DESIGN OF RECONFIGURABLE MANUFACTURING SYSTEM

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CERTIFICATE

This is to certify that the thesis entitled, "**DESIGN OF RECONFIGURABLE MANUFACTURING SYSTEM."** submitted by **ROUPYAKANTA KALO** in partial fulfillment of the requirements for the award of Bachelor of Technology in **Mechanical Engineering** at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/ Institute for the award of any Degree or Diploma.

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ABSTRACT

RMS aims at providing sufficient flexibility by the principle of modularity, integrability, scalability in a shorter period of time while the other manufacturing system provides generalized flexibility designed for anticipation variation .Here we have presented the different components of manufacturing system, comparison of manufacturing system, their merits ,demerits. capabilities ,characteristics which plays an important role .In this thesis we have analyses design the automotive bumper system with the help of manufacturing system design decomposition and replaced the experimental testing for the impact test by finite element analysis technique .we can improve any system if we focus on the strategic design and systematic procedure. Thus RMS is an optimized system configuration and economic machining system that fits the customer requirements.

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CHAPTER 1

INTRODUCTION

DESIGN OF

RECONFIGURABLE MANUFACTURING SYSTEM

1.1 INTRODUCTION

The current day manufacturing environment is facing numerous challenges and changes. A typical manufacturing company faces constantly changing product volumes and mix. It is commonly recognized that traditional manufacturing system are not up to the mark market competition and a shift is needed. A great amount of research efforts has been put on looking for new manufacturing system .However many newly emerging approaches lack a unified global view of manufacturing and are addressing only some perspective of manufacturing .The requirement of product design in the 21st century present an ever increasing challenge .Now Consumer demand that product that suits their specific ,yet constantly changing, needs. The additional improvement of a product does not guarantee the customer will exactly receive what they want.

These changes in manufacturing environment characterized by aggressive competition on a global scale and rapid changes in process technology requires to create production system that are themselves easily upgradeable and into which new technology and new functions can be easily integrated. These conditions require a responsive new manufacturing approach that enables. Rapid integration of new function and process technology to existing system. New product models to be under taken very quickly, rapid adjustment of the manufacturing system capacity to market demand. Easy update of variable quantity of products.

The manufacturing systems which we are using for this new approach must be rapidly designed so that it, able to convert quickly for the production of new models, able to adjust capacity quickly and able to integrate the technology and to produce an increased variety of products in unpredictable quantities.so from there people feel the need of RMS.

The system which are designed at the outset for rapid production capacity, functionability and adjustment in response to market circumstances by basic change of its structural hardware and software components are called RMS.

CHAPTER 2

LITERATURE REVIEW AND SURVEY

2.1 OBJECTIVE OF RMS

The functionality and capacity when needed we have to provide it at that time .so we have to modify the RMS as dedicated or flexible as needed. RMS goes beyond the economic objective of FMS by permitting

1) For launching new system and reconfiguration reduction in lead time.

2) Quick integration and modification of new technology into the existing system.

3) In the layout design stage a modularity based design structure must be there to produce various variants.

4) RMS should be upgradeable in process technology with new operational requirements and able to adjust the capacity quickly.

5) The design problem can be decomposing into various sub problems like cost estimation measuring, flexibility, system configuration and lay out configuration. The same set of machine under different configuration shows different results. Therefore decision making process involved in this should be qualitative and quantitative.

6) This is to give high level performance by modification the configuration to meet the multiple functional requirements and operating conditions.

The reconfigurable manufacturing system is designed for change in structure in order to adjust production capacity and functionality.

2.2TYPE OF MANUFACTURING SYSTEM

I) MACHINE SYSTEM

One or more metal removal machine tools and tooling and auxiliary equipment that operate in a co-ordinate manner to produce the required volume and quality.

ii) DEDICATED MACHINING SYSTEMS

It is a machining system designed for production of a specific part, and which uses transfer line with fixed tool and automation. Objective is to cost-effectively produce one specific part type at the high volumes and the required quality.

iii) FLEXIBLE MANUFACTURING SYSTEM

It is a machine system with fixed hardware and fixed but programmable software to change in work orders production schedules part programs and tooling of several parts. Objective is to manufacturing of parts cost effectively, that can change over time, with shortened changeover time, on the same system at the required volume and quantity.

IV) RECONFIGURABLE MANUFACTURING SYSTEM

Machine system which can be created by modifying both process modules-both hardware and software which can be rearrange or replaced quickly or reliably.IN this adding, removing, modifying specific process qualities, control, software and machine structure to adjust production capacity in response to demand.

2.3COMPARISION OF MANUFACTURING SYSTEMS

Comparison of the manufacturing system According to the

i) COST

ii) FUNCTIONALITY/

iii) WASTE

COST

Reconfigurable manufacturing system is not more expensive in comparison to FMS and DTL. Because unlike others RMS aims to be installed with the exact functionality and product capacity which is needed may be upgraded in future if needed. It will be associated with adding process capabilities, auxiliary devices, more axis motions, larger tool magazines and expensive controller.

Functionality

Dedicated transfer lines are typically having high capacity but limited functionality and are cost effective because as they produce a single few parts and demand exceed .But saturated markets and increasing pressure of global competition there are times when DTL doesn't work at their full capacity.

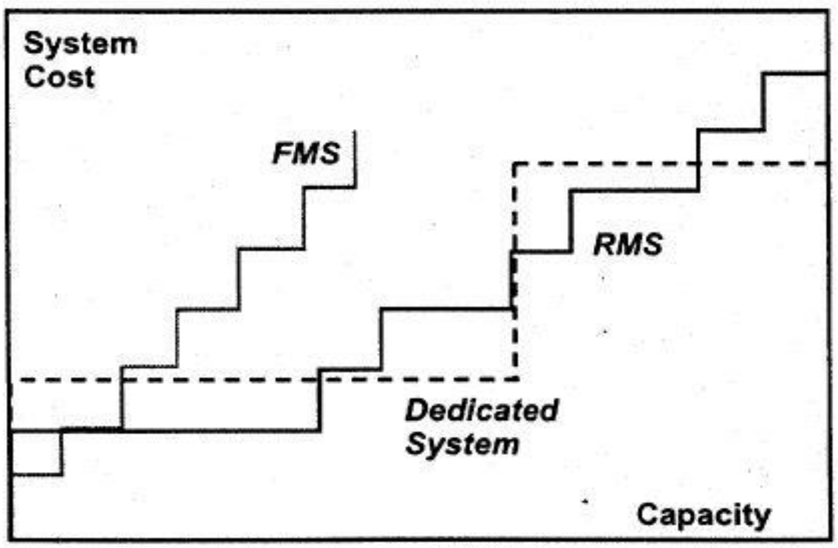

Fig.2.3 Manufacturing System Cost vs Capacity

FMS built with all the flexibility and functionality available, sometimes it is available with those that may not be needed at the installation time .In these case the capital lies idle on the shop floor and a major portion of the capital investment is wasted.

