OPTIMZATION OF MACHINE SHOP LAYOUT FOR AUTOMOTIVE SPARES MANUFACTURING UNIT USING QFD (QUALITY FUNCTION DEPLOYMENT)

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ABSTRACT

In today's competitive working environment quality assurance stands important in almost all the sectors across the globe. Quality need to ensured in all processes, right from ordering of materials, performance in workstation in an organized manner and packing the finished goods till the shop floor end with due considerations upon work and cost. In this paper, it has been highlighted that quality assurance can be confirmed through focusing on the design of machine shop layout with relevance to automotive parts manufacturing unit. Using QFD (Quality Function Deployment) attempt has been made to evaluate different factors of plant layout like flexibility , linear flow of materials , Ergonomics , safety , cost of production , Inventory space utilization, floor ambience etc . The above listed factors are categorized in two levels such as customer requirements and company requirements as demanded in Quality function deployment (QFD) and a house of quality table is constructed. Survey technique using Questionnaire has been adopted to collect Data from 30 respondents. The respondents were chosen among the final year students of Mechanical Engineering in Manakula Vinayagar Institute of Technology. The Objectives of the problem is to improve the production throughput by simplifying the flow pattern of materials by reducing the wastages within layout such as inventory and space consumption of layout.
Keywords: *QFD (Quality Function Deployment, Plant Layout, Ergonomics, Safety, Linear flow of Materials.*

1.INTRODUCTION

In this work focus is made on optimizing the shop layout in automotive unit using Total Quality management tool such as Quality Function Deployment (QFD). The main objective of plant is to improve the flow of material pattern movement inside the shop by simplifying the layout based on the consideration of expert's opinion within the organization. A layout generally applies to physical location of resources required for transformations like facilities, machines, equipment, operators, etc. This physical location impacts the several aspects of shop floor like flow of materials, increase in production efficiency and cost reduction.

In this paper we have taken alpha automotive manufacturing unit as problem illustration for improvement the layout plan as per QFD tool (Quality Function Deployment) .In the existing work environment following facilities are provided within the plant such as follows

1. **Inventory stores**
2. **Shop floor unit with work in process buffers**
3. **Material transfer units**
4. **Finished goods warehouse**

(The above facilities are taken as Reference from ACCL (Automobile Component Manufacturing Limited, Chennai)

These are the facilities available in the alpha manufacturing unit as mentioned above. The main focus is to study the critical aspects of layout based on that quality must be improved in increasing the throughput rates of production in every shifts. So in this paper effort has been taken to collect various data's from different articles based on that two main types of descriptors are classified as presented below:

1. **Customer requirements**
2. **Technical requirements**

It is understood that any plant layout within the industry must be constructed based on the requirements of customers also the with respect to the need of company facilities in order to move the components / products fast to the market segment on time. The existing situation can be analyzed by using QFD (Quality Function Deployment) tool in order to

prioritize the customer and organization needs based on house of quality matrix table. From the percentage of importance based on scores we can focus the areas for possible improvement to enhance the quality within the shop layout. The existing layout design is illustrated as shown in Fig 1.

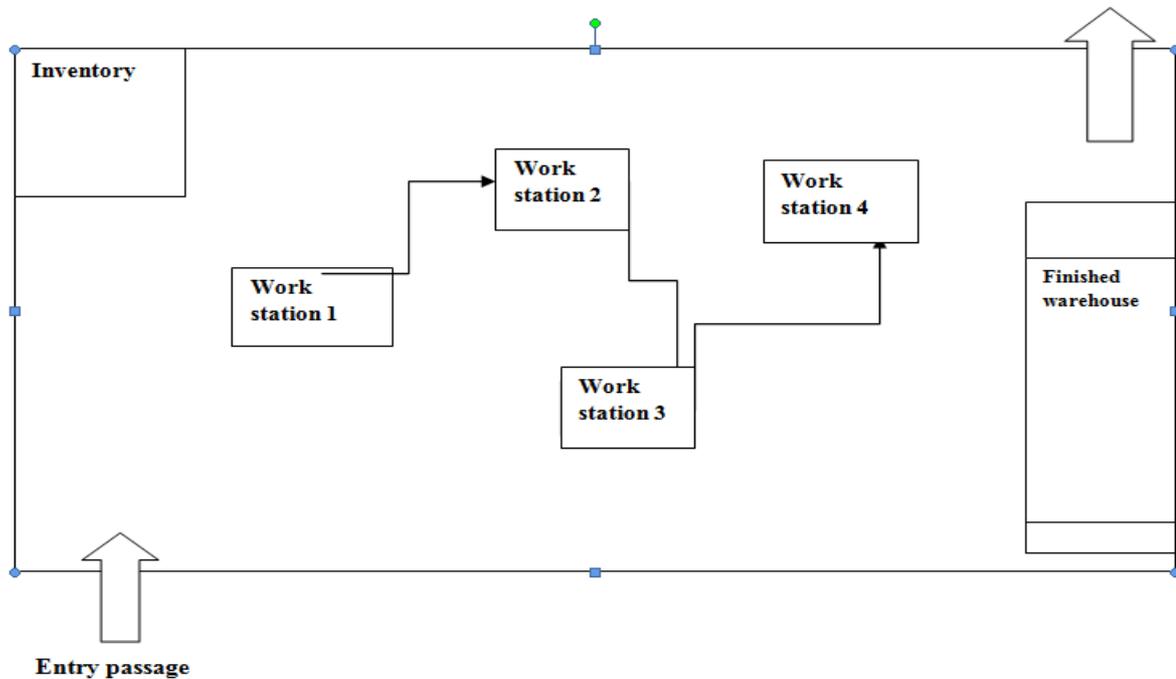*Reference from* **ACCL (Automobile Component Manufacturing Limited, Chennai)**

