Available online at www.sciencedirect.com

ScienceDirect

Materials Today: Proceedings00 (2015) 000–000

www.materialstoday.com/proceedings

PMME 2016

Implementation of Concurrent Redesign & Manufacture procedure for an automotive component

B.Vijaya Ramnath [a] *, C.Elanchezhian [a] , E.Naveen [b], G.Rekha [c], M.Vidhyarajan [d] , M.Manivannan [d] and J.Dhanush [d]

[a] Professor- Department of Mechanical Engineering, Sri Sai Ram Engineering College, Chennai- 600 044, India.
[b] Assistant Professor-Department of Mechanical Engineering, Sri Sai Ram Engineering College, Chennai- 600 044, India.
[c] Former PG Student-Department of Mechanical Engineering, Sri Sai Ram Engineering College, Chennai- 600 044, India.
[d,] UG Student-Department of Mechanical Engineering, Sri Sai Ram Engineering College, Chennai- 600 044, India.

Abstract

With the development of Global market, it has become a major challenge for most of the manufacturing enterprises around the world to optimize their production strategies because of the demand for "The better quality product with shorter lead time and lower life cycle cost". In order to meet these requirements, many enterprises face a critical need for advanced system engineering for Engineering. The changeover from the Traditional method of manufacturing to Concurrent method of manufacturing is one of the solutions. The front fork of the leading two wheeler was chosen for implementing the Redesign in Concurrent Engineering (CE). The main objective is to reduce the Manufacturing lead time and the cost of the product. The Co-ordinates of the already existing Front fork of a leading 2 wheeler was done using Co-ordinate Measuring Machine (CMM) and the model of the fork was obtained in CATIA, which is a Reverse Engineering concept. The model of the fork was stored in a database, such that it can be retrieved anytime in future. Slight variations in the design in future can also accommodated. Parts with similar design attributes can be grouped such that the Group Technology is achieved. The machining simulation was done using CATIA. The machining simulation can also be used to group the components having similar manufacturing attributes by storing the machining codes generated, in the database. The buckling analysis of the component was done using ANSYS for compressed loading condition. As the number of iterations in the Redesign-Concurrent method increased, both time and the cost reduced drastically.

Selection and Peer-review under responsibility of International Conference on Processing of Materials, Minerals and Energy (July 29th – 30th) 2016, Ongole, Andhra Pradesh, India.

Keywords: Concurrent Engineering; Redesign; Reverse Engineering; Group Technology; CATIA

* Corresponding author. Tel.:+91 9841446655
E-mail address: vijayaramnathb@gmail.com

Selection and Peer-review under responsibility of International Conference on Processing of Materials, Minerals and Energy (July 29th – 30th) 2016, Ongole, Andhra Pradesh, India.

1.0 Introduction

Concurrent Engineering (CE) is also known as simultaneous engineering. In which the Product development has changed from the traditional serial process of design followed by manufacture to a more organized concurrent process where design and manufacture are considered at a very early stage of design the concept of concurrent engineering is no longer new and yet it is still applicable and relevant in today's manufacturing environment. With the development of global economic market, it has become a major challenge for most manufacturing enterprises all around the world to optimize their production strategies because of the demand for the better quality product with shorter lead time and lower life cycle cost. In order to meet this requirement, many enterprises face a critical need for advanced system engineering tools and methods. One solution to improve competitiveness is to change from a traditional design and development process to a concurrent engineering process.