WASTE

IN RMS two types of wastes are eliminated

1) By adding extra capacity when needed

2) By adding extra functionality.

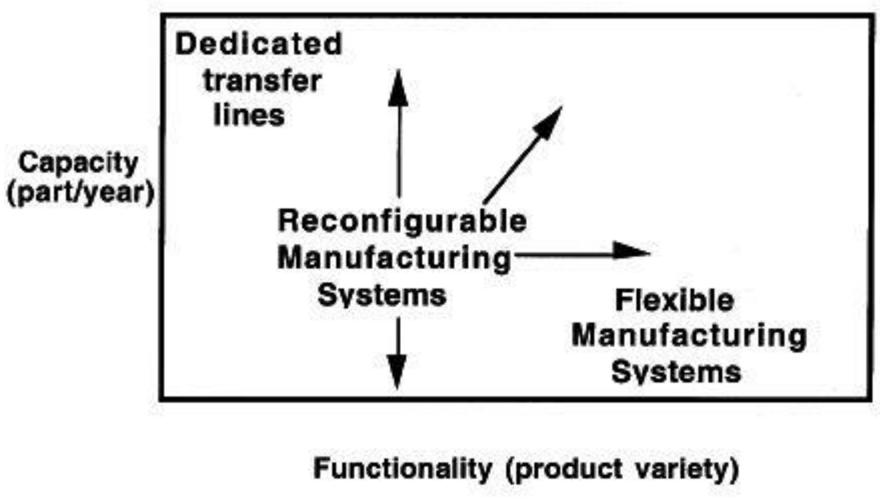

Fig 2.3.1: Capacity Vs Functionality

MERITS OF RMS

- Increased product quality.
- Reduce time required for product change over.
- Enhance the development of prototype with ease.
- For launching new manufacturing system reduce the lead time.
- Rapid upgrading and quick integration of new process technology.

DEMERITS OF RMS

- Difficult integration of machine
- Expensive controller.
- Difficult selection of machine modules
- Difficult in measurement of changeability, configurability and their relationship.
- Difficult to prepare model to adequate the level of changeability.

MERITS OF FMS

- Reduction in inventories.
- Reduction in lead time.
- Improved machine integration.
- Reduction in labor times.
- Reduced equipment cost.
- High product quality financial benefit.

DEMERITS OF FMS

- FMS are quite expensive.
- It is complex than transfer lines.
- Highly knowledgeable persons are required.

2.4 COMPONENTS OF RMS

RMS has two important components

i) Reconfigurable machine tool.

ii) Reconfigurable controller.

RECONFUGURABLE MACHINE TOOL

The uniqueness of reconfigurable manufacturing system is that both its structure and machine control can be rapidly change according to the market change it should be modular. Where we can easily change, add and modify the system parts.

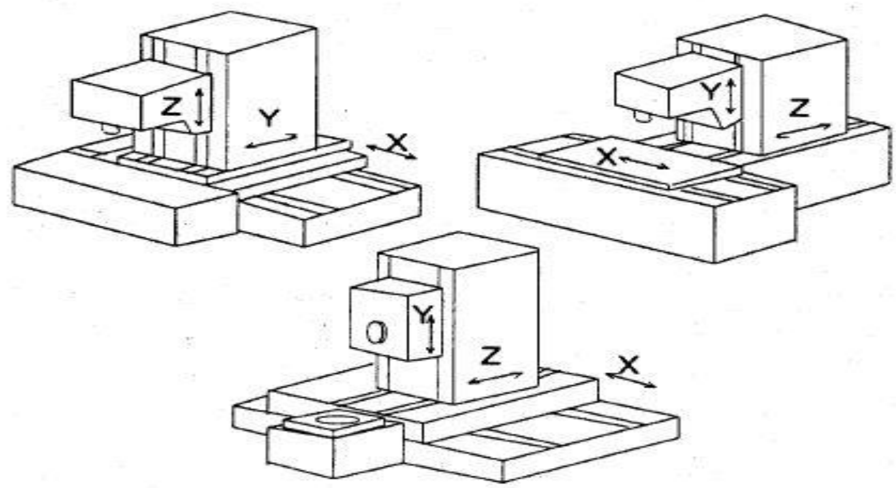

Fig.2.4 Figure of 3-Axis Modular Machine

In fig 2.4.shows a schematic illustration of 3-axis modular machine and the basic focus here is how to increase the configurability of this type of machine tools.

A major component of RMS is the RMT (reconfigurable machine tool).these are designed to produce the specific customized range of cycle time. Its main aim is to cope with the various changes in the product part to be manufactured.

IN RMT work piece size, part geometry and complexity, production volume and rate, accuracy surface quality, material property like hardness are taken into consideration .

IT introduce several new challenges for RMT controller

i) Physical machine tools are reconfigured.

ii) Control of multiple tool working independently AND RMT with axes in non-orthogonal configuration.

iii) Integration of heterogeneous hardware and software component.

iv) Requirement of broad knowledge.

RMT TOOL MACHINE MOTION FAMILY

It has to obey some modules

i) Automatic part transfer system control module

ii) Automatic part clamping rotating system modules

iii) Automatic part lifting system control module

iv) Automatic tool changing system module.

RECONFIGURABLE CONTROLLER

TO control any machine any specific function or class must be designed into a reconfigurable controller.it is dynamically reconfigured for a particular mechanism.