Fig 1, Existing plant shop layout model

From the above illustration as given in figure 1 it is understood that the flow pattern is so complicated in nature it is not so simple say linear pattern. So we need to study the choices of selecting the simplest layout by using QFD tool survey mechanism according to the customer description. The following are the various parameters fixed to improve the layout design for automotive manufacturing unit as listed below:

A. Customer Requirements:
1. Flexibility
2. Linear flow
3. Ergonomics
4. Safety
5. Cost of production
6. Inventory
7. Fast delivery

B. Technical Requirements :
1. Modern Material Handling systems
2. Conveyor Flow
3. Cubic Utilization
4. Throughput time
5. Special tools and Fixtures
6. Alarm/Signal systems
7. Ambience

These are the list of parameters to be considered for optimizing the layout facilities within the shop.
The above parameters are evaluated in detail with the help of house of Quality (QFD chart) and the graphical representation of mapping the customer descriptors and technical descriptors as mentioned above.

3. LITERATURE REVIEW:

A thorough survey about the Quality Function Deployment (QFD) is made by utilizing broad study as an approach. The main consequences of the examination are:

QFD displaying and applications are uneven; prioritization of specialized credits just expand consumer loyalty without considering cost (ii) we are still missing significant information about organizations for foreseeing improvement measures in consumer loyalty (iii) further investigation of the resulting stages of QFD is required (iv) more choice help frameworks are expected to robotize QFD (v) inputs from clients are not represented in current examinations (**Sunday AyoolaOke , 2013).**

An industry must always aim for world class manufacturing to accomplish the quality in manufacturing to sustain long in the developing business organization. Consequently it is significant for a MSME area (Manufacturing Industry) to build up their method of working constantly according to World Class Standards. In this literature work, current design of a fabricating MSME industry is considered and another design is created dependent on the efficient format intending to lessen the meter development, looking through time and increment profitability. The new plant format has been planned and contrasted and existing plant design with the assistance of Spaghetti Diagram. The new plant design shows that distance and in general expense of material stream from stores to dispatch region are fundamentally diminished. The execution of proposed model will help in the general improvement of creation execution of assembling industry. This exploration work additionally serves to other little businesses having such sort measure design in expanding their efficiency furthermore, accomplishing 100 % productivity.(**Gaurav Goyal, Devendra S. Verma , 2019).**

The present Pandemic situation has brought many new changes in layouts of manufacturing activities focused on volume as well as number of job orders to be scheduled. Therefore it is important for any sector to work efficiently with the recent situation surrounded by us by maintaining world class standards. This is an outcome of comparing Old tradition layout and new design layout. It introduces the new innovation in the business process design by optimizing the layout with improved safety and reduced cost. This removes the unsafe associations in the layout (**Prateek Pathak , Dhananjay Yadav , Pink Raj , 2020**).

The maintenance of plant shares huge working expenses. Lean reasoning can be consolidated into support exercises through applying its standards and practices/instruments. Lean upkeep or Lean Management (LM) is an essential for lean assembling frameworks. This exploration proposes another design for LM (Lean Management) measure dependent on a methodical writing audit of a critical number of related articles that were distributed on LM (Lean Management). Using lean management techniques one can able to optimize the space of layout by minimizing the wastages within the shop floor management system (**Sheriff Mostafa , 2015**).