In traditional design and development process such a serial engineering environment it has been known that different stages such as product design, process, review and manufacturing are conducted separately and sequentially therefore if some problem arises during design review this may cause the need for product to be redesign and this redesign activity adds overall time to market for the product. This factor weakens the competitiveness of product. The concurrent engineering is a systematic approach to the integrated design for manufacturability, testability, quality and serviceability equally and in parallel with product design the concurrent engineering environment integrates the expertise from the various engineering discipline during the actual design stage. With proper forethought many of the problem that can be occurred under the serial engineering process can be completely prevented the elimination of design iteration reduces product development cost and shorten time to market for new product. Kayas et.al [1] analyzed the challenges of product design and development in Concurrent Engineering. The inheritance of risks between different phases were modeled and quantified by Concurrent Engineering process which are impossible by Traditional Project Management Techniques. The also released a user-interactive, unique and dynamic management software for Concurrent Engineering which was commercialized successfully. Xue and Yang [2] designed a database representation model and introduced it for supporting various life cycle aspects in concurrent engineering. A Web-based system architecture was proposed to model distributed design database and allow team-members for different product development life-cycle aspects at different locations to access the design database. This newly introduced approach provided the foundation for developing the next generation CAD systems with concurrent engineering functions. Fredric Demoly [3] enabled Geometric skeleton computation for concurrent product engineering and assembly sequence planning. The objective of their research was to integrate assembly process engineering information and knowledge in the early phase of the product development process in a top-down and proactive manner, in order to provide a geometry skeleton-based assembly for Engineers. Edwards [4] designed strategic ideas for manufacture and assembly based on priorities of concurrent engineering. He investigated the strategic application of materials and manufacturing process information during the design process. The basics were analyzed for the application of quantifiable data. A discussion was also made on designs of new process and advancements of old existing product methods. Liu et.al [5] simulated an FE for concurrent design and manufacture of automotive sheet-metal parts. It can be considered as an effectiveness of enabling concurrent design and manufacture, particularly for those components that were formed by plastic deformation. They studied it for three parts- the deep drawing of an oil pan, and the stamping of outer and inner panels of an automobile.

Tsai et.al [6] applied concurrent engineering in the installation of foam fire extinguishing piping system. They implemented the idea of concurrent engineering in construction industry to make an improvement in the construction process. They used Delphi questionnaire analysis to establish a framework for piping installation. Sapuan [7] developed a knowledge based system for materials selection in mechanical engineering design. He indicated the importance of knowledge-based system in the context of concurrent engineering. The selection of material data bases and material selection packages were also studied. Abdelraoof Mayyas et.al[8] developed the use of quality function deployment and analytical hierarchy process for material selection of body in white. They presented a manuscript discussing the usage of multi-attribute decision making tools to assist in material selection for vehicular structures. The main analysis was done to depict the effectiveness of concurrent engineering process.

Sapuan and Mansor [9] presented a review on concurrent engineering approach in the development of composite products. Various studies of CE techniques was made and it was implemented on the process of composite products for CTQ improvement. The analytic hierarchy process helped them select the composite material equal to the selected engineering components. Jung-Seok Kim et.al [10] studied on the development of concurrent engineering system for design of composite structures. The commercial and non-commercial programs related to design and analysis of composite structures were done for concurrent engineering purposes. For integration of software a multi-tasking system was built.

Xenophon Koufteros et.al [11] studied the types of concurrent engineering and its consequences. The research carefully defined CE and creates a valid and reliable instrument to assess CE. They also identified some of its major consequences and implied it in certain number of firms. Dunbing Tang et.al [12] re-engineered the design process for concurrent engineering. A graph was drawn to indicate the design process and the inter dependency between them was related. An algorithm was also presented and the various order levels were characterized.

Shehab and Abdalla [13] did a research on manufacturing cost modeling for concurrent product development. They proposed a system and discussed the development process for cost modeling of machining process. Their developed system differed from the normal methods and supported concurrent engineering. Janez Kusar et.al [14] presented on how to reduce the new product development time. They achieved it by working it and changing the process from sequential engineering to concurrent engineering. A survey was also published that depicted the advancement in time when considering the concurrent engineering process. Gao [15] studied the implementation of concurrent engineering in the suppliers to the automotive industry. The implementation in larger industries like the automotive industry were discussed upon usage of concurrent engineering process for sequential engineering process. The usage of computer aided engineering was also studied. Siti Mahfuzah Mohamad and Ahmad Razlan Yusoff [16] improvised a take away water cup design by using concurrent engineering approach. A take away water cup was designed and the voice of customers were taken into consideration. Based upon the collected details the take away water cup was re-designed and again improved. QFD was used to take voices and to improve the design of the cup. Venkataraman et al [17,18,20] used value stream mapping (VSM) techniques to improve machining process. Vijaya Ramnath et al [19] used VSM to improve material flow and productivity.