2.5 CHARACTERISTICS OF RMS

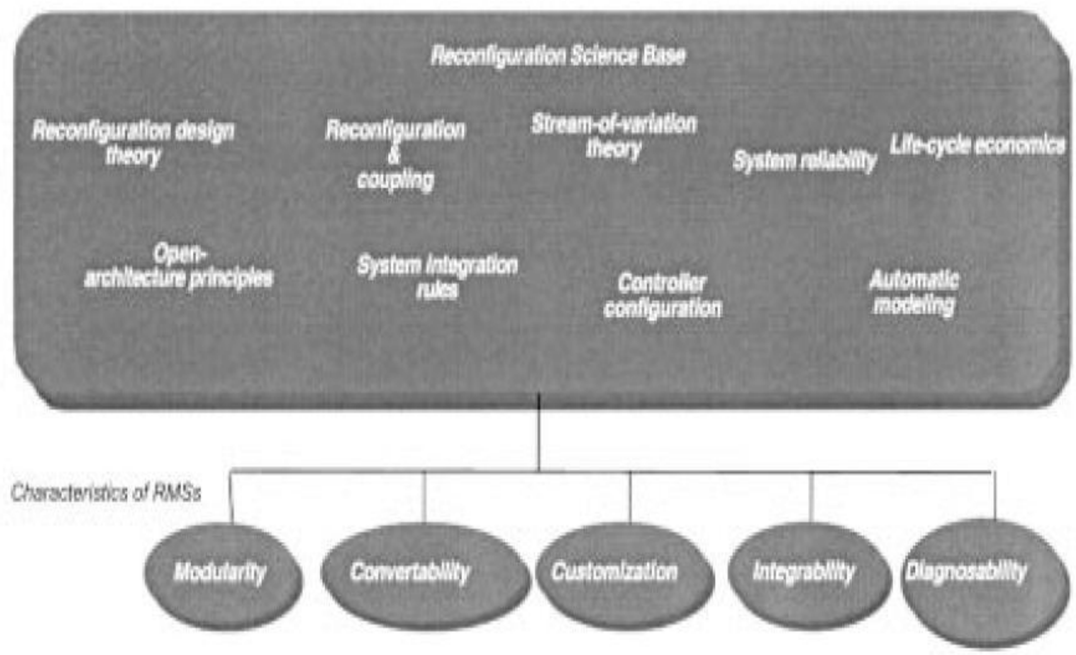

Fig 2.5 Characteristics of RMS

RMS possesses several key characteristics that are

i) MODULARITY

ii) CONVERTABILITY

iii) CUSTOMISATION

IV) INTEGRABILITY

V) DIAGNOSABILITY

MODULARITY

All the major components (structural components, axes, control, software and tooling) are modular .As by this technology the system can be easily reconfigured by simply removing, changing, the constituents units or modules.

CONVERTIBILITY

THE optimal operating mode is configured in batches should complete in one day ,with short conversion time between batches.it requires part programs, changing tools and fixtures and also require adjustment of passive degree of freedom.

CUSTOMISATION

It has two aspects customized flexibility and customized control.

Customized flexibility provides only flexibility needed for specific parts by reducing cost. And customized control is achieved by integrating control modules with the addition of open architecture technology.

INTEGRABILITY

MACHINE modules are designed with interface for component integration .this performance is predicted by the per given performance of its components and the interfaces of both software and machine hardware modules.

DIAGNOSABILITY

Detecting unacceptable part quality is critical in reducing ramp up time in RMS.

CHAPTER 3

AUTOMOTIVE BUMPER DESIGN

ARRAY LAYOUT OF RMS

The typical arrangement of RMS is presented in fig

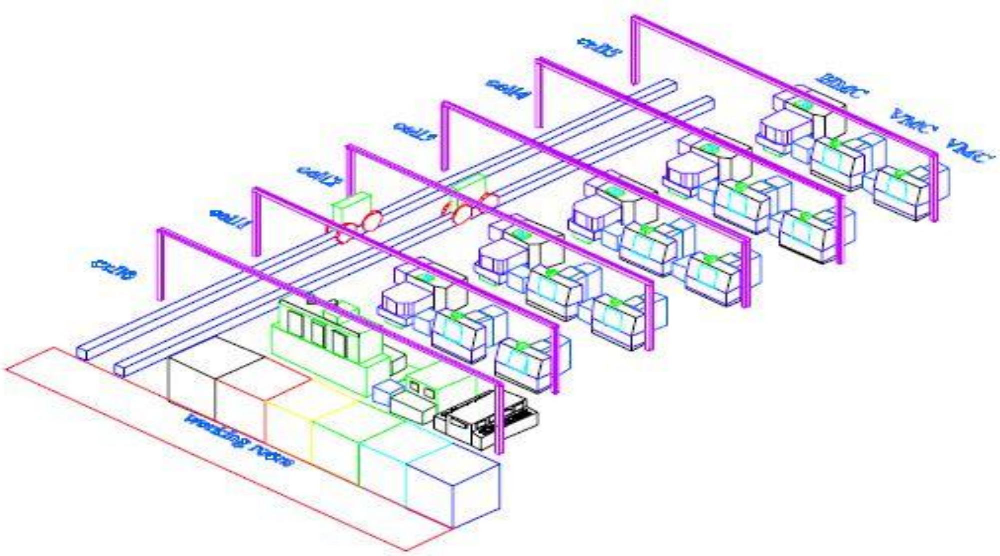

Fig 2.6 Array Layout of RMS

3.1 PROBLEM STATEMENT

Design of automotive bumper system with the help of Reconfigurable Manufacturing System.

3.2 PREPARATION OF MSDD FRAMEWORK

The MSDD (manufacturing system design decomposition) framework is required to evaluate the manufacturing system desugn.IN general MSDD is used to evaluate the automotive component manufacturing plant. Various advanced manufacturing system are there for the design and decomposition of system design process. A MSDD focus upon the understanding and relationship between the requirements and methods.

ITS primary objective is to provide a structured approach for the design of manufacturing system by designing of parameters and the means of achievements. These are decomposed from a high level to a detailed level of operation activity.

It is designed to satisfy the following requirements

i) Clearly separate means of achievements from requirements.

ii) Relate the high level and low level requirements.

iii) To portray the interaction among the different elements of the system design .

iv) Communicate the decomposition of requirements and the means of requirements.

MSDD FRAME WORK (MANUFACTURING SYSTEM DESIGN DECOMPOSITION)

Based upon the Axiomatic design the MSDD defines the foremost requirement for any manufacturing system for long term return on investment. The DP for this requirement was determined to be the design of this manufacturing system.

A stable manufacturing system design should be

- Producing right quantity in every shift
- The right mix
- Perfect quality
- In time

The above requirement must be satisfied in spite of variation or disturbance, with in a safe, ergonomically sound working environment

IN ORDER to satisfy this MSDD was developed using AXIOMATIC design.

