Efficiency Improvement of Plant Layout Design And A Workpiece Holding Mechanism For The Small And Medium Scale Powder Coating Industry

Hari krishnan V K
Dept of Mechanical Engineering
Bannari Amman institute Of Technology

Abstract- *Amenities are changed day to day enrichment the technology The convenient layout should be flexible and sufficient for modern changes While using this type of essential plant layout it develops the production and the produces maximum output The performance ability of production based on how well the various machines, services production amenities and employees' convenience are located in a plant The work piece holding system controls the transportation time And it reduces the human effort of the work piece movement In this study, the plant layout system was designed for small and medium scale powder coating industries to take care of the future development of new facilities The research involves identifying and solving plant layout problems This approach aims to study and improve the current plant layout and s analysed & designed by using a string diagram*

I INTRODUCTION

In recent days, industrial sector development is much more The same time, most of the small scale industries are followed the old and traditional manufacturing techniques The competitors between the industrial peoples are increasing day today So that the future development of the industry and to win over competitors the industry development and current trend upgrade s much more important These manufacturing techniques can be designed to cater for overcome the challenges of getting high growth in the marketplace The layout design is the arrangement of machines and equipment's of a plant in a way that will control the workflow and handling time In processing the product from the raw materials to the dispatched of the finished product The research paper presents solving an industrial problem using the principle of a string diagram The cleaning process takes twenty minutes of time And then the preheating it makes thirty minutes of time, the powder coating it makes thirty seconds for each body And then the bore cleaning t makes ten seconds Loading and post heat treatment it having a one hour of time In this working process the material handling and lag of technology upgrade

1.1 Research problem sources

- Personal experience
- Lag of employees
- Material transportation problem Social issues

II. LITERATURE REVIEW

Due to the layout redesign the efficiency of the layout t will be increasing by using a string diagram and systematic layout planning The fundamental guidelines are, the basic guidelines of the layout to be followed during layout design and redesign It produces the basic details of the material flow through the shop floor And the relevant of various activities It also explains the material flow and layout design using a systematic diagram [1]

Our research explains the work planning and procedures of material flow The layout types designed and implemented and also provided the key element for the layout design The material flow type and the requirement of the process of the redesign are also explained [2]

Many industries use ARC and diagrams for layout redesign and layout planning The use of ARC n designing a layout has provided steps for layout planning [3]

One more research focuses on the problems occurring in the flexible plant layout for manufacturing While the product demands are subject to variability A flexible layout is one that controls low material handling costs despite fluctuations in the product demand levels [4]

The research explains the warehouse redesign of a manufacturing plant layout [5]

The work process of the plant layout and working flow s detailed in the automation process [6]

The conveyor powder coating the system plant contains the paint phosphating material pre-treatment and material post-treatment and powder coating process are fully controlled by the conveyor system [7]

Current work Methodology

Cleaning the aluminium bodies' in the Phosphoric chemical for rust cleaning and machining cutting oil cleaning The material transportation problem on the oven for pre-treatment Each work piece t will powder coated one by one The excess powder s deposited on the inside bore t will clean with the help of pressurized air After cleaning the bore, the work piece t loading to the oven trolley by using steel rods Post-processing heat treatment for the powder-coated work piece Then the completed process the work piece unloading from the oven trolley

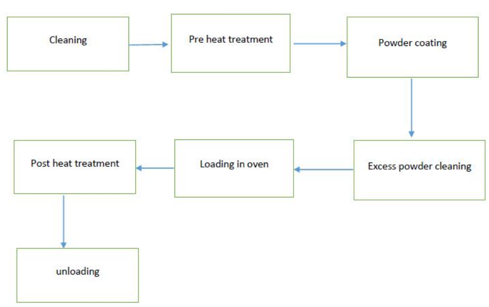


Fig-1 Plant layout flow diagram

III. PROBLEM DENTIFICATION

The research problem identification is the first process and the basic step of the research Nowadays most entrepreneurs are starting there own business by there own experience So they follow there own work experience and follow there own deal So that the workflow is getting heavy lag of work process due to traditional idea and using already working plans and they getting more material transportation time and the work process is fully controlled by employees If any shortage of an employee means the wok process is completely stopped

Problem on Work Process

In industry, the mass production product s half HP, quarter HP motor body powder coating process The powder coating process following sequences

Step 1 Motor body acid phosphating
Step 2 Motor body pre-treatment
Step 3 Motor body outer casing powder coating
Step 4 Motor body D powder cleaning
Step 5 Body loading to the oven
Step 6 Oven post-treatment
Step 7 Motor body unloading

