Computer Integrated Product Manufacturing Development

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Abstract—Computer Integrated Product Manufacturing Development is a method or program which tells how computer (including robotic hands, modern machinery, etc) are helping in the manufacturing of the products at industry level. We have discussed some basic essential functions, uses and characteristics of Computer integrated product manufacturing along with the bit of information about the Finite Element Analysis.

Keywords—Integrated product manufacturing, product manufacturing development, Computer integration, manufacturing development, product development, Integrated manufacturing, Computer integrated manufacturing.

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1. Definition

Computer Integrated Manufacturing (CIM) is defined as the manufacturing of products including objects, different items, and devices through computer-controlled automated system (Computer Integrated Manufacturing, n.d.)

2. Introduction

Computer Integrated Product Manufacturing consists of both hardware and software components of computer automated system, which are considered as essential for the enrichment of manufacturing industry. Computer Integrated Manufacturing has been considered as a real revolution in the technology, it has evolved all the old and modern methods of technology. If we look back into the 1980's we discover that, at that time manufacturing occurred through a group of automated machines worked together in a chain process. CIM associated with the collection of some multiple disciplines, some are given below

- CAD/CAM/CAE/GT.
- Manufacturing Planning and Control.
- Factory Automation.
- General Business Management.

1.1 CIM Hardware and CIM software

Few examples of Computer Integrated Manufacturing (CIM) hardwares given below.

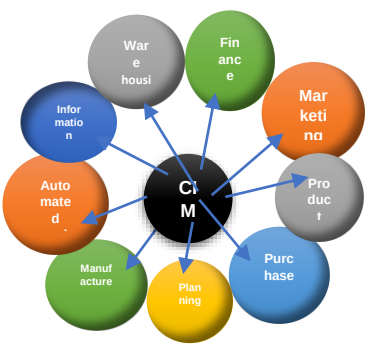
Equipment like CNC machinery and other computerized work centers, automatic/robotic work cells, systems of DNC/FMS, product and tool handling devices, devices that stores data, and sensors, terminals and workstations, barcode and QR code readers, printers and plotters, cables and modems, and other peripheral devices, etc.

Where Computer Integrated Manufacturing (CIM) Software are given below.

- Finances.
- Designing and Modelling.
- Database Management system.
- Materials handling.
- Drivers of devices.
- Planning of processes.
- Workflow Automation.
- Management Information System etc.

1.2 Main Elements in CIM System

(Main elements of CIM (Figure 1)(Abdulghafour)



1.3 Development of Computer Integrated Manufacturing (CIM)

CIM has brought a revolution in the manufacturing society, it is frequently providing benefits in every setting of the manufacturing industry, it has improved the ability of manufacturing complex materials, it has brought advances in accuracy of production, it has reduced the ratio of errors, it is helping in producing more products in less time etc. by keeping all such advantages of CIM, scientists/engineers has made enormous changes to modernize and has made it more advance (Amalnik, 2014) CIM technology has been reached in every production across the world, it has been enhanced in many ways, from 1980's till date we can clearly see the change in this technology over time, this technology has adopt new ways of analysing anything/material/product using CIM (S, n.d.)

1.4 Manufacturing Through CIM Technology Can be divided into four categories

- Product design.
- Manufacturing planning.
- Manufacturing.
- Computer-Aided Inspection and reporting.

1.4.1 Product design: For product design Computer Aided Design (CAD) allows to draw and analyse task which is going to be performed, this system helps to draw the data available in designer's mind in the form of presentation form.

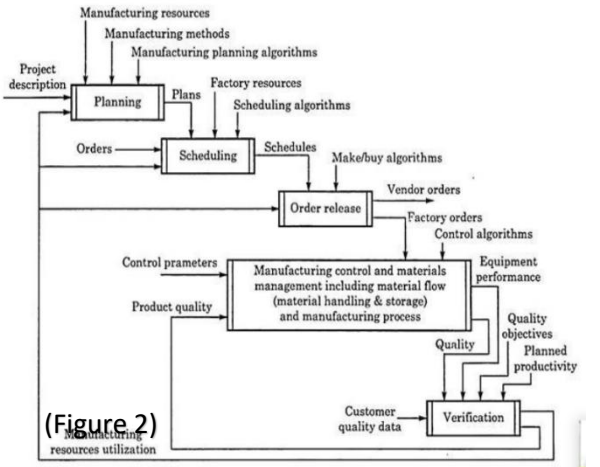
1.4.2 Manufacturing planning: This technology helps to give sequence to the schedule so that work can be done smoothly.