Implementation of lean assembling standards in shop floor systems helps to improve the efficiency of layout in terms of maximum productivity .With the frequent change in the layout one can able to maximize the throughput time by reducing the wastages such as unwanted material flow , poor inventory maintenance systems etc. Plant layout improves asset usage and gives intends to use of lean devices, for example, 5S, kanban, Just In Time (JIT), and so on.(**Syed Asad Ali Naqvi , Muhammad Fahad , Muhammad Atir , Muhammad Zubair & Muhammad Musharaf Shehzad , 2016**).

The success of plant layout depends upon effective utilization of men, materials, machineries and space will have positive impact on improving the productivity of organization. Case study focused at furniture manufacturing plant in Harare, Zimbabwe and moreover this work presents the research findings and proposals for optimized plant layout and material handling systems using basic tools like work study to improve the simple motion as well as the quick accessibility of components within the layout (**Wilson R. Nyemba, Charles Mbohwa, and Lloyd E. N. Nyemba , 2016**).

In the competitive environment, optimization is the key role which focused about improving the productivity of organization. Using optimization techniques we can minimize the wastages within the plant layout system by simplifying the system performance. The most common thing in plant layout are throughput efficiency, cost etc. This paper particularly focuses on discrete event simulation of manufacturing systems (**Parminder singh and Manjeet singh , 2015**) **.**

In general machine shop layout problems can be solved either traditionally or modern techniques like computer simulation graphs. Since traditional techniques are more cumbersome work it is not possible to have solutions more accurately for real time problems. So in this work flexisim is a simulation tool used to model the manufacturing environment. The modern approach of plant layout can be done by simulation experiment using software's. Flexisim is analyzed to perform a model for 5 iterations (**Rajtilak J. Patil, Pravin R. Kubade, Hrushikesh B. Kulkarni , 2020).**

In the manufacturing of parts or spares virtual cells similar to traditional cells would be formed and it would group and re grouped to constitute new virtual cell. In virtual cell layout it would be often adjusted based on the batches in which the parts are manufactured with available resource and production control. It has been found that the traditional cell layout exhibit poorer performance due to imbalance in operations which influenced by processing times, reduced throughput and resource utilization (**K.Arun Prasath, et. Al ,** 2014).

3.1. Summary of review:

Based on the review of literature it is observed that various authors have contributed their ideas in improving the facilities of plant layout like simulation, optimization using mathematical etc. It has been suggested to increase the level of factor on the response variables and exclusion of one or more factors as per customer requirements or depending on customers' interference. (QFD Applied). It has also been suggested to include equipment costs due to obsolescence, maintenance, upgrade and replacement. In this paper attempt has been made to develop house of Quality matrix using QFD (Quality Function Deployment) by considering various descriptors that can be categorized based on consumer and technical requirements.