2.0 Problem Definition

In Traditional Design process, if an existing part is to be designed, it should be again newly designed. This consumes more time and cost. The Analysis and simulation of the component also consumes more time. In order to overcome the market competition, the Traditional design process should be replaced by a new design process that reduces both time and cost. Redesign in Concurrent Engineering paves the way for reduction in both cost and the time. In this process, the existing component's coordinates are measured using CMM and the coordinates are converted into a 3d model. This model will be stored in a database such that this model can be retrieved in future. In our work, a leading 2 wheeler's Front Fork was taken to compare the Traditional & Redesign in Concurrent Engineering process.

3.0 Methodology

3.1. Creation of CAD model from CMM

The front fork's co-ordinates were measured using CMM. The CMM which is used here is Daisy 8106 with a 1mm diameter Ruby touch-trigger probe. The Co-ordinates of the fork was converted into a model in CATIA software. CMMs are used in surface and boundary continuous probing, or scanning of parts, as well as the extraction of geometric feature data from points cloud data. The output data of the CMM are coordinate values of the center of the probe and normal vectors in the X, Y and Z direction at the position of the tactile point. Additionally, the output format of the measurement data does not accord, which requires of the generation of a CAD model. The format of the measurement data output must be transformed into a format that can be accepted by CATIA software. CATIA is CAD/CAE/CAM integrated. CMMs have become very powerful parts of measuring tools. The data processed can be used directly for the creation of a CAD model of the part. Fig 1 shows the CAD model of the Fork in CATIA. This CAD model is stored in a database that is dedicated. Any slight variations in the designs of the fork in future is accommodated. The components having similar design features can be grouped into part family, such that Group Technology is achieved.

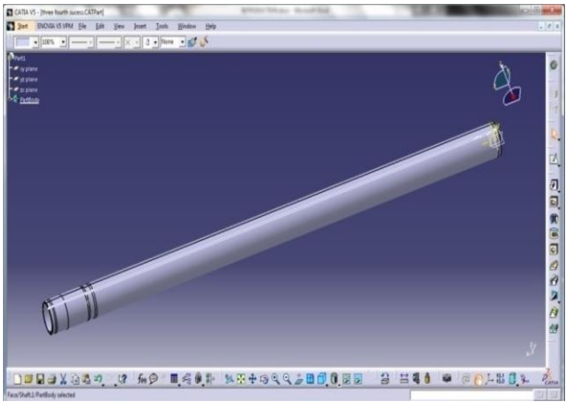

Figure 1. (a) CAD model of the Front Fork

3.2. Machining Simulation using CATIA

It is quite certain that the knowledge gained from simulation will improve product development by improving part design, process design, tool design and manufacturing, and tool try-out. Differences still, however, exist between "virtual manufacturing" affected by simulation and manufacturing practice in industry, in terms of accuracy of the analysis and the feasibility of the design. These exist largely due to the inability to incorporate actual processes and practical manufacturing knowledge into design and analysis. In order to obtain a more practical solution, detailed information on the, the tools, the process parameters and the blank material is needed to initiate a simulation. These parameters and variations cannot be considered in detail or accurately in currently commercially available simulation software. At the same time, shop-floor measurement repeatability is not delicate enough to support proper comparison with simulation. The main aim of the numerical simulation is reported in this paper is to formulate strategies of process improvement and tool design optimization for the selected automotive parts. With this aim in mind simulation has been used to assess the sensitivity of the forming process to the variations of different parameters and to determine the corresponding areas affected. The simulation, which simulates tool try-out processes, was adapted to optimize the process and tool design, with reference to the specifications on the product's performance and quality. Knowledge provided by a process engineer played an important role in this optimization process. The experiences gained through the simulation helped greatly, in later tool try-out. Figure 2 shows the Machining Simulation of the Front Fork in CATIA. The Machine codes are automatically generated by CATIA, such that it is stored in the database. In future if the parts having similar manufacturing attributes, can be grouped together, such that once again the Group technology is achieved.