1.4.3 Manufacturing: In the form of micro-processors it helps to identify the problems and errors to make CIM technology work error free.

1.4.4 Computer Aided inspection and reporting: It provides a feedback loop (S, n.d.)

1.5 Developmental time period of CIM Technology

- In 1909 FORD proposed the concept of production line.
- In 1923 Automated Transfer Machine was introduced by Morris engine Factory.
- In 1952 punch paper tapes were generated.
- In 1954 NC mailing machine was first introduced by Parson cooperation of USA by MIT.
- In 1959 first launch of computer control system at Texaco refinery USA.
- In 1970 CAM, GT, CAD, DNC and flexible automation developed.
- In 1980's FMS and CIM became popular (Vezhan, 2012)

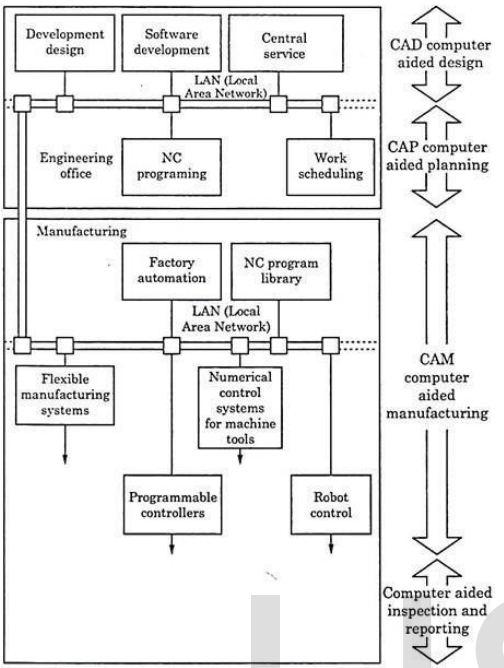


(Figure 2)

1.6 CIM and 21st Century

As it has been discussed above that Computer Integrated Manufacturing (CIM) has been grown rapidly by passing over the time period. Old CIM technology has been left behind so far and the new tactics and methodologies has replaced the old machinery, today sensors have been in the launched in the manufacturing of the goods to monitor every single micro activity and error, robotics has replaced the high need of labour in the industries, as all actions are carried by the robotic hands and machines, advancement in the CIM has made the production feasible and affordable for the consumers to purchase as it consume less energy and produce bulk of production in a single round. CIM doesn't only mean to have hardware hands to function all the necessary actions here software part is also installed in those robotics to do the specific tasks, special purpose softwares have been design to in the 21st century who help those robotic hands to work in a proper manner according to the need of specific manufacturing industry or firm (Goldhar & Jelinek, 2003)

Let us look into the internal systematic operations functions



As it is elaborated in this sample diagram that all the essential elements including Officials and machinery are working together constantly, this whole procedure of the manufacturing industry collective known as Computer Integrated Manufacturing (CIM) (S, n.d.)

(Figure 3)

2. Finite Element Analysis

2.1 Definition

A physical body consisting of engineering design to solve the mechanical/engineering problems, these are three dimensional solid elements, the word "finite" means limited number of things, finite elements are connected in a chain process through interconnected joints, (Harish, 2020).