STEP-1

While cleaning the aluminium bodies in the Phosphoric chemical for rust cleaning and machining cutting oil cleaning While cleaning continuously labours getting directly touch with the chemicals So the chemicals not suitable for all the workers It makes some skin allergy and the chemical smell t would make some unhealthy situations The cleaning goods are stored in the chemical tank for 20mins of soaking For remove the dust particles and the rust removal

STEP-2

The rust cleaned goods are moved from the cleaning area to the oven And then load the goods in the oven to heat for a temperature 140deg for drying The material transportation problem has occurred in the preheating

STEP-3

After preheating the powder coating process is performed The 1-micron powder particles are directly applied to the work piece The powder will be fused by positive and negative charges Each work piece t will powder coated one by one so that the time of the coating process t will make much more In the current situation each body takes 30sec to powder coat

The powder will be fused by positive and negative charges Each work piece t will powder coated one by one so that the time of the coating process t will make much more In the current situation each body takes 30sec to powder coat Because inside the bore the powder will be deposited If t's not clean means t makes a huge issue on assembly so that the bore cleaning s much important to clean The excess material it will remove by the pressurized air The air will be in the 5bar pressure to clean the bore

STEP-5

After cleaning the bore, the work piece t loading to the oven trolley by using steel rods The trolley size s 4*4*7ft t carries the 700 piece at a single load If t below the 700 pieces are loading means t makes a loss of cost

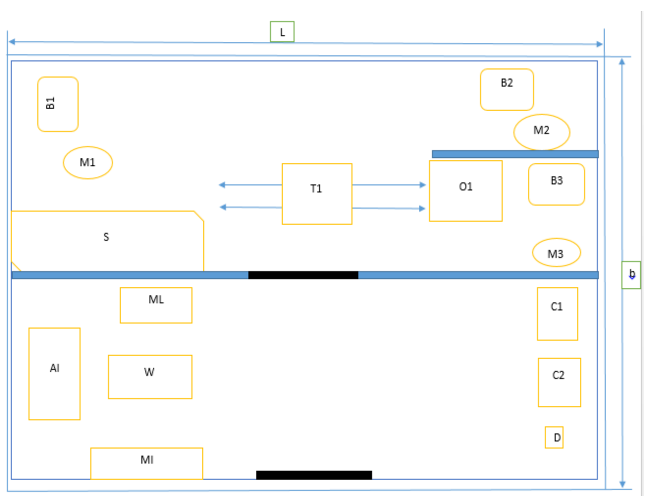
STEP-6

Post-processing heat treatment for the powder-coated work piece The oven size s 4*4*7ft so the full load will make more efficiency If we produce low load means the efficiency of the machine is reduced and it makes some losses

Step -7

The completed process the work piece unloading from the oven trolley While unloading the finished products are carefully handled If any mishandling means the powder-coated area will be affected

IV. CURRENT PLANT LAYOUT



B- Powder coating booth
M- Powder coating machine
O- Oven
T- Trolley
S- Powder storage
w- Cleaning water
B- Breath

C- Air Compressor
D- Air dryer
MI- Material incoming
ML- Material loading after cleaning
AI- Aluminium cleaning phosphating
L- length

The total area of the layout s 1742 4 sq ft And it is divided into two portions in 1st portion as 871sqft and another one as a 871sqft

Merits of an Automated Powder Coating

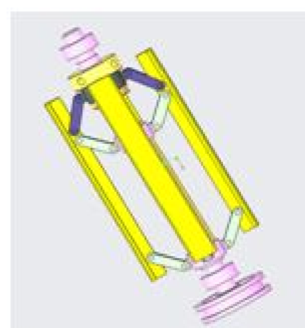
- Efficiency
- Uniformity
- Waste Reduction
- Saving

V. AUTOMATION TECHNIQUES AND DESIGNS

Body Holding Mechanism

The body holding mechanism it's designed by the linkage assemblies The **mechanical linkage** is an assembly of bodies connected to manage forces and movement The movement of a body, or link, s studied using geometry so the link is considered to be rigid The connections between links are modelled as providing deal movement, pure rotation or sliding for example, and are called joints A linkage modelled as a network of rigid links and deal joints s called a Kinematic chain Linkages may be constructed from open chains, closed chains, or a combination of open and closed chains Each link in a chain is connected by a joint to one or more other links Thus, a kinematic chain can be modelled as a graph in which the links are paths and the joints are vertices, which is called a linkage graph

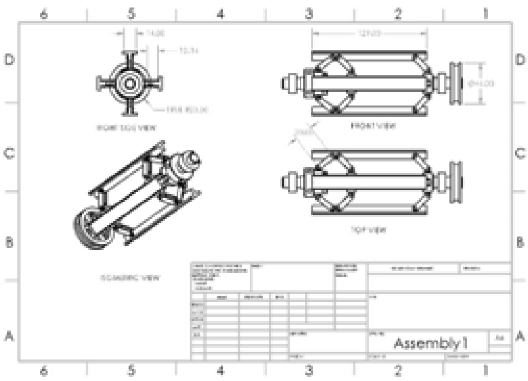
The 3D Design of the body holding mechanism