4. METHODOLOGY

In this section QFD tool is used to evaluate various parameters of plant layout as mentioned earlier in the introduction chapter. The input data's such as customer requirements and Technical Requirements are gathered through survey mechanism by framing questions nearly 10 respondents were answered. Under each response the relative parameters are compared based on that outcome of the system can be stated as strong, medium and weak. Therefore the house of Quality matrix is constructed as shown in fig 2. From
The fig 2. The relative importance and percentage importance of each technical parameter are evaluated using empirical equation as shown below
Formula for evaluating technical weights/Importance:
Technical Importance = $\sum t_j * c_j$
             Where j = 1 to n
T_j – Technical parameters, c_j = customer rating
Percentage of Importance (%) = $\sum t_j/n$
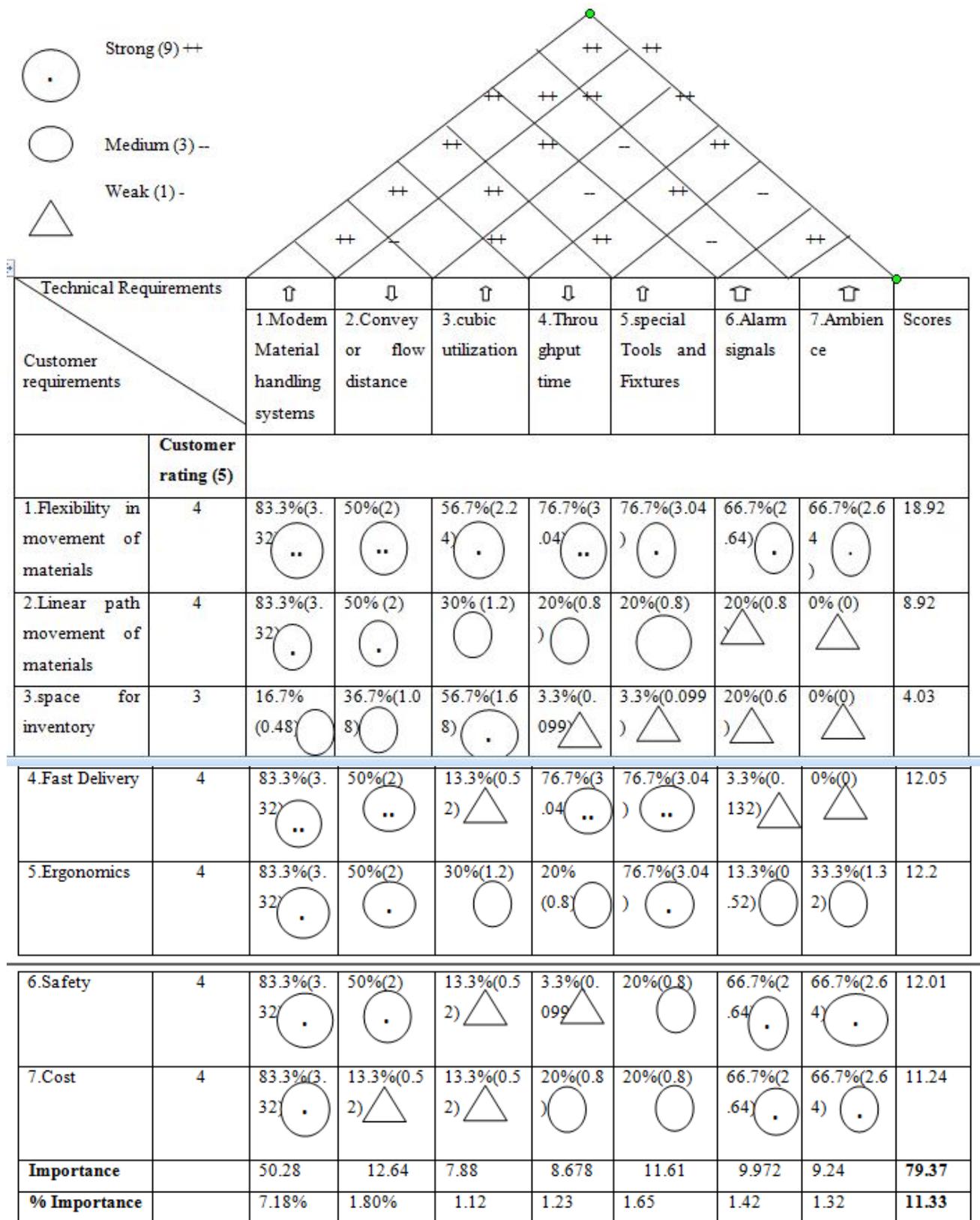n- No of factors

International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org

Volume 10, Issue 3, March 2021   **ISSN 2319 - 4847**

Technical Requirements / Customer requirements	Customer rating (5)	1.Modern Material handling systems	2.Conveyor flow distance	3.cubic utilization	4.Throughput time	5.special Tools and Fixtures	6.Alarm signals	7.Ambience	Scores
1.Flexibility in movement of materials	4	83.3%(3.32)	50%(2)	56.7%(2.24)	76.7%(3.04)	76.7%(3.04)	66.7%(2.64)	66.7%(2.64)	18.92
2.Linear path movement of materials	4	83.3%(3.32)	50% (2)	30% (1.2)	20%(0.8)	20%(0.8)	20%(0.8)	0% (0)	8.92
3.space for inventory	3	16.7% (0.48)	36.7%(1.08)	56.7%(1.68)	3.3%(0.099)	3.3%(0.099)	20%(0.6)	0%(0)	4.03
4.Fast Delivery	4	83.3%(3.32)	50%(2)	13.3%(0.52)	76.7%(3.04)	76.7%(3.04)	3.3%(0.132)	0%(0)	12.05
5.Ergonomics	4	83.3%(3.32)	50%(2)	30%(1.2)	20% (0.8)	76.7%(3.04)	13.3%(0.52)	33.3%(1.32)	12.2
6.Safety	4	83.3%(3.32)	50%(2)	13.3%(0.52)	3.3%(0.099)	20%(0.8)	66.7%(2.64)	66.7%(2.64)	12.01
7.Cost	4	83.3%(3.32)	13.3%(0.52)	13.3%(0.52)	20%(0.8)	20%(0.8)	66.7%(2.64)	66.7%(2.64)	11.24
Importance		50.28	12.64	7.88	8.678	11.61	9.972	9.24	79.37
% Importance		7.18%	1.80%	1.12	1.23	1.65	1.42	1.32	11.33

