An Overview of Concurrent Engineering & Virtual Manufacturing Application in Motorcycle Sprocket Production

Abhishek Barua, Siddharth Jeet and Sasmita Kar

Abstract— In a conventional design and manufacturing background, the flow of data and operations are sequential. To optimize product development and manufacturing time and cost, parallelization of operations is necessary. This can be achieved by the help of Concurrent engineering and Virtual Manufacturing process. It helps in shortening the product development time, improves the quality and decreases the overall production cost. The designing and manufacturing process of a chain sprocket is intricate due to the presence of various designing, machining and testing parameters. This paper reviews the elementary principles and tools of Concurrent Engineering concept that entails parallel activities in integrated product and process development, through the application of CAD, CAM and CAE specifically in the simulation of production, i.e. Virtual Manufacturing. By the help of these technologies, expensive physical prototypes and experiments can be sidestepped, development time can be considerably reducing and many design alternatives can be verified leading to quality improvements. Based on this, modification in the manufacturing process of chain sprocket is also proposed. So by employing concurrent engineering and virtual manufacturing process, reduction in number of repeated test, enhancement in quality, reduction in cost and reduction in total production operation time can be achieved. These methods can also be helpful in development of an optimized product.

Index Terms—CAD, CAE, CAM, Sprocket, Concurrent Engineering, Simulation, Virtual Manufacturing.

1 Introduction

A Chain sprocket is a profiled wheel with teeth that mesh with indented object like chain or track either to impart rotary motion between two shafts where gears are unfit or to impart linear motion to a track, tape etc. The conventional sprocket manufacturing process is sequential but the process can be optimized by increasing the precision, decreasing the cost and time by introducing the concept of Concurrent Engineering and Virtual Manufacturing.

1.1 Sequential Engineering Vs Concurrent Engineering

Concurrent Engineering (CE) is an organized approach to integrated product development process. It is different than the old sequential approach since the product development in CE is simultaneous. By concluding the tasks in paralelamente, the development of product can be done more efficiently substantially saving the costs. In the traditional approach, finishing all the physical manufacturing of a prototype before realizing any test, but in the concurrent engineering it allows to design and numerous analysis at the same time, and at different times, before the real unfolding. This multidisciplinary approach emphasizes work in equipment by using cross-functional equipment. A Schematic comparison between Sequential and Concurrent engineering is represented in Fig. 1.

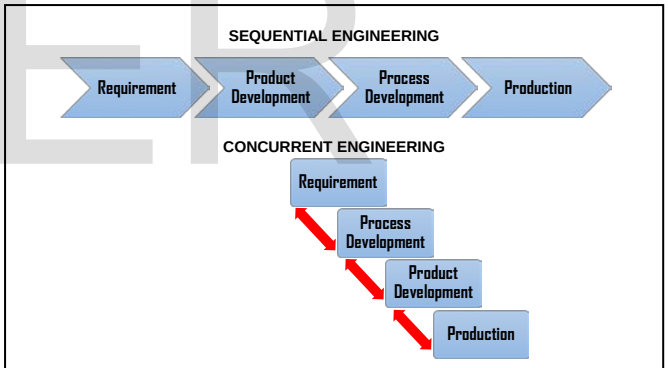

Fig. 1. A typical comparison between sequential and concurrent engineering.

The following are some of the benefits of concurrent engineering:

1. It lessens the time to market of a product.
2. It reduces the production cost.
3. It maximizes the quality of the manufactured product initially
4. Reduces production time.
5. It gives you a competitive advantage.
6. Increases productivity by minimizing errors.

There are some drawbacks related to the putting in initial use of concurrent engineering, including the requirement of the significant modernization of organization and the extensive retraining of workforces. Also, there are generally considerable problems in data transfer between employees in miscellaneous departments that can require supplementary pursuit of computer software applications. Besides these significant

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initial investments, the organizations which adopt a concurrent model of the work of engineering normally wait for several years before considering the advantages of this changeover.

1.2 Virtual Manufacturing- Revolution in Manufacturing

Virtual manufacturing (VM) include the use of computers to design a model, simulate and optimize the precarious operations and objects in any factory plant. The main technologies used in VM include computer-aided design (CAD), 3D modeling and simulation software, product life cycle management (PLM) systems, virtual reality, high-speed networking and rapid prototyping. It provides distinctive design flexibility for process development. Through virtual simulation software, engineers can solve process related issues before building any processes. This gives the manufacturer the ability to cut costs by creating components for testing and quality assurance purposes using simulation softwares.

