can be classified as [15]:

i. Continues transfer
ii. Intermittent transfer
iii. Power and free transfer

i) Continues Transfer

In continues transfer method, the work parts are conveyed constantly at a specific speed. This requires the work heads to move during processing in concern to provide continuous registration with the work part. For some types of operations, the movement of the work heads during processing is not appropriate. By using the continuous transfer system, we can achieve the high rate of production since it is comparatively easy to the design.

ii) Intermittent Transfer

In this method, the work parts are transferred with an intermittent or incoherent motion. The workstations will be in fixed position and the work parts are carried between the stations and then the proper locations are enrolled for processing.

iii) Power and Free Transfer

In power and free transfer method, the system allows each work part to change to next station when the processing is completed at the present station. Each part moves separately with other parts. Thus, the parts are being refined on the line with same time that other parts are being transferred between stations.

3. ANALYSING AND DESIGNING THE VARIABLES

There are various variables involved in designing the best assembly process to transfer the work products through a manufacturing operation process. The more complex is the product, the more extensive is the product mix. As product mix or quantity increases, the traditional material handling methods may prove incomplete or counter-productive.

Basically, assembly challenges include, numerous parts, components, and subassemblies and synchronization of the work at each stage. Therefore, assembly operation requires explicit, repeatable process, and special environment provisions such as clean rooms, temperature control etc. Operations to accommodate model variations with different lot sizes and products requiring up to 100% inspection.

Companies successfully managing the demands of continues, profitable growth have recognized the need for a mechanized solution, i.e., Conveyor system designed for assembly flexibility. More often, the best product assembly strategy depends upon the right mix of automated and manual operations and the ability to adjust the mix as necessary. Thus, flexible assembly conveyors, seamlessly integrated into the assembly process they support, which provide the best solution for today's complex assembly conditions.

3.1 Conveyor System

The conveyor system is a common segment of mechanical handling equipment which associates the movement of the product from one place to another place. In 1913, Henry Ford popularized the assembly line conveyor system in manufacturing process [16], in which commutable parts was added to a product in a continuous movement to create a finished product which is much faster than the manual method. By using this technique in mass production the worker's job was stable as it is being done in phased manner [17].

3.2 Why do we need Conveyor System?

Conveyor systems provides a various benefit to manufacturing companies, warehouses and other facilities that are added into the continuous operation. The benefits of using conveyor system are listed as [18]:

a) Speed

It provides a decisive and quick mode of forwarding work products from one assembly phase to another assembly phase which results in continuous flow of materials into a constant process, thus it leads in improving productivity and firmness in the product.

b) Labor cost

Since the assembly process is automated, only less workers will be required for the assembly process. This helps companies to use the work force or reallocate the workers based on the demand in other processes.

c) Adjustable flow

Based on the demand and production requirement the speed of the conveyor system can be increased or decreased by using variable speed which helps us to meet the needs or accumulate the flow of work conditions

d) Visibility

Since the assembly parts in the conveyor system are easily seen as they move through the conveyor system, which reduce the defect in products and helps workers in greater chance of spotting the work flow.

e) Safety

The risk of injury to workers is reduced, since the workers are not manually carrying materials from one place to another place.

3.3 Parameters affecting Line Balancing

Line balancing is normally used to diminish imbalance between machine which helps us to meet the required output from the assembly line. Line balancing is a mechanism, used to improve the assembly line by reducing manpower. The main job of line balancing is to attach a series of workstations in the assembly line where the total workstations and total amount of unproductive time are reduced for required output [19].

By using line balance, unevenness can be minimized between the workers by allocating specific time limit at each station in order to meet the production demand. Basically, line balancing method is used in many industries for productivity improvement, which helps in reducing manpower and arresting the cycle time in assembly line and also enables us to produce more products at same time.

The following criteria has to be considered in line balancing process:

a) Takt time
b) Cycle time
c) Downtime
d) Minimum number of workstations

a) Takt time

It is a pre-consideration method while carrying-out line balancing task. Takt time is the measure of production that regulate with production demand. It helps us to show how quick the manufacture need to be completed in order to meet the customer orders.

b) Cycle time

By using the cycle time, we can predict how the product is produced in the production line by using the available resources and staffing. In the assembly line, each operator will have a specific time to complete his work.

c) Downtime

Downtime determines the time which is non value added. Basically, it is usually associated with 5 wastes that are:

- Overproduction
- Defects
- Redundant inventory
- Improper processing
- Transportation

d) Minimum number of Workstations

A workstation is a substantial place where, the assembly process is done by workers with one or more products in the assembly line which performs a particular product. The workstations can be created based on the products need to be assembled in the assembly line. By using more number of work stations the work can be completed soon.