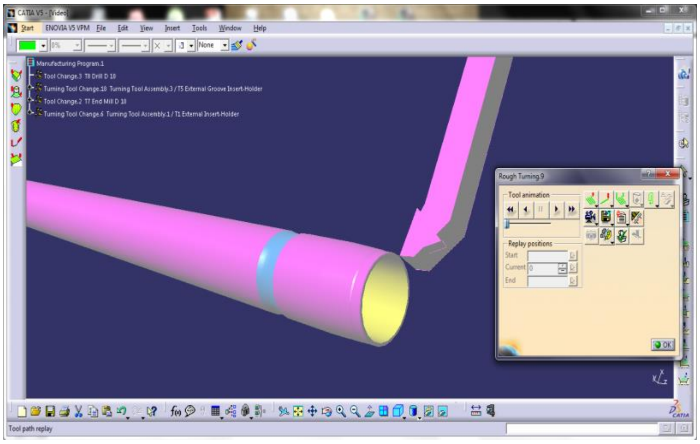

Figure 2. Machining Simulation of Front Fork using CATIA

3.3. Analysis of the Front Fork using ANSYS

Thin structures subject to compression loads that haven't achieved the material strength limit can show a failure mode called buckling. Buckling is characterized by a sudden failure of a structural member subjected to high compressive stress where the actual compressive stress at the point of failure is less than the ultimate compressive stresses that the material is capable of withstanding load. In other words, once a critical load is reached, the splendor component draws aside instead of taking up additional component. This failure can be analyzed using a technique well known as linear buckling load factor, λ, and the critical buckling load. In this buckling analysis of the fork three various loading conditions were applied those loads were based on weight acts on the bike that is the empty weight of the bike-130Kg then the weight of the bike with one passenger-210Kg then the weight of the bike with two passenger-290Kg.The material of the Front Fork was Steel. The Equivalent Stress & the Elastic Strain of the Front Fork for 290 Kg is shown in the Figure 3(a) & 3(b) respectively.

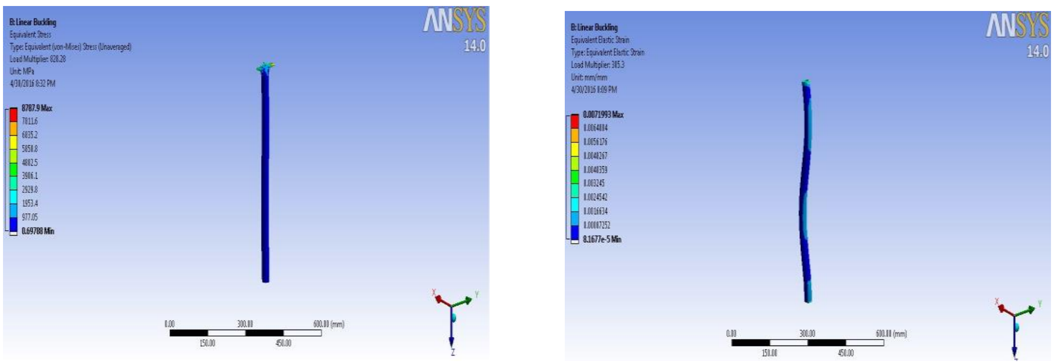

Figure 3. (a) Equivalent Stress of the Fork 3. (b) Elastic Strain of the Fork

4.0 Results and discussions

4.1. ANSYS Results

Table 1: Stress & Strain Results for various Loading Conditions

LOADING (N)	EQUIVALENT STRESS(N/m^2)		ELASTIC STRAIN	
	Minimum stress acting In the fork	Maximum stress acting In the fork	Minimum strain acting in the fork	Maximum strain acting in the fork
1275	0.504	2056.4	$7.196e^{-6}$	0.041226
2060	0.612	6458.5	$1.2849e^{-5}$	0.064942
2845	0.698	8787.7	$8.1677e^{-5}$	0.007199