There are three main subdivisions of Virtual Manufacturing:

1. Design-centered VM – It provides information about the manufacturing process to engineers and designers so that they can optimize products for production purposes. They can also save money by testing 3D product replicas and processes instead making of physical prototypes.
2. Production-centered VM - It simulates manufacturing processes so that they can be tested for their quality, durability and can be optimized.
3. Control-centered VM - It simulates the controls that are used to run the actual production processes.

2 Literature Review

Several attempts have been made by numerous researchers by introducing the concept of Concurrent Engineering and Virtual Manufacturing at different place to get optimized results. Some have tried to introduce CE either in production management or in designing process. Some have tried to simulate the manufacturing process via Computer Aided Manufacturing (CAM) and Computer Aided Engineering (CAE). For this review, many international and national papers were helpful. Worldwide researchers have applied the efforts to optimize the designing and manufacturing process as:

An effort has been made to capture the phenomenon of chip formation and machining of different kinds of gears using two types of process. Using rapid prototyping technology, a conceptual method was proposed to ascertain the efficiency of the virtual manufacturing. (G. Pohit and K. Kumar 2012).

An effort was made to generate expressive design data for spur and helical gears and the corresponding rack form cutter necessary for the manufacturing. Solid models for the cutter and blank were developed and gear-manufacturing processes were simulated in a virtual manufacturing environment (Goutam Pohit 2005).

An effort was made to simulate the spur and helical-gear manufacturing process with the chip formation, in a virtual manufacturing environment. The user has the option to manipulate the various parameters necessary for the manufacturing operation. (Kaushik Kumar, Sanat Kumar Mukherjee and Goutam Pohit 2008).

A. Hambali et. al (2008) reviewed the basic ideologies and gears of Concurrent Engineering and discussed its employment. Some modifications of the existing product development processes were also proposed to safeguard a product development process in the Concurrent Engineering environment to run easily and efficiently.

J. Schmitz and S. Desa (1993) proposed a theory for product development based on concurrent engineering ideologies which can be used for creation of a reasonable computer-based implementation of concurrent engineering, called virtual concurrent engineering (VCE) They demonstrated the effectiveness of VCE by applying it to improve a method, called design for producibility (DFP) by using AUTOPROD (Automated Producibility) software.

A machining process simulator for concurrent engineering CMPS was developed to meet the requirement for an effective simulator. A solid Ray-representation method and the Voxels plus B-representation algorithm was used which simplified the Boolean operation process by improving the material removal simulation speed. Lastly, CMPS was applied to an actual NC milling process. (Han Xiangli, Yang Gang and Xiao Tianyuan 1996).

At first, a team approach to concurrent engineering and various aspects of multi-disciplinary teams were discussed. on Use of Quality Function Deployment (QFD) in a concurrent engineering environment was shown. The parameters of the product selected were identified and analyzed. The treatments and combinations having the maximum effect on the design outcome were also identified. Optimum levels of these parameters based on yield and cost were determined was also presented. (S. Dowlatshahi and M. S. Ashok 1997)

Janez Kusˇar et. al (2014) presented an overview of quality-related standards in an automotive industry. the principles of sequential and concurrent product realisation and the course of concurrent product realisation and quality assurance of products was also shown. A case study of the project of concurrent realisation of products (components for the automotive industry) was conducted which represented the requirements of quality standards for the automotive industry.

Takeshi Miki (1999) explained the concept of Concurrent Engineering and how it can be used for production of machine parts using steel bars and wires.

An automobile covering part was taken and based on the finite element analysis software AUTOFORM die design and forming simulation was done. According to the outcome of simulation, prediction of the defect of forming and modification in the forming process can be done. By using concurrent engineering, different type of optimization in the process is possible. (Min Fu et. al 2013).

Joze Duhovnik and Joze Tavcar (1999) presented the methodology for analysis of information creation and information flow. They identified utmost vital requirements and presented some concrete solutions for the creation of an appropriate information system. They connected tool production and the development of serial products and managed to reduce the time for product fabrication. They set up a virtual toolmaking factory to increase capacity during peak production periods.