2.2 Introduction

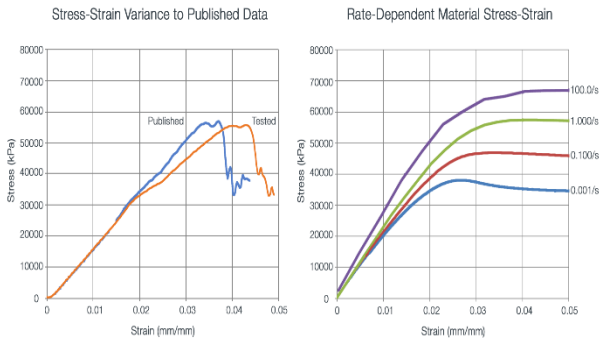
Some records have described that the history of FEM finite element methods/ FEA finite element analysis comes from the 16th century, where some mathematicians has called it as the work of Shellback's in 1851. It was first design to solve the mechanical problems (Harish, 2020) It is a combination of mathematics and engineering with the collaboration of physical phenomena of the material, while designing it is important to keep some important things in mind while designing it for example expansion of fluid, carrying or passing heavy weights through etc. FEM is been working since last few decades and has solved the manufacturing industry problems. These Finite Element methods also control/monitor by the computers (Harish, 2020)

2.3 Application of Finite Element Methods (FEM) into engineering design problems

It is created by connecting millions of large and small parts join all together to form a structure, all of these parts are connected passing through an absolute calculation (TWI, n.d.) CIM needs to remove all the barriers that come in between the production to enhance the marketing, entry of the orders, manufacturing of product design etc. it make a chain of all the department link together to work and controlled by the single computer, it gives speed to the product of the product to make the customers trust and come again for next order. Reducing time is an alternative of the cost reduction, when more productions will be occurred in less time it proves that it is reducing the expenses and increasing rate of production (Gunasekaran)

2.4 Application of Finite Element Methods (FEM)

- Mechanical Engineering: used as thermal analysis in solids and fluids, stress analysis in solids, automated design and manufacturing cycle imitation.
- Geotechnical Engineering: Used as analysis of slope stability, soil structure interactions, seepage of fluid, analysis of dams and tunnels, boreholes etc.
- Aerospace Engineering: Used for analysis of natural frequencies structure, modes, shapes and aerodynamics.
- Nuclear Engineering: Used as Thermo-viscoelastic analysis of reacting components, analysis of fixed transient temperature-distribution of reactors etc
- Electrical and Electronic Engineering: FEM used as electromagnetics, analysis of high voltage equipment's etc.
- Metallurgical and chemical Engineering: In metallurgical engineering it is used as metallurgical process simulation, moulding and casting etc. where in chemical engineering it is used as chemical process and chemical reaction simulation.
- Meteorology and Bio-engineering: Used as climate predictions, monsoon and wind calculations, FEM is used in bio-engineering for example checking blood circulation calculations and in-fact total synthesis of human body. (Ponnusamy, 2015)

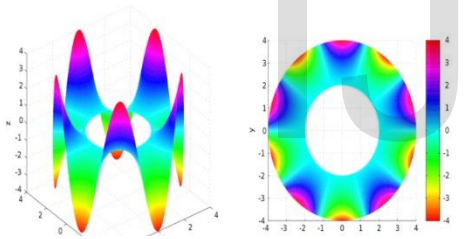


(Chart 1)

(Harish, 2020)

2.5 Material properties of FEA design

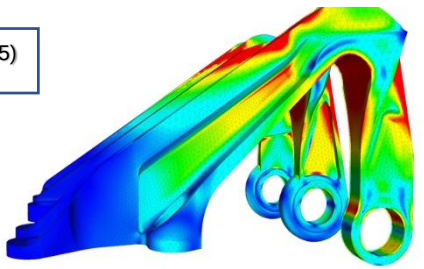
Least Properties that are required for common type of FEA are described in the form of table below.



As (Figure 4) Finite Element

Laplace equation on an annulus. Image by Fourthirtytwo [CC BY-SA 3.0

(Figure 5)

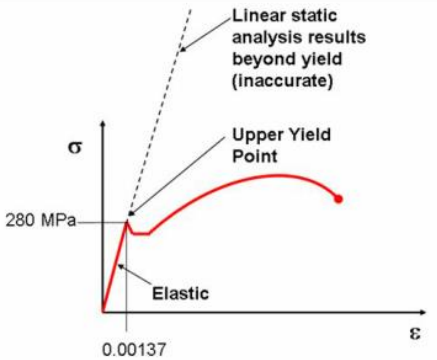


described in the table above that FEA material does not require be very hard or stiffed, where its need of hardness and stiffness depends on the type of work that where it is needs to be applied.