3.3 AXIOMATIC DESIGN

Design is the continuous interplay between what we want to achieve and how we want to achieve. Design requirements are always stated in the functional domain, solution always stated in the functional domain. For the solution need the mapping between the requirements of functional requirements to the physical requirements.

IN Axiomatic design designer first determines the requirements of a design (FRs) then designer chooses the design parameters(DPs) to satisfy the FRs. Design thus guides a designer to solve a particular FR by selection of a specific mean shown in fig 4.2.1.

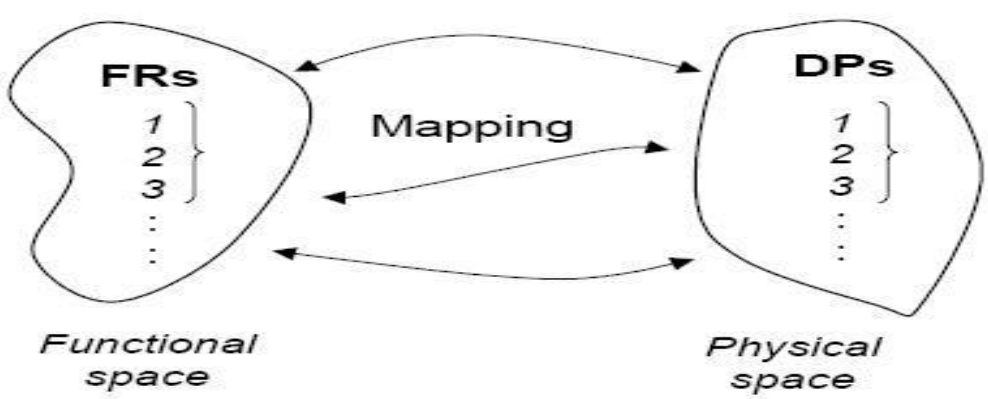

Fig 3.3. Representation of Axiomatic Design Process

This design is a process of determining the DPs to satisfy the FRs.

It follows two axioms to select the best possible design parameters

- Independence Axiom
- Information Axiom

Independent Axiom: maintain the independence of Functional requirements by selection of design parameters. (it is one to one relationship).

Information Axiom: It believes in simpler designs .So it try to simplify the design because simpler designs are better than complex design.

IN Axiomatic design the relationships between FRs and DPs are represented in graphical or vector form .In graphical form, an off-axis arrow from a functional requirements to the design parameters represents its influence upon other .

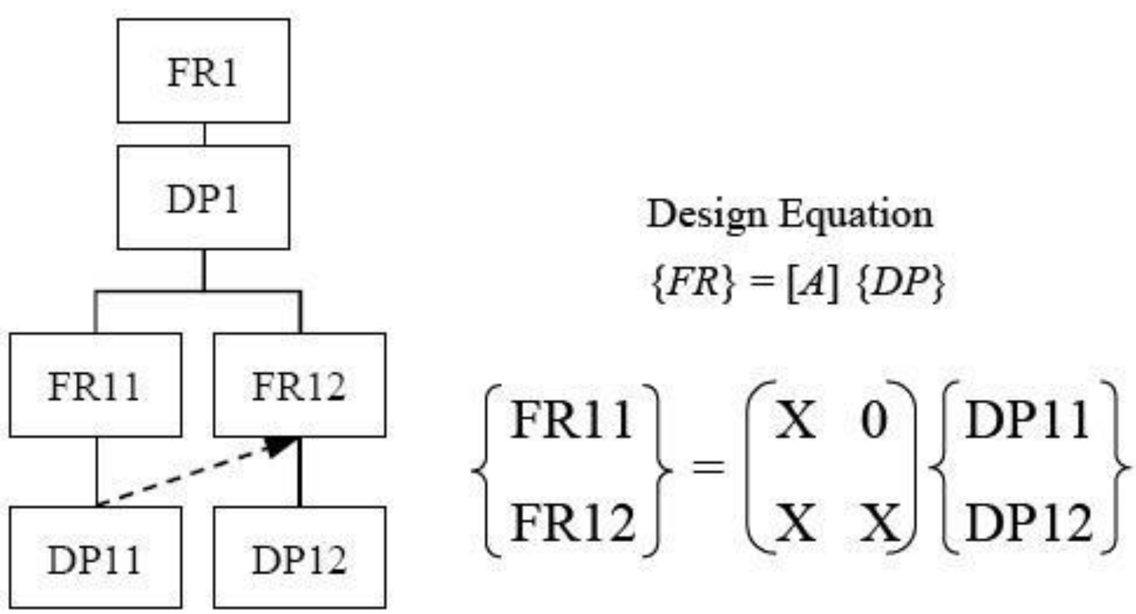

Fig 3.3.1 Mapping of FRs to DPs

Uncoupled design is the best type of design where one DP effects only one FR. The implementation sequence is graphically represented by left to right ordering because the DPs effect the left most functional requirements shown in fig 4.2.2.

The steps involved in the Axiomatic design process can be therefore

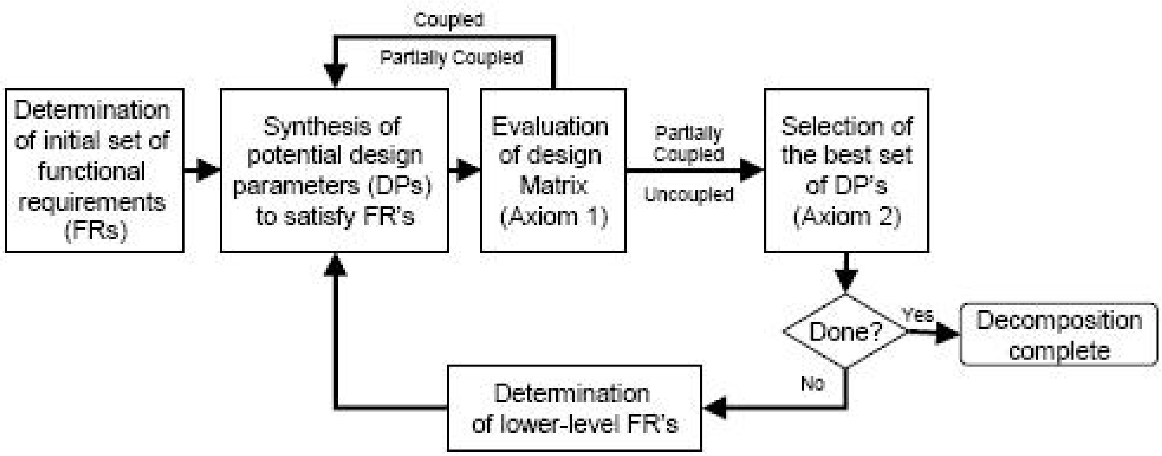

Fig 3.3.2: Simplified Design Decomposition Process

This design provides the methodology to structure one's thinking during the process.