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and related processes. By applying numerical FE/FV simulations expensive physical prototypes and experiments can be avoided. They illustrated the application of CE concept through numerous case studies of numerical simulations of processes using SIMUFACT forming software.

Hong C. Zhang and Daguang Zhang (1995) discussed the history and principle of Concurrent Engineering (CE), and then overviewed seven areas of CE study in the manufacturing engineering perspective as well as several industrial applications.

A methodology was developed by using Concurrent Engineering which will model the different contemplations as an abstracted network, called a CE-Nets. The basis of CE-Nets was also described. (Tong Wu and Peter O'Grady 1999)

The concurrent engineering method was accepted to ensure design optimization of mechanical systems. Design optimization problems was deviced based on the nature of the relation between the parameters and the restrictions imposed by virtue of operational conditions. The concept of modeling was used to develop a set of attributes which will provides the best possible result. (M. A. Seif 1998)

A prototype concurrent design system was developed in which information regarding features in the design was provided to the designer. The system extracts geometrical and technological information regarding a part from its computer aided design (CAD) model and it will generate the required manufacturing information as required. (D. T. Pham and C. Ji 1999)

A hybrid computer aided process planning (CAPP) system named ProPlanner was designed to aid concurrent product development. It will automate the information acquisition, product design interpretation, manufacturing process planning, cutting tool selection, set-up planning and operation sequencing. The system employed a hybrid approach utilizing a combination of rule-based reasoning and object-oriented programming. It helped in detection of design errors during the design stage before manufacturing and incorporated a feedback mechanism for correcting errors and gave suggestions to modify the product design. (D. T. Pham and C. Gologlu 2000)

An overview of Virtual Manufacturing was presented. concurrent simulation of all the activities and functions revolved throughout the life cycle of a product can be done by employing Virtual Manufacturing process. (Chetan Shukla 1996)

Fig. 2. Manufacturing layout of a Motorcycle Sprocket

By using CE & VM during the design stage, manufacturing information can be accessed at any instant of time to evaluate the design and if any error is found proper modification could be done. Different types of manufacturing environment can be simulated by using a vast range of CAD, CAM and CAE softwares. By using CAM softwares machining of the sprocket can be simulated by using different machining paramenters and detailed study can be conducted for finding an optimal parameter which will be suitable for machining. By using CAE softwares, metal forming techniques can be studied and simulated which will help in enhancement in mechanical properties of the product. These initial process can help in minimizing the errors, time and cost in manufacturing. After Virtual Manufacturing process, the manufacturing of the product can be done in a computer gonverned environment which is also known as Computer Integrated Manufacturing (CIM). Fig. 3. shows the use of Concurrent Engineering & Virtual Manufacturing in the traditional Manufacturing process of Motorcycle sprocket.

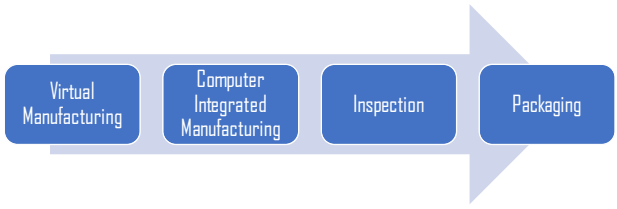

Fig. 3. Manufacturing layout of a Motorcycle Sprocket after using of Virtual Manufacturing and Concurrent Engineering

4 Conclusion

Here, overview of Concurrent Engineering and Virtual Manufacturing is presented. It is interesting to observed that researchers have applied the principles of CE & VM in different ways. Some have tried to optimize the designing using CE, some have tried to optimize the manufacturing of product or the whole manufacturing process of a factory plant. VM is a powerful asset in the phase of conceptual product design and development and assessment of different solutions for consistent technological processes, as a criterion for the application of the concurrent engineering. Since the modifications are

made on the virtual models of the process, verification of all design alternatives can be done and all possible errors and defects can be recognized in a short time with least costs. Besides, the optimization of the product manufacturing and its element, but also of the tool itself and its life cycle, leads to drastic enhancement of product quality and the reduction in manufacturing and maintenance costs, which has positive impact on competitive position of company. Hence these techniques can be helpful for faster and precision manufacturing of the sprockets, also for further development of chain sprocket.

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