The movement of an ideal joint s generally associated with a subgroup of the group of Euclidean displacements The number of parameters in the subgroup is called the degrees of freedom (DOF) of the joint Mechanical linkages are usually designed to transform a given input force and movement into the desired output force and movement 3D Design of the body holding mechanism

The ratio of the output force to the input force is known as the Mechanical advantage of the linkage, while the ratio of the input speed to the output speed is known as the speed ratio The speed ratio and mechanical advantage are defined so they yield the same number in an ideal linkage

The 2D Design of the body holding mechanism



Work piece loading process

The body holding mechanism s also called t a body holding cartridge The cartridge which is designed for an inner diameter of the motor body Because the inner diameter of the motor body s machined for an international standard So the D of the body will maintain the same size So the outside surface of the cartridge s mating to the inner diameter of the motor body The linkage n the cartridge s having a deviation limit to ±5mm the deviation limit s to make a press-fit lock

Conveyor control system

- **Free Systems** with hand pushed trolleys available with a complete line of curves, brackets, switches, turntables, crossovers, lowerators, etc
- **Power Systems** with chain, drive(s) and a complete line of horizontal and vertical curves, take-ups, attachments, load bars, safety devices, etc
- **Power and Free** with chain, drive(s), trolleys with load bars, horizontal, and vertical curves, switches, take-ups, stops, etc

Design Specification For Overhead Conveyor

1) Length x width x height: 10670x5500x3387 mm
2) Desired capacity: 500 kg
3) Material: Steel 42

Material

1) Steel 42
Cr-0 8 to 1 1%, C-0 48 to 0 53%, Mn-0 75 to 1 0%, Si-0 15 to 0 35%, P-0 03%, S-0 04%, Mo-0 15 to 0 25% [17]
2) Young' Modulus: 2e5 Mpa
3) Poisson's Ratio: 0 3
4) Ultimate Tensile Stress: 420 Mpa

Bending Moment calculation

RA+RB = 5000
ΣMA = 0
= (RBx2175) - (2500x1587 5) - (2500x1087 5) = 0
RB = 3075 N
RA = 1925N
Bending Moment at D = (3075x587 5)
= 1 81x106 N-mm
Bending Moment at C =(3075x1087 5)-(2500x500)
= 2 09x106 N-mm
Max Bending Moment at C = 2 09x106 N-mm

Moment of inertia for beam

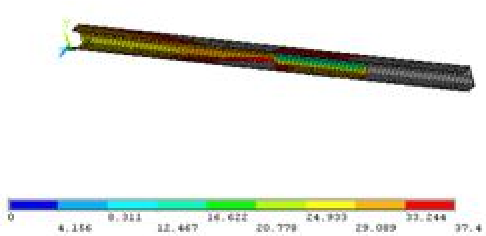
Yield stress = 420 Mpa
Factor of Safety = 3
Design Stress = Yield Stress / Factor of Safety
= 420/3
= 140 Mpa
Design Stress = (Moment x Y) /
(Equation1 16 Design Data Hand Book-K Mahadevan and K Blaveera Reddy)
Y= Distance from neutral axis to extreme fibre = 150 / 2 =75 mm
I= Moment of inertia
I= (Moment x Y) / Design stress
I = (2 09x106x75) / 140
I = 1 12x106 mm4

Moment of inertia for -section

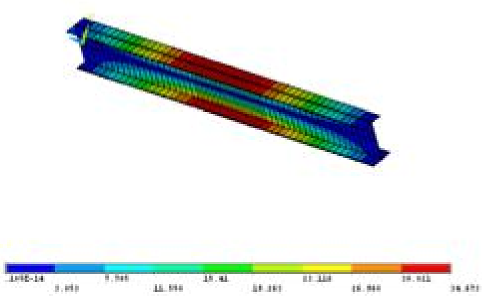
I = (BH3-bh3) / 12
(Table 1 3 Design Data Hand Book-K Mahadevan and K Blaveera Reddy)
B=80 mm
H=150 mm
b= B-t = 80-5 2 = 74 8 mm
h= 142 2 mm
I= ((80x1503) - (74 8x142 23) / 12
I=4 5x106 mm4
The moment of inertia of the –sections larger than the moment of inertia of beam, so the dimensions of the -section are acceptable

Design stress

Design Stress= (M x Y) /
(Equation1 16 Design Data Hand Book-K Mahadevan and K Blaveera Reddy)
Design Stress = (2 09x106 x75) / (4 5x106)
= 34 22Mpa
The design stress s less than the allowable stress140Mpa, so the design s safe