From the ANSYS results, we can observe that as the Loading increases, the Stress increases proportionally. This is in accordance with the Strength of Materials rule. Also it is seen that the Fork design is safe for loading upto 290 kg.

4.2. Time Analysis

Table2: Time taken for each operation using 2 methods

OPERATION	Time taken for each operation (hrs.) using 2 methods			
	Traditional Method	Redesign 1 in Concurrent Method	Redesign 2 in Concurrent Method	Redesign 3 in Concurrent Method
Coordinate measurement of existing component	3	3	NIL	NIL
Drafting of the Fork	4	4	1	0.5
CATIA 3D design of fork	24	5	2	1.5
CATIA machining of fork	4	4	2	0.5
ANSYS analysis of fork	4	4	3	2.5
Coordinate measurement of finished component	3	3	3	3
Total Time (hrs)	**50**	**23**	**11**	**8**

From the Table 2, it is evident that if the Traditional Method is used for designing the Front Fork 3 times it totally takes 150 hours. But if the same thing is done using the Redesign in Concurrent Engineering method, it only takes 40 hours, in which three fourth of the time is approximately saved.

4.3. Cost Analysis

Table3: Cost for each operation using 2 methods

OPERATION	Cost for each operation (Rs.) using 2 methods			
	Traditional Method	**Redesign 1 in Concurrent Method**	**Redesign 2 in Concurrent Method**	**Redesign 3 in Concurrent Method**
Co-ordinate measurement of Existing fork	8,000	8,000	NIL	NIL
Design & Development of Fork	20,000	6,400	2,200	1,500
Machining Simulation of Fork	25,000	25,000	12,500	3,100
Analysis of Fork	10,000	10,000	7,500	6,300
Manufacturing of the Fork (1 No.)	1,300	1,300	1,250	1,200
Coordinate measurement of the finished Fork	8,000	8,000	8,000	8,000
Total Cost (Rs.)	**72,300**	**58,700**	**31,450**	**20,100**

From the Table 3, it is inferred that if the total cost taken for designing 3 Front Fork using the Traditional method was Rs.2,16,900. But if the same thing is done using the Redesign in Concurrent Engineering method (ie, 3 redesigns), the cost drastically came down to Rs.1,10,250. Approximately 50% of the cost is saved. The huge investment on the Traditional design can be minimized.

5.0 Conclusions

The Concurrent Redesign process for the purpose of manufacturing of front fork of a leading 2 wheeler was successfully implemented. In this process, machining simulations were done by CATIA software to support part design, process model development and tool try-out. Machining simulation plays an important role in the integration of design and manufacturing during the development of automotive products. By means of this simulation result and code generated from the CATIA software, machining was done using the CNC machine, which reduced the time of machining. Simulation result played a vital role in reducing machining time. Additionally the linear buckling analysis was also done using the ANSYS software to determine the compression stress, strain and failure modes of front fork of the bike. Thus this work integrated the Redesign, Concurrent Engineering, Reverse Engineering & Group Technology, which is a new strategy.