3.4 Benefits of Conveyor System

The following benefits can be incurred by using conveyor system in a production unit [20]:

a. Phased implementation
b. Reduced work in process
c. Line balance flexibility
d. Material flow options
e. Reduced footprint

a) Phased Implementation

To increase the productivity system, the assembly tasks can be elevated on-line, later the manual stations can be replaced with automation stations as per our requirements.

b) Reduced work in progress

By shortening the level of work in progress, we can have a major encounter on lowering assembly costs. Thus a development from batch to continuous assembly can pave the way to reduce the process which is necessary for just-in-time operations.

c) Line Balancing Flexibility

Stabilizing the work load is essential goal for assembly operations. Without the flexibility to retort completely to changing the production requirements, and the capacity to maintain optimal line balance may be actively compromised.

d) Material flow options

Material flow over an assembly efficiency can be altered by changing in any phase of the assembly operations. These can combine the changing of manual work stations with automated workstations. The existing modular conveyor line can easily acquiesce material flow to be modified or recompose.

e) Reduced Footprint

A wide range of production demand different types of conveyor which are geared system which conserve space. Standard construction allows complete freedom in configuration the system which includes, carousel and in-line assembly method. The straight line produces another significant opportunity to reduce space which has the ability to run more product.

3.5 Importance of Higher Productivity

A manufacturing industry or a firm may initiate a number of key steps which helps in improving productivity. William J. Stevenson [21] lists these steps for improving productivity:

- Developing the productivity measures all the operations: which is the first step in executing and handling an organization
- By checking the overall system, the most critical operations must be examined and based on the critical operation the over-all productivity must be improved
- To develop the productivity improvements, we need to study how other firms increase the productivity and must be examined the way work is done
- Feasible goals have to be created for improvement
- Management should guide and boost in productivity improvement which credits the workers for their incentives for their contributions

It is necessary to know the importance of higher productivity in manufacturing industries. Thus the importance can be summarized as follows [22]:

i. Productivity is a key to prosperity
ii. Higher productivity leads to economic growth and social progress
iii. Higher productivity requires elimination

i) Productivity is a key to prosperity

The rise in higher productivity results in higher production of products which has the direct impact on the market demand. It decreases the cost per unit and increases the worker wages and profit for the organization. The higher the demand the more opportunities for the employment.

ii) Higher growth leads to economic growth and social progress

When the production is higher, it helps us to reduce the cost price which makes the product easily affordable at cheaper rate. Therefore, it results in profitable for consumers. By lowering the price of the product the demand of the product increases which bring profit to the organization by manufacturing more products. Higher profit empowers organization to higher allowance.

iii) Higher productivity requires elimination of waste in all forms

To improve productivity, it is important to get rid of wastage from raw material. Different methods like quality control, work study, operation research et are to be utilized to reduce wastage of resources.

3.6 Improvement of productivity by Work study

Work study is the organized methods of carrying an activity to improve performance by effective use of resources and setting up the activities which need to be carried out. The main objective is [23]:

- To analyze the present method, in order to develop a new method
- To increase the productivity, by using the best of human, material, machines and other resources to achieve quality at minimum cost
- To enhance operational efficiency