Finite element Validation Vonmises Stressin Section



Finite element Validation Vonmises Stress n C- Section

Constraints

1. Stores and heat treatment sections should not be interchanged or changed
2. Dimensions of current departments and aisle should not be changed

Objectives

The problem genesis led to the formulation of the following objectives:

1. To study the current flow pattern and relation of overall plant layout and develop a new plant layout
2. Relocating the workstations for simpler flow and reduction iin check points
3. To improve the efficiency of the plant layout using simulation

Tools and Techniques

The various tools and techniques used for plant layout redesign are:

Checklist: The layout evaluation checklist is used to identify the key problem areas in the present layout

String diagram: The string diagram s one of the simplest techniques of method study for recording and examining movement of workers and materials It is a tool for analyzing and designing work spaces in such a way that the movement of material, men, equipment etc

Outline process chart: An outline process chart s a process chart giving an overall picture by recording in sequences only the main operations and inspections

Flow process chart: It is a process chart used for setting out the sequence of the flow of a product or a procedure by recording all events under review using appropriate process chart symbols

Final Redesigned Layout

1 Work piece loading
2 Phosphating Plants
3 Pre Heating
4 Powder Coating
5 Post Treatment
6 Unloading

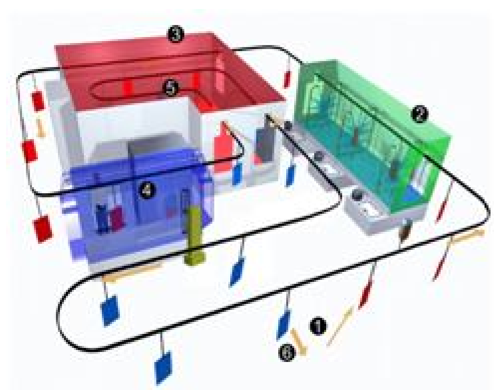


Fig 20 Final Redesigned Layout

$$\text{Percentage reduction in transportation length} = \frac{\text{difference in material movement}}{\text{current material movement}} \times 100$$

$$\text{Percentage Reduction in transportation length} = \frac{309.37}{672.08} \times 100$$

$$\text{Percentage Reduction in transportation length} = 46\%$$

PARAMETER	PRESCRIBED BY DGCA(DIRECTOR GENERAL OF CIVIL AVIATION)	EXISTING LAYOUT	PROPOSED LAYOUT
Simulation efficiency in percentage	80.24%	68.67%	94.67%

VI. CONCLUSION

This research paper has provided a good exposure to facility planning and layout designs for the improvement of the efficiency The choice of which type of facility layout to adopt can have a significant impact on the long-term success of a firm This decision, therefore, should not be considered lightly, but only after a thorough analysis of the operational requirements has been completed A major issue to be addressed n facility layout decisions in manufacturing s: How flexible should the layout be in order to adjust to future changes in product demand and product mix The study of layout has become extremely important The most common objective of layout design, that is to minimize distance travelled,is not always suitable for all the manufacturing industries Congestion in a specific area may have to be tolerated while maintaining minimum separation between facilities Instead of criterion of minimizing total distance travelled, one may wish to minimize the total distance of the material travelled The proposed plant layout efficiency is 126 05% which is greater than the efficiency of the current plant layout i e , 68 02% The efficiency improvement of the plant was increased up to 85 31% And the reduction in transportation length of 46% was achieved

REFERENCES

[1] Richard Muther, '*Pant layout and flow improvement*', McGraw-Hill Companies: New York, 1994

[2] Micheal Schenk, "*Manufacturing Facilities - Location, Planning and Design*", PWS-KENT Publishing, Boston U S A , vol 12, pp 337-339,1988

[3] Nehal Elsayar, Elwood S , Armour G C and Vollmann, T E , "*Allocating Facilities with Computerized Relative Allocation Facility Technique*", Harvard Business Review, Vol 42, No 2, pp 136-158, March-April 1964

[4] Saifullah benjafaar & Hillier, F S , "*Quantitative Tools for Plant Layout Analysis, Journal of Industrial Engineering*", IIE Transaction, Vol 14, No 1, pp 33-40, 1963

[5] Tobiah r master, Francis, R L ; L F McGinnis; and J A White "*Facility Layout and Location: An Analytical Approach*" 2nd ed Englewood Cliffs, NJ: Prentice-Hall, vol 9, pp 153-155, 1992

[6] https://www gemapowdercoating com/fileadmin/documents/User_Manuals/English/Equipment_and_Controls/System_Controls/TouchScreen-PC-en pdf?hash=1424266607

[7] https://www umashankarinternational com/powder-coating-plant html