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3.4 DESCRIPTION OF AUTOMOTIVE SUPPLIER PLANT

This is based on design evaluation of the plant.

In general the bumper fascias require 3 basic operations:

- injection molding
- painting
- assembly

Machines are grouped into department according to performance of the process. Let seventeen molding machines are feed one high speed paint line and it is supplied to 10 assembly station. Between departments parts are kept in automated storage or retrieval system. These are transported by an overhead conveyor system.

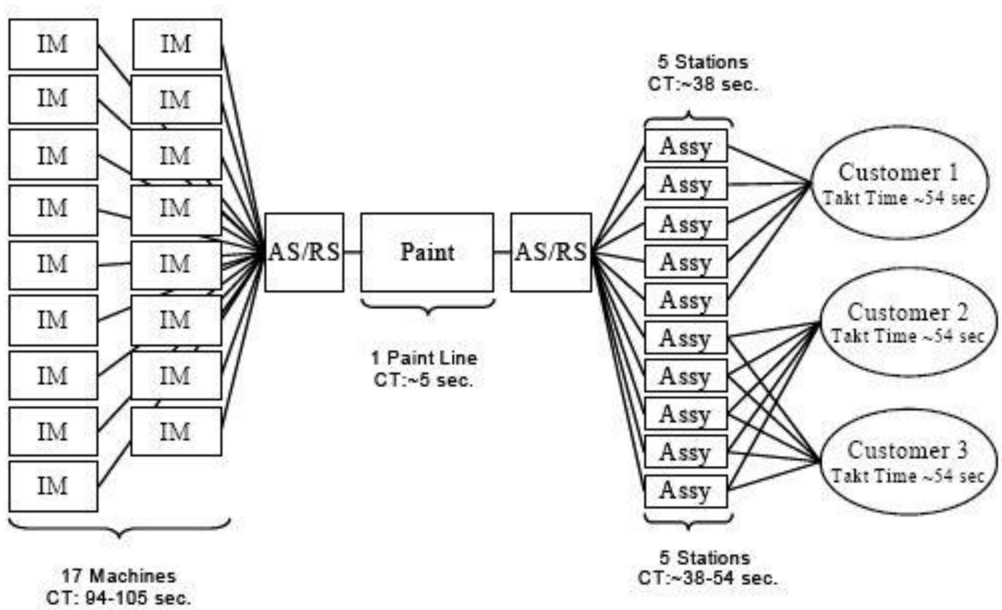

Fig 3.4. Material Flow in the First System

This material flow system shown in fig 4.3.1 operate 5 days per week, seven hour shift to supply fascial to the external customer.it receives several types of electronic information from its customer: a ten day forecast, daily requirement, five day schedule. Due to high variation in paint and shipping delays the schedules frequently changes.

Its primary aim is to reduce the direct labor to reduce manufacturing cost.

Labor efficiency measured by performance ratio

Performance ratio=current work standard/actual time worked

CWS time=parts produced *current work standard

CWS time defines the time based upon industrial engineering time standard. Based upon the production efficiency the plant manager performance is measured.

If we use two main area like injection molding area and the paint area. Five injection molding machines are feeding the standard work in progress area in the injection molding. SWIP supply parts to paint and assembly systems. If each paint line operate at a cycle time of 23 seconds, then each painted pair of bumper are ready within 46 seconds shown in fig 4.3.2.

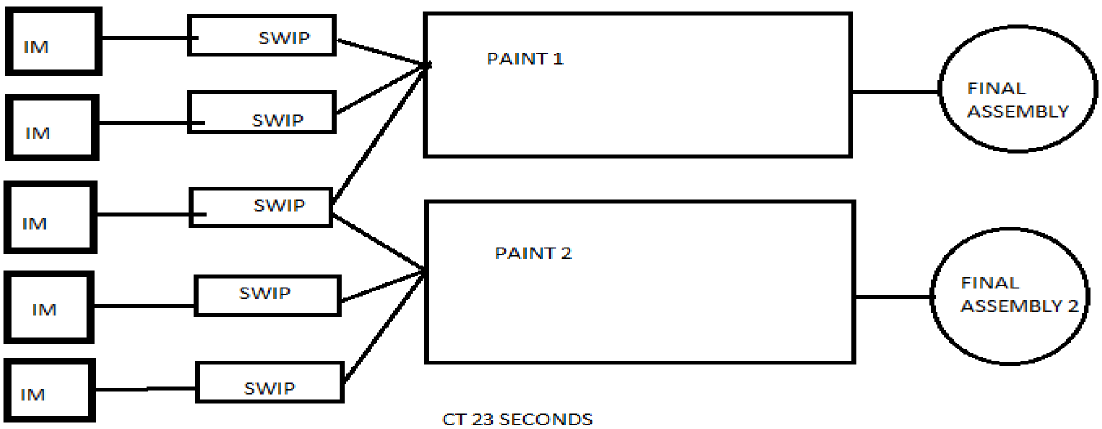

Fig 3.4.1: Material Flow in the Second System

Talk time is defined as the time necessary to produce one piece of product. Which is equal to the total available working time divided by required production quantity, cycle time and takt times are not same.

It operate 9 hours a day to deliver bumper fascias to final automobile assembly line.it uses the “one-time-use –kanban”.paint lines receive the information in order to determine the color. Shipping area also obtain the same kanban for in-sequence delivery to the final assembly.

The second system focuses on operating and improving the system design.

3.5 EVALUATION OF SYSTEM DESIGN USING MSDD

The evaluation of the manufacturing system is based only on the leaf FRs,FRs that are not decomposed any further. The evaluation approach adheres to the principle of axiomatic design, where the higher –level FRs are only satisfied if the lower level are satisfied.