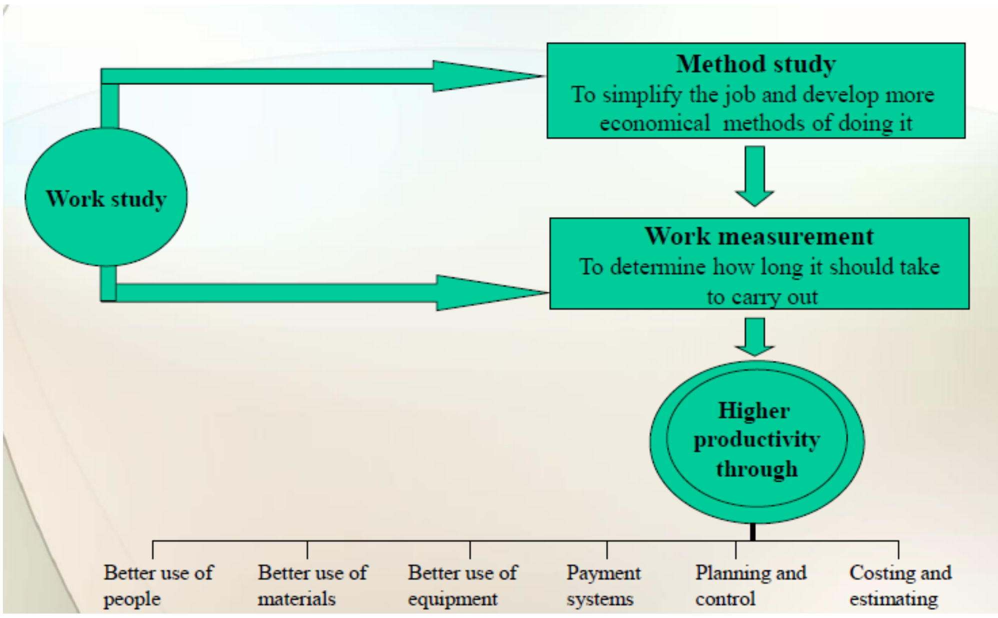

Fig. 3.1. Systematic method of Improving Productivity

3.7 Manual Conveyor system used in Assembly Line

Today in most of the manufacturing industries, roller and belt type conveyor are used in the assembly line process, and it is used to move isolated loads from one work phase to another work phase with sufficient sixe with the minimum friction but with very small changes of level.

The most traditional way of controlling conveyor system involves using manual approach. The maximum productivity and other production parameters achieved were low when compared to automated conveyor system. The main reason found is in the equipment used in the conveyor system.

The manual conveyor system is of two types, and they are with belt drivers or roller driven. The belt driven conveyor system consists of two rollers on both ends which are powered manually by rotating the sprocket and chain. The belt mounted on those rollers moves and carries material on them to be processed.

The roller conveyor system consists of a series of roller which are also powered manually. The material moves on the mounted rollers and is taken to next stage of production. The main disadvantage of manual conveyors is more and uneven lead time. There is a requirement of higher man power and time taken for overall production of goods increases significantly.

With the invention of labour policies, the amount of time allocated for each personnel has to be marginalized in such a way that the next personnel start working immediately, in continuous manufacturing environment. In such cases, enough man poet has to be allocated for compensating absence of responsible personnel due to reasons like industrial accidents and personnel leave levied by the individual.

Factors like ergonomics and personnel fatigue have to be included while designing manual conveyor system. The overall labour effectiveness factor has to be very high in manual conveyor system.

4. DATA ACQUIRED FROM COMPANY

Data required for assembly line details were directly acquired by visiting the manufacturing plant. A considerable amount of time was spent for observation and recording of data from various processes involved in the manufacturing line. The acquired data was validated through periodical meetings with the operations manager. The following analysis shows the performance of assembly line in real time.

4.1 Manual Conveyor System Details

The manual conveyor system, which was used before automation is:

Table 4.1. Manual Assembly line details

Conveyor type	Roller type conveyor with manual pull and push
No. of employee used	30 to 40 employee per shift depending upon the demand
Time required to finish 1AC	30mins approx. (with packing)
Product assembled per day	90 to 110 product approx. per shift basis

From the ***Table 4.1,*** we can understand that plant is capable to produce from 90 to 110 units per shift basis and based on utilization maximum production capacity has been assessed.

4.2 Capacity Assessment

Table 4.2. Capacity assessment in Manual Conveyor

No. of Shifts	No of Workers	No of Product Assembled/Shift	Working days	Production Capacity
1	30 to 40	90 to 110	26	2340 to 2860
2	30 to 40	90 to 110	26	4680 to 5720
3	30 to 40	90 to 110	26	7020 to 8580

Table 4.2 shows the production capacity, based on the shift wise and no of workers used in the working days to meet the demand.

4.3 Manual Conveyor Specification

Table 4.3. Specification of Manual Conveyor

Width	850mm (inner)
Height	850 mm+ 50mm
Top section Material	Aluminium
Leg Frame	75*40 MS channel
Fixture moving method	Roller type
Length	15 m

4.4 Materials and Tools required in Conveyor System

The following materials are required while using the conveyor system in the manufacturing industries and are as follows:

1. AC drive & tail unit with complete assembly with geared motor and frequency
2. Pneumatic pipe line with ball valve
3. Pneumatic stopper with mounting plate and foot valve
4. Pop up unit for vacuum and testing station
5. Ball table for vacuum and testing station
6. Roller conveyor for packing