6.0 Reference

[1]B. Kayas, G. Arndt, M. Zhou, S. Savci, Y. B. Khoo and A. Rispler: Risk quantification for new product design and development in a concurrent engineering environment. *CIRP-Annals Manufacturing Technology 55(1): 147-150, 2005.*

[2] D. Xue and H. Yang: A concurrent engineering oriented design database representation model. *Computer Aided Design 36 (2004) 947-965.*

[3]Fredric Demoly, Luis Toussaint, Benoit Eynard, Dimitris Kiritsis and Samuel Gomes: Geometric skeleton computation enabling concurrent product engineering and assembly sequence planning. *Computer Aided Design 43 (2011) 1654-1673.*

[4] K. L. Edwards: Towards more strategic product design for manufacture and assembly- Priorities for concurrent engineering. *Materials & Design 23 (2002) 651-656.*

[5]Y. Liu, X. Peng and Y. Qin: FE simulation for concurrent design and manufacture of automotive sheet-metal parts. *Journal of Material Processing Technology 150 (2004) 145-150.*

[6]T. P. Tsai, H. C. Yang and P. H. Liao: The application of concurrent engineering in the installation of foam fire extinguishing piping system. *Procedia Engineering 14 (2011) 1920-1928.*

[7]S. M. Sapuan**:** A knowledge-based system for materials selection in mechanical engineering design. *Materials and Design 22 (2001) 687-695.*

[8]Abdelraoof Mayyas, Qin Shen, Ahmad Mayyas, Mahmoud Abdelhamid, Dongri Shan, Ala Qattawi and Mohammed Omar: Using quality function deployment and analytical hierarchy process for material selection of body-in-white. *Materials and Design 32 (2011) 2771-2782.*

[9]S. M. Sapuan and M. R. Mansor: Concurrent engineering approach in the development of composite products: A review. *Materials and Design 58 (2014) 161-167.*

[10] Jung-Seok Kim, Chun-Gon Kim, Chang-Sun Hongand R. Thomas Hahn: Development of concurrent engineering system for design of composite structures. *Composite structures 50 (2000) 297-309.*

[11] Xenophon Koufteros, Mark Vondermbse and William Doll: Concurrent Engineering and its consequences. *Journal of Operations Management 19 (2001) 97-115.*

[12]Dunbing Tang, Li Zheng, ZhizhongLi, Dongbo Li and Shiqi Zhang: Re-Engineering of the design process for concurrent engineering. *Computers and Industrial Engineering 38 (2000) 479-491.*

[13]E. M. Shehab and H. S. Abdalla: Manufacturing cost modeling for concurrent product development. *Robotics and Computer Integrated Manufacturing 17 (2001) 341-353.*

[14] Janez Kusar, Joze Duhovnik, Janez Grum and Marko Starbek: How to reduce new product development time. *Robotics and computer Integrated manufacturing 20 (2004) 1-15.*

[15] J. X. Gao, B. M. Manson and P. Kyratsis: Implementation of concurrent engineering in the suppliers to the automotive industry. *Journal of Materials Processing Technology 107 (2000) 201-208.*

[16]Siti Mohamad and Ahmad Razlan Yusoff: Improvement of take-away water cup design by using concurrent engineering approach. *Procedia Engineering 53 (2013) 536-541.*

[17] K.Venkataraman, B. Vijaya Ramnath, S.Kannappan, L.Vinoth Selva Bruce, K.Vetri Velmurugan : Comparative Analysis of AHP and ANP Model for Lean Production System Justification. *International Journal Applied Mechanics and Materials, Volume 591, June 2014, Pages 197-201.*

[18] B.Vijaya Ramnath, Vishal Chandrasekhar, C.Elanchezhian K.Venkataraman, Vinoth Selva Bruce L: Value stream evaluation and simulation to improve material flow and productivity. *International Journal Applied Mechanics and Materials, Volume 612, 2014, Pages 89-95.*

[19] K.Venkataraman, B.Vijaya Ramnath, V.Muthu Kumar, C.Elanchezhian: Application of valve steam mapping for reduction of cycle time in a machining process. *International Journal Procedia Material Science, Volume 6, Pages 1187-1196.*

[20] K.Venkataraman, B.Vijaya Ramnath, R.Sarvesh, C.Rohit Prasanna,: Selection of Manufacturing Method using Artificial Neural Network. *International Journal Applied Mechanics and Materials, Volume 766-767, 2015, Pages 1201-1206.*