If we compare the two plants then second system performance is superior because second system was designed to be balanced customer takt time

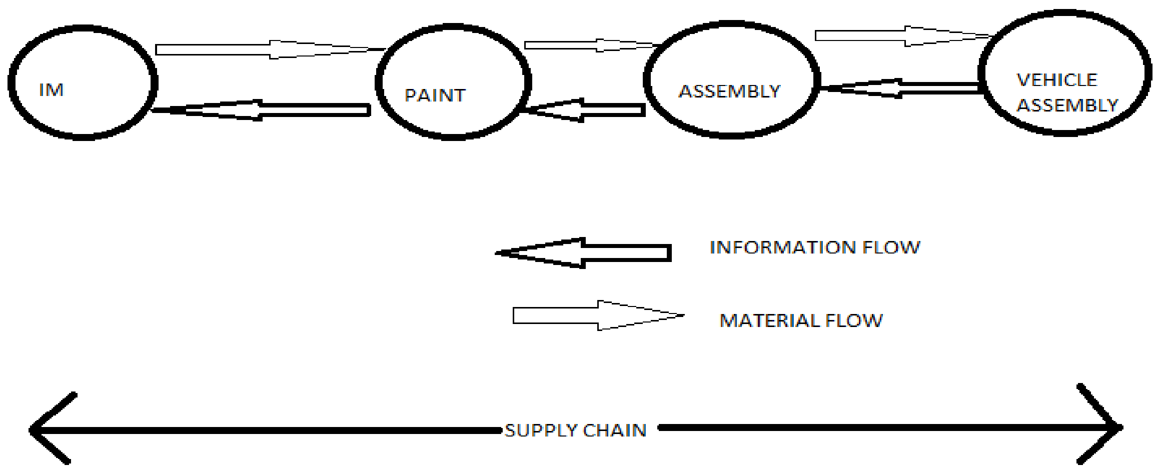

Fig 3.5: Ideal Balanced Designed With Linked Cell

In the second system it integrates assembly work with paint unloads work to achieve balance to takt time. In second system it supply bumper directly to final assembly without storage. In the first system it separates all the process in different departments so as a result high imbalance is there, path complexity, large amounts of inventories between departments.IT focuses directly upon the labor performance, machine utilization regardless of customer demand. Where as in second system it is used for the purpose of labor efficiency even though labor cost is fixed due to labor contract.

QUALITY

The quality of second system is better than first system because in the first system defective parts are detected but not removed, operator assignable of quality problem. In paint operator can mislead the bumper onto the racks and causes scratches and nicks. Higher rate of defects are due to lack of addressing the root cause for defect and non-standardize work. Where as in in second system the primary aim is for improving the machine quality.

DELAY REDUCTION

The delay reduction branch describe the system design to meet the costumed demand in lead time .five delays are defined: lot size delay, run size delay, process delay, transportation delayed systematic operational delay.in the first system to minimize the number changeover policies are there to rum the machine as long as possible so the parts produced are not desired mix and quantity at the demand interval. Also there is transportational delay in first system it stores the parts in the AS/RS so delay occurs.

OPERATIONAL COST

Its focus is to effective utilization of direct labor by eliminating the non-value sources of cost.

3.6 ASSEMBLY PART DESIGN

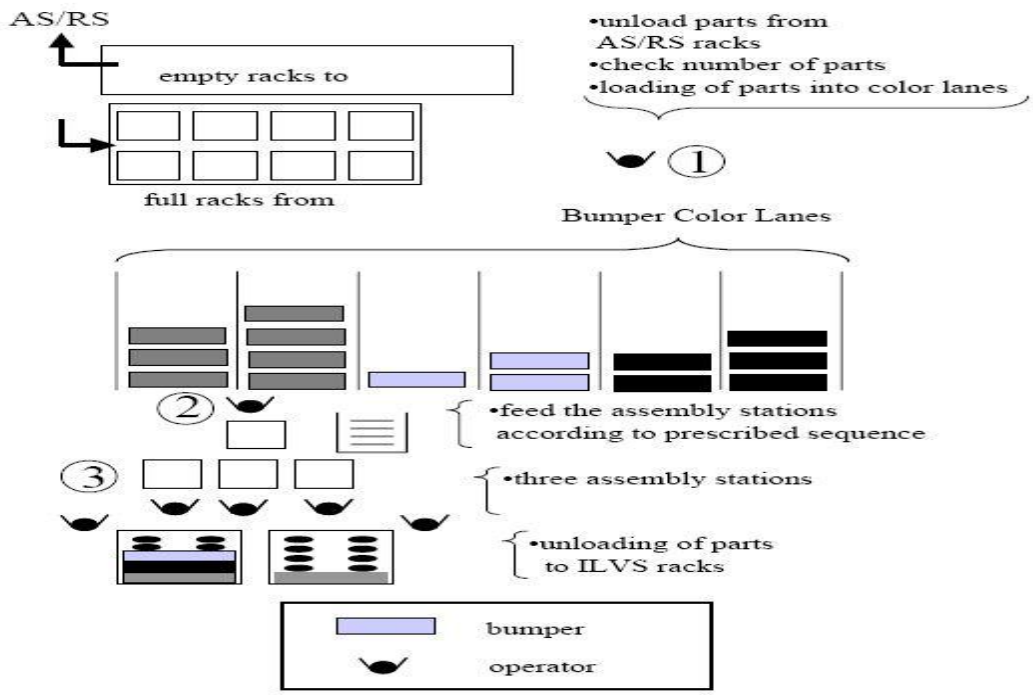

Fig 3.6. Assembly Part Design For First System

In the first system operator 1 unloads the bumpers from AS/RS racks, and loads it into appropriate color lane. Similarly operator 2 select proper color from color lane and place the bumper in short conveyor. Operator 3 then picks up the bumper attach the purchased part and load them into the ILVS (In line vehicle sequence) racks.

In this both the operators have significant idle times as they also perform a lot of motion for the assembly in loading and unloading the parts between the racks and conveyor. After the bumpers are assembled the operator covers the bumper with protective film in order to minimize the damage during shifting to the final assembly.