4.5 Stage Wise Process Executed in Assembly Line

Table 4.4. Stage wise process in Conveyor system

Sr. No	**Stage Wise Process**	**Tools Used**
1	Base tray with valve plate fitting	Pneumatic gun
2	Coil screw fitting	Pneumatic fun
3	Compressor fitting	Pneumatic gun
4	Fan motor fixing	Pneumatic gun
5	Control panel fitting	Pneumatic gun
6	System tubing fitting	Pneumatic gun
	Capillary fitting	Pneumatic gun
		N2 Regulator
		Hose pipe
		Couper ½
		Hose clamp ½
8	System tubing brazing	Brazing torch
		Regulator
		Hose pipe
		Cylinder trolley
9	High pressure N2 test	N2 cylinder
		N2 regulator
		Hose clamp

10	Fan blade fixing	Pneumatic clamp
11	Gas charging	Gas charging machine
12	Front panel fixing	Pneumatic gun
13	Compressor terminal connection	Pneumatic gun
14	Performance testing	Digital thermometer
		Inficon 500
15	Valve shutoff and valve cap fix	Air flash nozzle
		Fix spanner
16	LH panel fixing	Pneumatic gun
17	Top panel fixing	Pneumatic gun
18	Hand cover panel fixing and unit cleaning	Pneumatic gun
		Touch-up paint
19	Installation kit	Sealing machine
20	Base tray edge board making	Pneumatic gun
21	Top cushion & poly bag covering	Packing boxes
22	Packing box making and covering	
23	Strapping	Strapping machine
24	Unit unload from the line	

4.6 Total Capital Investment on Machinery

The following ***Table 4.5*** depicts the amount of capital spent on each machinery, which is the approximated value.

Table 4.5. Total Capital Investment

A/C Peripherals	Amount (₹)	Amount (€)
Conveyor system	2000000	26498.10
Vacuum Pump	1000000	13249.05
Gas charging Machine	10000000	132490.48
Leak Testing Machine	1000000	13249.05
HLD	1100000	14573.95
Packing Machine	300000	3974.71
Air pipe, tools and tackles	1000000	13249.05
Air Compressor	3750000	49683.93
Conveyor Erections & commission	900000	11924.14
Total	**21050000**	**278892.46**

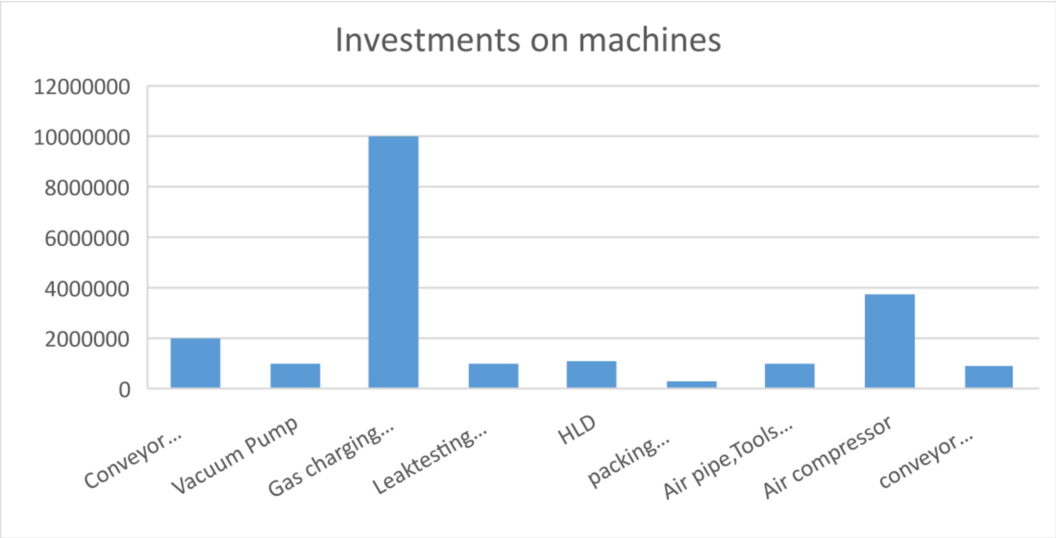

Fig. 4.1. Investment on machineries

From the ***Fig.4.1***, we can see that the highest amount of capital investment is done in Gas charging machine. The compressor is the most important part of an Air Conditioner. The refrigerant is filled in compressor which undergoes a thermodynamic cycle for the proper functioning of the air conditioner.