It has explained through the chart that material strength depends on these factors. However, there is a significant behaviour in their material property depending on their temperature, magnitude and strain rate, above test results shows that how simulation of material property made, simulation errors occurs because of publish manufacturers and actual test results and stress rate variance on a single plastic material (Vision, n.d.)

	Linear Static	Non-Linear Contact	Non-Linear Material	Thermal	Fatigue HCF	Modal & Seismic
Young's Modulus	✓	✓	✓	✓	✓	✓
Poisson's Ratio	✓	✓	✓	✓	✓	✓
Mass Density						✓
Thermal Expansion Co-efficient				✓		
Stress – Strain Curve			✓			
Endurance Limit (SN)					✓	

3. Hook's Law of FEA/FEM



Typical Stress – Strain Curve for Low Carbon Steel

From the above graph we can calculate Young's Modulus as follows;

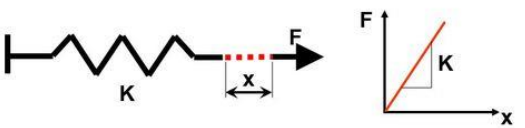
Yield Stress $\sigma := 280MPa$

Strain at Yield $\varepsilon := 0.00137$

Young's Modulus $E := \frac{\sigma}{\varepsilon}$ $E = 204.38\ GPa$

for the analysis of linear static, when the load will be doubled the displacement on the yield will be doubled too. Some products like plastic does not follow the Hook's law

4. Young's Module of FEA/FEM



$\sigma := E \cdot \varepsilon$

$E := \frac{\sigma}{\varepsilon}$

Where E is Young's Modulus, σ is stress and ε is strain.

Method and materials used in the making of FEA/FEM

At first its designed made on a computer using any designing software, after design approval by the authorities it goes to the department where material can be selected for the design to give it a physical face. While designing engineers keep every calculation in mind like its ratio, depth, density etc for best fitting in to the body (Canpolat, 2016) however material depends on where that specific part of FEA is going to be fitted and for what kind of work, because FEA design in a manner that it should bear the temperature in accordance with the manufacturing need, it must not be leak from anywhere because it will may be used for the liquid matter and etc. all these things needs to be consider while manufacturing and designing of FEA.

5. Overview

CIM is a computer-controlled manufacturing program in which hardware and software both types work together in a single or multiple process, it's just like a helping robotic hand in the manufacturing firm and other multinational or local organizations to reduce the work force and maximize the production rate. Where FEA/FEM are the working tools I must say which help the CIM work smoothly, they are actually comprised of Physical material body, each part is connected well to form a structure according to the need of the work production.

6. Conclusion

CIM is the overnight increasing trend in the today's modern technology of manufacturing, as it has been always an essential thing to consider in the production market till now CIM haven't decreased its value, on the other hand its value has been because of its enormous results, nonetheless, FEM/FEA is playing as a most critical part of the CIM, quoted from a famous saying that "it is important to have a body with the soul, here FEA/FEM acts like a soul of CIM body. We have many disciplines available where CIM and FEM are functioning significantly, like some disciplines discussed above (electrical engineering, chemical engineering, nuclear engineering, bio-engineering etc)

7. CIM Results

- CIM has increased the work efficacy.
- Low error rate.
- More production in less time.
- Increased Durability of the product.
- More trusted method of manufacturing.
- Reliable.
- Valid.
- Affordable product value for consumers.
- Assures firm accountability.
- Healthy and friendly working environment because of CIM.
- Firm's credibility.

8. FEA/FEM Results

- Durable structure.
- Can be moulded as per requirements.
- Helps and easy to create Flexible structure.
- Easy to launch at any place.
- Safe and secure way of generating task.
- Accuracy.
- Adaptability.
- Effective Visualization.
- Divided in boundaries so easy to identify.
- Time dependent reproduction.

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