But in case of second system first operator directly moves the bumper from the paint system conveyor to the assembly workstation, assemble some parts and hand it over to operator2 .second operator finish the assembly part and load the bumper into rack beside him as shown in figure

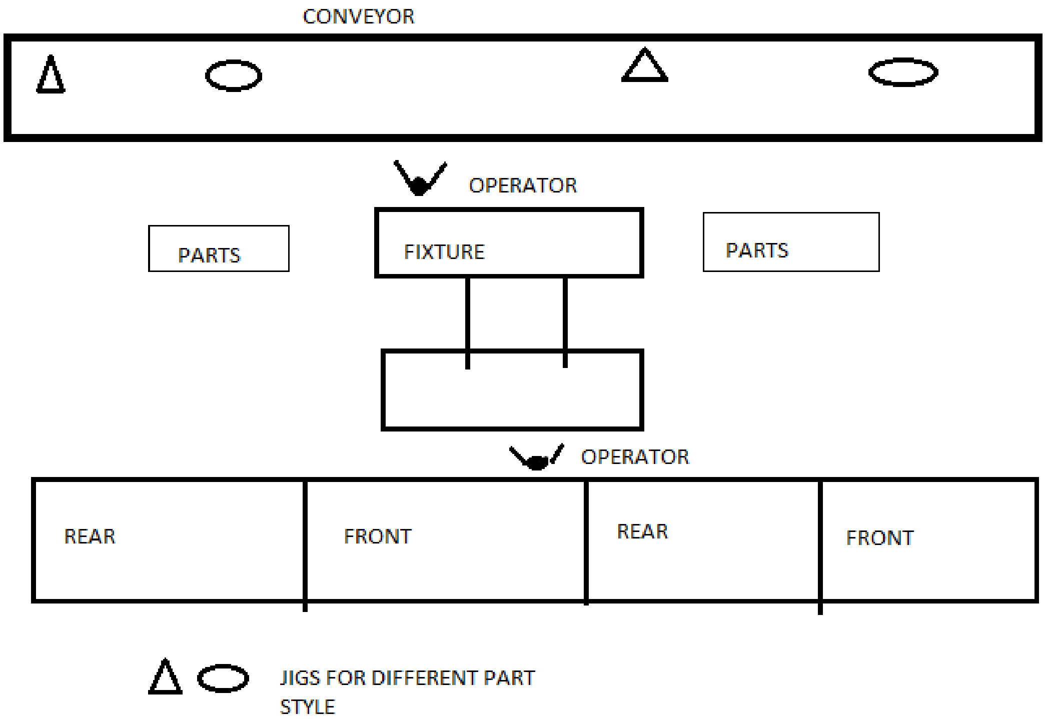

Fig 3.6.1 Assembly Part Design For Second System

3.7 PAINT SYSTEM DESIGN

In the first system color is applied by four robots. To enable 5-second cycle time each robot sprays 25% of the bumper. There are two types of change over style and color changeover .for each change reduces run size delay. The resulting cost is results high degree of paint loss necessary to evacuate the paint lines. The center box is 30 feet away so the paints lines are so long.

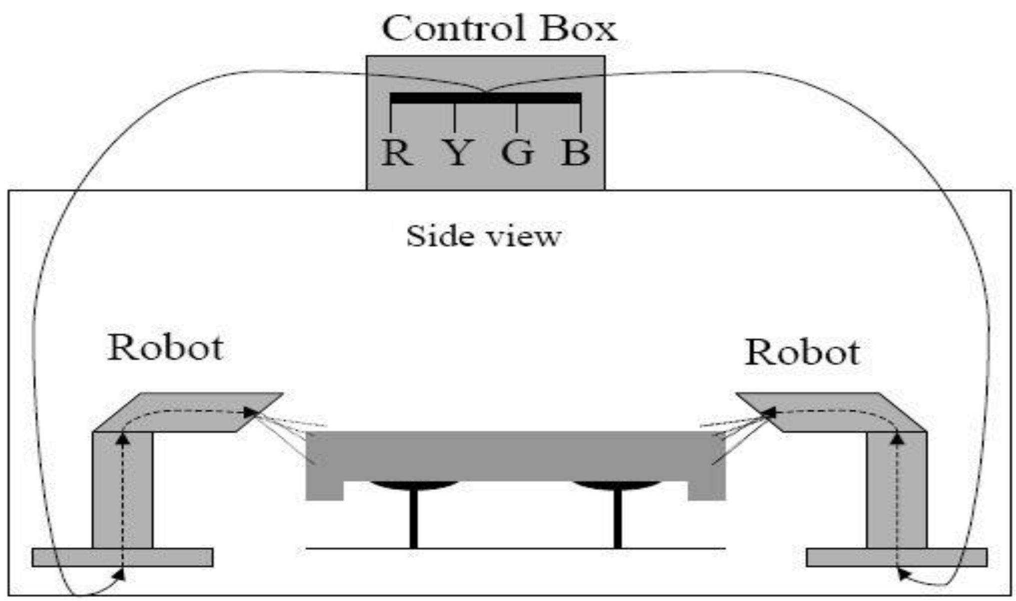

Fig 3.7 paint system design   for first system

Where as in second system the process is same but design are completely different.it can be done by both manually and by robot .here in manual spray booth the operator removes the spray nozzle from line 1 to line 2 and paint. For robot it has separate color lines separated by different indexing device. Changeover only requires a proper indexin.

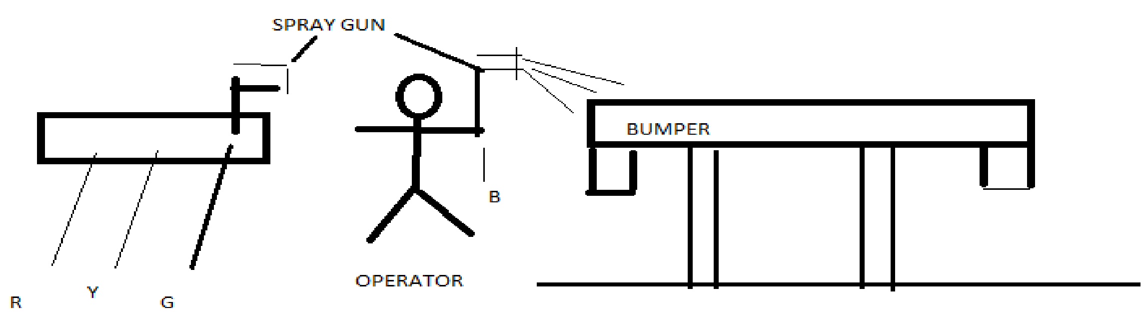

Fig 3.7.1 Paint System Design for Second System

The superior performance of second system is a reflection of superior achievement of FRs. system design approach the necessary investment to achieve FRs of a system design.