4.7 Production Details in Manual Conveyor System

Based on the shift basis and the production for the Jan'16 and Feb'16 are:

Table 4.6. Number of Production in Manual Conveyor System

Month	Production in Numbers	Rejection in Numbers	Rejection in %
Jan'16	2653	51	1.92
Feb'16	2792	52	1.86
Total	**5445**	**103**	**1.89**

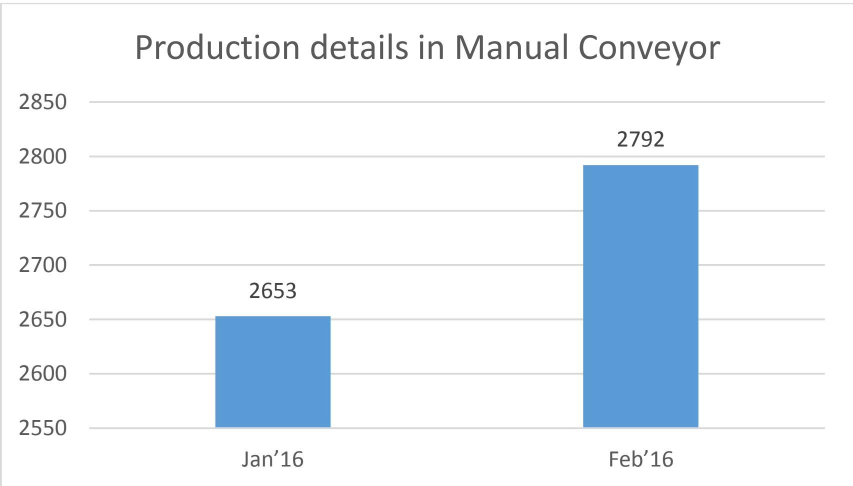

Fig. 4.2. Monthly Production details in Manual Conveyor

Fig 4.2, shows the number of products produced in manual conveyor system for the month of Jan'16 and Feb'16.

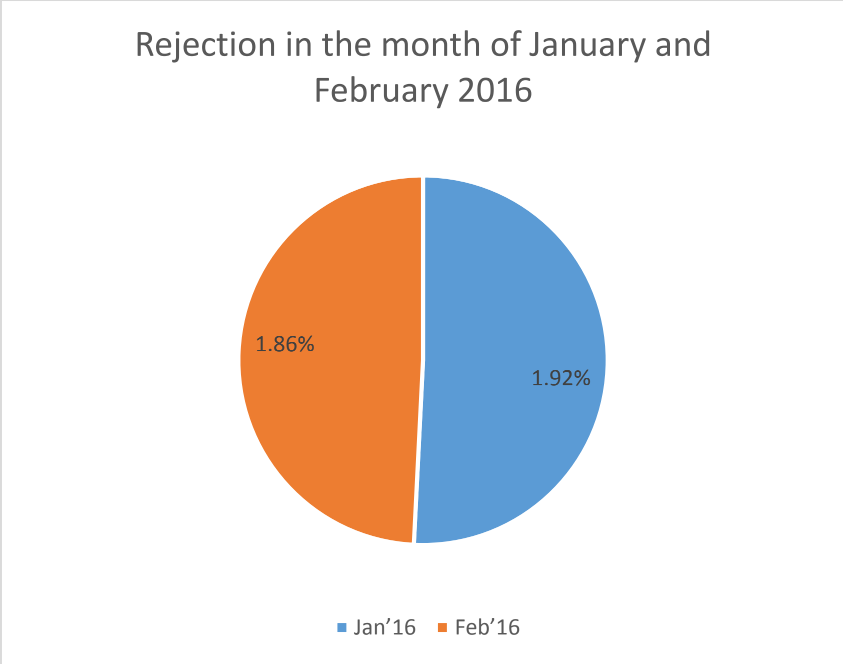

Fig. 4.3. Monthly rejection in numbers

The above ***Fig 4.3*** represents the number of rejections per month based on the total production. The comparison trend presented in the above fig is with respect to the total production in the month of Jan'16 and Feb'16. The rejection of 1.86% and 1.92% in Jan'16 and Feb'16 is due to leakage problem and ergonomic errors which resulting in missing of bolts while fixing and paint scratch while handling and damage the product.

5. IMPLEMENTATION OF NEW METHOD

Based upon the data collection and study of the plant capacity, the following suggestion has been made and the same has been implanted to increase the production.

Continuous rotating chain has been added in two sides of the roller and it is running in closed loop method.

This enables us to carry the fixture being used for AC assembly from one stage to another stage in which, we eliminate manual pull and push, which enables the workers to concentrate on their work continuously.