Fig 2. House of Quality Matrix

International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org

Volume 10, Issue 3, March 2021   **ISSN 2319 - 4847**

4.1. Inference:

Based on the QFD matrix calculations it is focused that material flexible movement, linear flow direction, fast delivery, ergonomics, safety are said to be important from customer requirements point of view. Similarly from technical parameters like modern material handling, flow distance, through put time, use of special tools, alarm signals and ambience are considered to be the important factors from technical requirements point of view. These are the various observations drawn from the above house of Quality matrix.
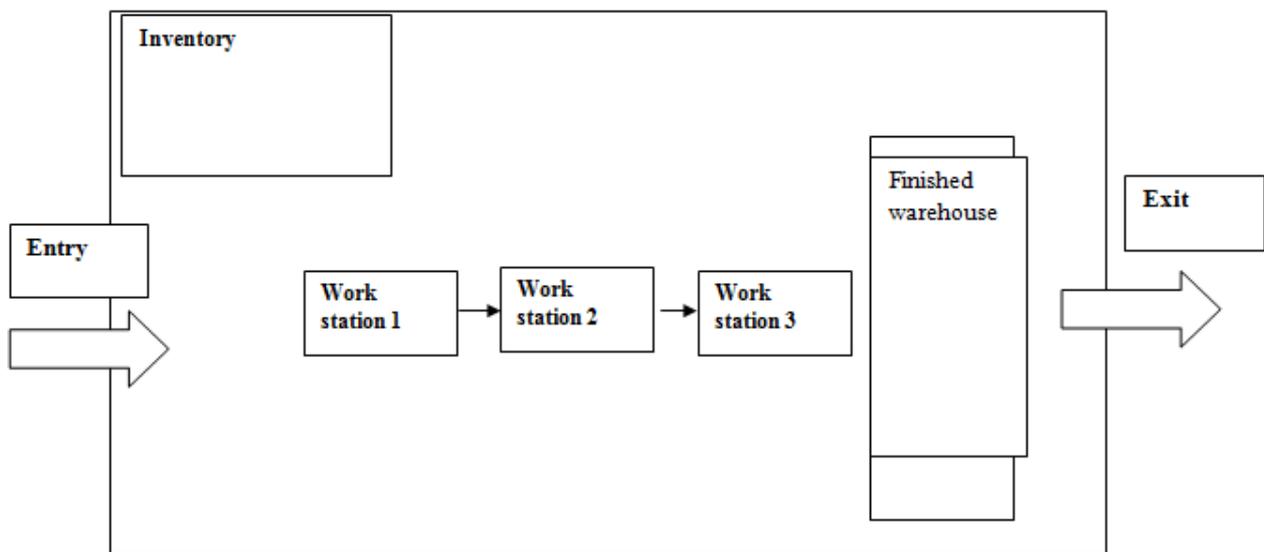

Fig3. Revised plant layout of automotive unit

Based on the importance the new revised layout is suggested in order to improve the flexibility of layout as well as the operation difficulties in addition to that the fastness in delivery of finished output is expected by keeping the linear flow of materials within the shop floor.

5. Conclusion:

Efficient plant layout design plays a vital role in increasing the throughput time or rate of the products as per schedule requirements. In this paper we made an attempt to develop a QFD matrix (**Quality Function Deployment**) for improving the Quality of automotive unit starting from inventory handling, flow of materials within the plant, dispatching of products from warehouse are some of the activities to be regularly streamlined. It can be done through improving the simplicity in production by reworking the internal facilities of layout. Based on the evaluation of QFD table the revised layout is suggested according to the customer requirements as well as company requirements. So QFD (**Quality Function Deployment**) is efficient management tool to measure the various weights of parameters according to the weights/scores as given in table we have to prioritize the importance of both customer and technical parameters to enhance efficiency and productivity of the operations through appropriate designing of layout and installation of them that confirms the growth of organization.

6. Limitation of study:

In this research authors have used qualitative tool such as QFD to measure the various parameters of plant layout using survey techniques based on the survey house of Quality matrix was constructed. There is no application quantitative model in the work hence that may be extended as future scope.

7. Managerial implications:

Based on the existing information from the plant layout as referred from Automobile **Component Manufacturing Limited, Chennai.** The materials are not arranged in well definite sequence since the machines are not in the proper

order that is in zig zag form. In the new proposed layout the materials are sequenced in linear flow with short distance such that it reduces the lead time by increasing the through put rate .

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