3.7 FINITE ELEMENT ANALYSIS FOR BUMPER DESIGN

The design of bumper system is not only for absorbing impact energy but also styling stand point. A great attestation has been focused upon the light weight and safety. The design is summarized as degree of absorption of impact energy .the experimental technique is very costly and time consuming so we can use finite element analysis and design.

This technique has been divided into two categories

i) Pendulum type impact

ii) Barrier type impact

Commercial finite element like ABACUS and MSC/DYNA are used to evaluate the displacement, strains, deceleration and forces of the bumper system.

PENDULUM TYPE IMPACT

Simple beam model utilizes the beam gap elements to stimulate the structural interaction of bumper system and pendulum. As the symmetric condition applies to the center line of vehicle we have taken only the left section and experimenting.

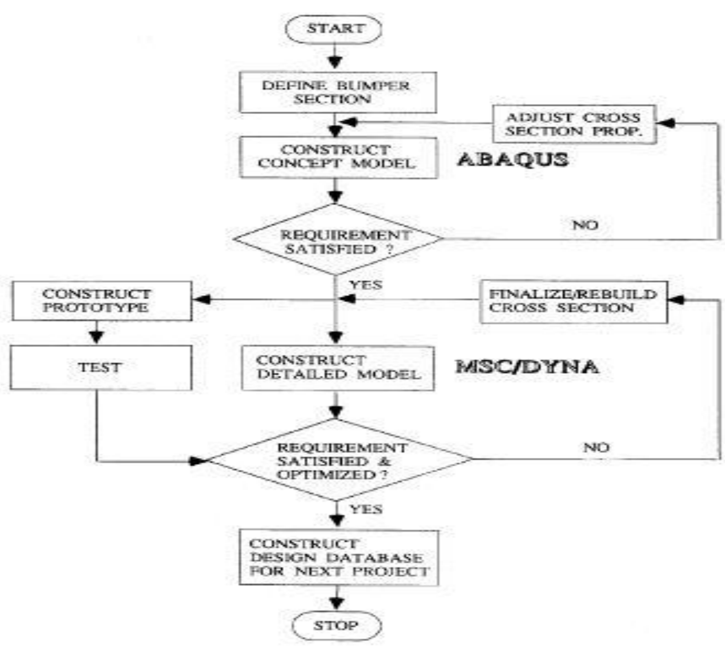

Fig 3.8 Design Analysis Procedure For Bumper System

PENDULUM HIT

In the following figure the bumper is undergoing through the operation of pendulum hit.

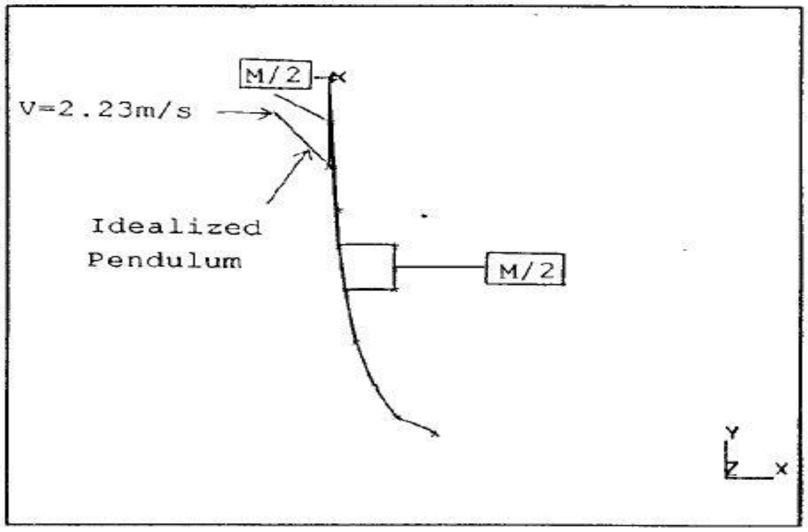

Fig 3.8.1 Simple Beam Model of Bumper System (Pendulum Hit)

BARRIER HIT

In the following figure the bumper is undergoing through the operation of barrier hit

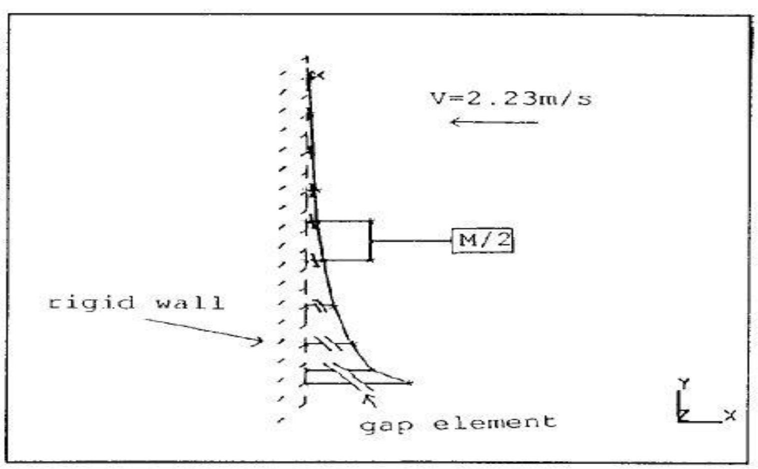

Fig 3.8.2 Simple Beam Model of Bumper System (Barrier Hit)

CHAPTER 4

CONCLUSION

ANALYSIS

In the first system the management strategy is to schedule operation for running as long as possible. These policies are made to minimize problematic changeovers and maximize potential output. As continuous production policy does not focus on the root cause of equipment reliability.

Whereas second system it is designed with strategic and system design intent. First it has one paint lines ensuring about t the cycle time equals the takt time. When we are adding the second vehicle line a second identical module was implemented as a modular chunk capacity. Implementation of capacity in modular chunk has the advantage of predictable system cost and future.

The finite element method with simple beam is more economical .so it can be used for bumper impact testing instead of experimental testing.

CONCLUSION

By introducing the RMS the components of the reconfigurable manufacturing system, characteristics of manufacturing system ,capabilities of the system plays active role in the supportive area that is very beneficial to manufacturing system. To match up with global economic competitions and rapid changes manufacturers have to face a new economic objective the manufacturing responsiveness for which RMS is needed. Because they are designed at the outset with the adjustable resource to provide the desirable functionality and capacity at the time of need. The research area of RMS is quite broad and possesses a number of areas for future research. Qualitative evaluation should be done to develop methodology for RMS.

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