5.1 Automated Conveyor System Details

After, introducing the automated conveyor system, we can see from the ***Table 5.1***, the product assembled per day has been increased from 90 to 100 to 100 to 120. Which shows that there is an improvement in the production, when compared with manual conveyor system.

Table 5.1. Specification of Automated Conveyor

Conveyor type	Chain and roller type conveyor
No. of employees used	30 to 40 employee per shift depending upon the demand
Time required to finish 1 AC	30mins approx. (with packing)
Product assembled per day	100 to 120 product approx. per shift basis

5.2 Revised Capacity Assessment

Table 5.2. Revised capacity in Automated Conveyor system

No of Shifts	No of workers	No of Product assembled/shift	Working days	Production Units
1	30 to 40	100 to 120	26	2600 to 3120
2	30 to 40	100 to 120	26	7800 to 9360
3	30 to 40	100 to 120	26	5200 to 6240

From the above table we can understand that roughly 10% production is increased from roller type conveyer system (manual conveyor system) to Chain with roller type conveyor system (automated conveyor system).

5.3 Automated Conveyor Specification

Table 5.3. Specification of Automated Conveyor System

Width	850mm (inner)
Height	850mm ± 50mm
Top section Material	Aluminium
Leg Frame	75*40Ms channel
Fixture moving method	Chain and Roller type of length 15 m
Geared Motor	2 HP
Frequency Drive	2 HP
Variable Speed	0-100 (range depends on the production)

5.4 Production details in Automated Assembly Line

The following table represents the total number of product produced and also rejection in month wise after introducing the automated conveyor system.

Table 5.4. Number of Production in Automated Conveyor System

Month	Production in numbers	Rejection in Numbers	Rejection in %
March	3269	65	1.99
April	10586	196	1.85
May	3004	52	1.73
Total	**16869**	**313**	**1.85**

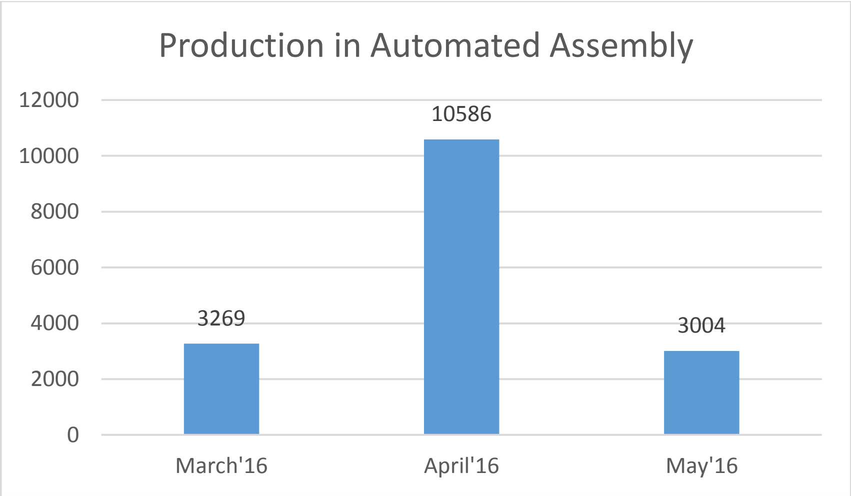

Fig. 5.1. Monthly Production details in Automated Conveyor

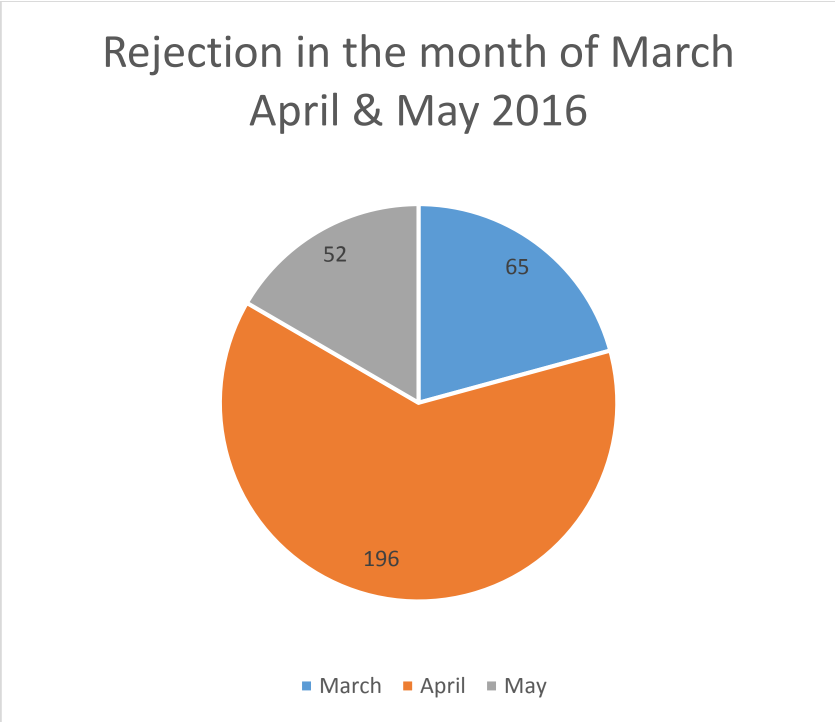

Fig. 5.2. Monthly Rejection in Numbers

From the ***Fig 5.1 & 5.2,*** we can identify that there has been more production in the month of April. This is due to summer climate, which as a result increased in demand for Air Conditioners. And also high amount of rejections (but not much change w.r.t percentage) is also evident from the graph as there were less number of workers and to keep such a high demand with less workers led to increase in labour efficiency.

6. COMPARISON OF MANUAL AND AUTOMATED CONVEYOR SYSTEM

Based upon the study and implementation of new method, ***Table 6.1*** shows the comparison of manual conveyor system and automated conveyor system. After, introducing the automated conveyor system, we can see the 10% increase in production, when it is compared with manual conveyor system.

Table 6.1. Before and after Comparison

Description	Before	After	Improvement
Conveyor Type	Roller type conveyor with manual pull and mush	Chain and Roller type conveyor	Motorized closed loop chain added to carry the work table/fixture
Unit production in a shift	90 to 110	100 to 120	Approx. 10% increase in production
Rejections	Approx. 1.89 %	Approx. 1.85 %	Not much difference
Cost Impact		INR 1.5 lakh invested for Chain and motor	

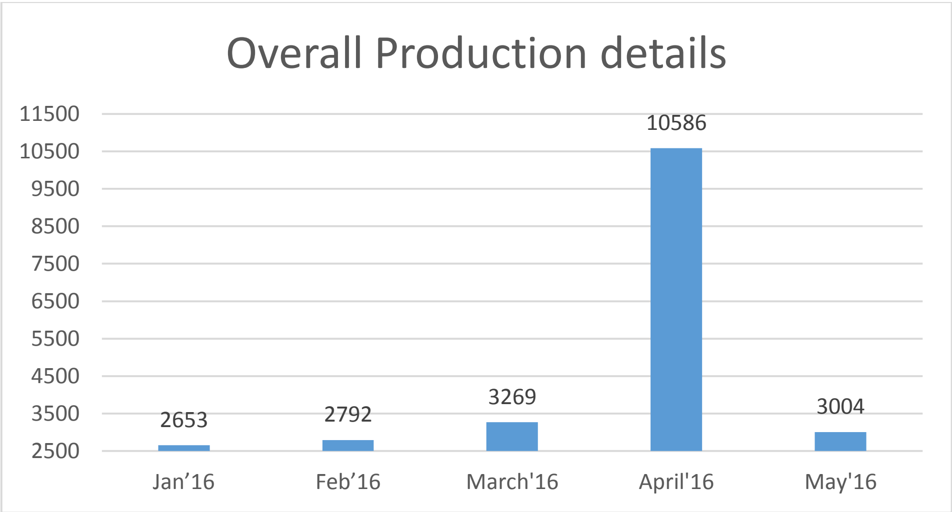

Fig. 6.1. Overall production details

From the ***Fig. 6.1,*** we can see the number of product produced in month wise and Jan’16 and Feb’16 shows the number of products produced in roller type conveyer with manual pull and push which is manual conveyor and the months March’16, April’16 and May’16 shows the total number of products produced in automated conveyor system

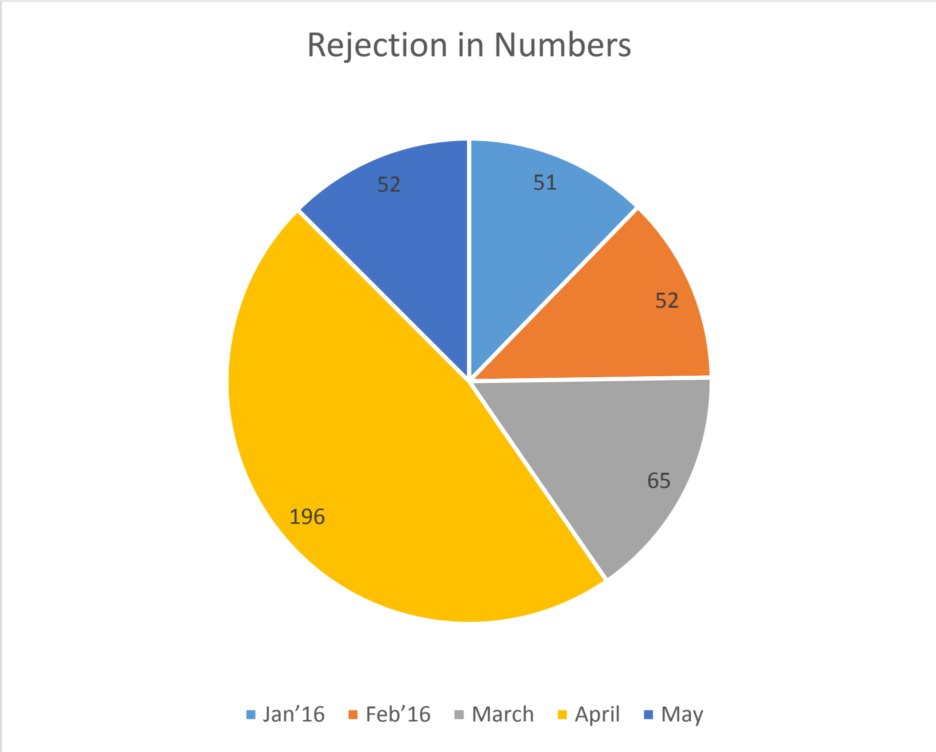

Fig. 6.2. Rejection in Numbers

CONCLUSIONS

The main aim of this project was to study the manual conveyer system used for assembling air conditioners and was trying to improve it by implementing appropriate automated conveyor system with least cost.

The following conclusions can be drawn from the analysis performed.

1. The total production in the month of February 2016 is 2792 products and the total production of March 2016 is 3269 products.

2. There are some minor fluctuations in the productions due to the influence of factors like labor strength and holidays.

3. To move the work table/fixtures from one stage of assembly process to next stage of assembly process, we introduced/added chain type closed loop with motorized system to the two sides of the roller end in the entire length of the conveyor. This has eliminated manual pulling from previous stage to their work station and pushing the same to next stage for next process.

4. After the implementation of automated conveyor system there was a cumulative rise in production by 10 % approximately.

From the study, we can conclude that we have introduced automated chain in the existing roller conveyor by elimination manual pull and push method and this has been achieved without affecting any quality detrition i.e. current rejection rate is retained as it is.

GENERAL SUGGESTIONS

The conveyor system being used at present in the assembly line air-conditioning unit in assembly process is manual and it takes a considerable amount of time and man power due to manual pulling and pushing of assembly fixture from one process stage to next process stage. In order to reduce the time constrains and man power, an automated conveyor is designed, which would co-ordinate with the existing of roller type conveyor system. The new conveyor is equipped with chain and roller type conveyor which would not require monitoring personnel.

In companies where man power need to be reduced or wages for the labourers needs to be reduced in order to compensate with the productivity improvements to meet the customer/market demands, this automation can be implemented. The cost of implementation could be recovered within the time period of first mass production. The labor personnel used for this manual process could be used for any alternative task, if reducing the manpower and labor wages is not the priority. Either ways, production will be quick and testing unit can use this valuable time for fine tuning the air-conditioner unit. The only demand of this concept is that, it can be only suitable for mass production companies which manufactures and assemble air-conditioner units on a global scale.

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APPENDIX A

LLOYD ELECTRIC & ENGINEERING LTD.
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RANIPET - 632 405. Vellore Dist. Tamil Nadu. India.
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LIVE THE FUTURE

Date: 10.03.2016

TO WHOMEVER IT MAY CONCERN

This is to certify that Mr. Arivazhagan Sarala Velayutham has successfully completed short term training from 23-Feb-2016 to 5-Mar-16 in our organization.

During his training he involved in detail study of Air Conditioner Assembly Line at Lloyd Electrical and Engineering Limited, being present in our Ranipet Plant, Tamilnadu, INDIA.

Throughout the course of this program his conduct was found to be good.

For LLOYD ELECTRIC & ENGINEERING LTD.

10/03/2016

Authorised Signatory

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