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New Product Development Time Reduction In Indian Bearing Industry By Concurrent Engineering Between Tool Design and Tool Manufacturing

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Abstract: *Bearings are essential components in mechanical systems involving relative motions. The purpose of using these mechanical devices is to minimize friction between rotating components. The industrialization has started with invention of the steam engine and currently the technology has advanced to the electrical devices. With the advancement in technologies, especially that of automobile industry, bearing design also needs to be changed to complement the new vehicle designs and new bearings need to be developed from the new designs. This entire process is quite time consuming but the same should be executed at a great pace to match the pace of changing market needs and wants. The critical issue is the excessive time being used for new product development. However, this issue can be addressed by adapting transition from sequential engineering to concurrent engineering at various stages of New Product Development; the article presents the concurrent tool design and development process in Indian bearing Industry. The study focused on Indian bearing industry to a transition from sequential to concurrent engineering (CE) and as a team based approach. The study does not deal with other design and development/ manufacturing issues. The results of design and development of transition to concurrent development in Indian bearing Industry are presented. It is also justified from the time analysis that shift to concurrent product development from sequential provides benefit to the organization.*
Keywords – *Concurrent Engineering, New Product Development (NPD), Time reduction, Bearing.*

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I. Introduction

In the present industrial scenario market share and profitability are the essential factors which determines the success of an organization. Furthermore, the determinates that would improve and influence the competitive edge of the company are quality, unit cost of a product and lead time. Hence the term “Concurrent engineering” as discipline has emerged with objective of better quality, improved delivery performance and reduced cost. Concurrent Engineering or often referred as simultaneous engineering (CE) was defined in 1988 by Institute for Defense Analyses (IDA), USA in its December report as “A systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is to cause the developers, from the outset, to consider all elements of the product life cycle from concept through disposal, including quality, cost, schedule, and user requirement”.The CIM Institute has defined Concurrent engineering as “the delivery of better, cheaper and faster product to market, by a lean way of working using multidiscipline teams, right first time methods and parallel processing activities to consider continuously all constraints”Thus Concurrent engineering besides being an engineering philosophy is a management approach for enhancing quality. There are significant concerns about cost and development time for new products and product modifications, which can be addressed by CE. The design and development activities of the product, along with the associated manufacturing resources and processes, necessary support tools for repair and maintenance activity are handled simultaneously. At present in the industry sequential practice is being deployed, wherein the manufacturing approach is established subsequent to the product is design and development is accomplished. The idea of the approach is in sharp contrast to concurrent engineering.The results of various studies by the researcher’s highlighting the importance and need of Concurrent Engineering can be summarized as; i) the increasing technical complexities and variety of product further prolong the developmental process. Thus, making it difficult to anticipate the result of design decisions on the performance and functionality of the final product being developed. ii) The concept of reengineering has led to an increase in the global competitive atmosphere. iii) An urge to answer the rapidly changing demand of the consumer .iv) the need for shorter product life cycle. v) In large organizations, numerous departments are engaged in developing various products in the same period. Thus, the new products are becoming obsolete in technology aspects within a short time frame because of innovative technologies.There are multiple dimension of CE approach which include external factors such as customer satisfaction, team work, company competitiveness, commitment a well as internal communication, culture, and early attention to manufacturing, support and test issues. “Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life-cycle from conception through disposal, including quality, cost, schedule, and user requirements”, (Herder and Weijnen 2000). “Concurrent engineering (CE) is an engineering management philosophy and a set of operating principles that guide a product development process through an accelerated successful completion. The overall CE philosophy rests on a single, but powerful, principle that promotes the incorporation of downstream concerns into the upstream phases of a development process. This would lead to shorter development time, improved product quality, and lower development and production costs”, (Yassine and Braha 2003). “Concurrent engineering (CE) is a process which can integrate all the steps in the process of product development including the design stages and manufacturing process and it can put them in a form in which we can observe and consider them concurrently. It unifies the processes involved in systematizing product design. The Multiple domain integration is the most outstanding characteristic of concurrent engineering. Concurrent engineering is an optimized operating model” (Luh et al., 2009).With the advancement in technologies, esp. that of automobile industry, bearing design also needs to be changed to complement the new vehicle designs and new bearings need to be developed from the new designs. This entire process is quite time consuming but the same should be executed at a great pace to match the pace of changing market needs and wants. Hence, bearing industry is consistently struggling to give the market the newly developed bearings to best suit their needs at the right time. To meet this challenging requirement, one of the major challenges is to substantially reduce the new product development time. Lots of management research is being conducted around the globe to reduce the design and development time of new products utilizing various software applications, various management methodologies, concurrent engineering and collaborative approach, etc however the focus of the same is limited in India. Thus, proposed study is in the light of Indian bearing industry and focusing on close integration between tool design and manufacturing activities involved during NPD cycle. This integrations is enabled by systematic process of analysis the tool design requirements, lead times, dependability with other functions and criticality.The advantage provided by concurrent product development over sequential product development lies in the level of interactions amongst the individual stages involved in the prior one. The interactions are facilitated by implementation of track and loop technology.

II. Literature Review

According to Haque et al. (2000) the collaborative contributions from all the departments of the firm which would either cause an improvement or up gradation in the existing product or new concept for the market or company is New Product Development (NPD). Anumba et al. (2002; 2000) in their paper on CE had highlighted the key features: concurrency and integration. Further adding that synergy in the development process of the product includes the designing of the product, simultaneously in its preparation and development, and preparation for regular volume production. The integration concept encompasses process and content of information along with knowledge throughout the project stages and spamming across tools and technologies used in the process of product development.Early considerations and multidisciplinary teams of all lifecycle issues affecting a product involves direct requirements in the integrated concurrent design of the product. NPD is a dynamic association between external and internal factors (Harmancioglu et al., 2007). According to Dowlatshahi (1995) CE emphasis on multifaceted path that employes programs, procedures, and rules, analyze, evaluate, and upgrade the design of products. According to Abdalla (1999), information management and organization methods are needed to integrate the development process by the efficient cross functional teams for the implementation of CE. Koufteros et al., (2001) supported this idea, they along withValle and Va´zquez-Bustelo (2009) further highlighted three vital principles of CE, (i) concurrent workflow (ii) early involvement of different function involve in product development (iii) team work. Several efforts have been done to understand the identifying components of CE by different researchers at different times. Jarvis (1999) summarized the key components of CE. He laid stress that CE requires a stability in the product specification ,clear understanding of customer needs, ability to build and support effective teams, a structured systematic approach ,design re-use and standardization to minimize the design content, availability of resources early involvement of all team members, appropriate technological support to minimize time. Following several key components, Tucker and Hackney (2000) differentiated between sequential engineering and CE and added that only CE can attempt diverse approach to new product introduction in which conceptual design stage that ensures lead times and costs reduction, the requirements of all stake holders, especially customers are discussed. The reduction of manufacturing cost can be achieved with simultaneous improvement of performance during the development of composite components however the adoption of CE approach calls for inclusion of elements from various stages of life cycle of the component starting from market research to product performance mapped as per user requirements. The IT support also forms an integral part of this process. Shina(1991) had identified that, simultaneously running multiple activities helps CE approach to reduce development times. Multiple actions are being performed simultaneously, and the sequential activities are not hindered even if one item in the new product development process slips from schedule. Similarly Bradley in his paper, (1995) demonstrated the benefits of concurrent engineering approach over the limitations of techniques adopted by traditional design. An important aspect of the recommendation involves approach of team building in the initial phase and working closely with the clients and adopting computer modeling for further move towards virtualization. At present in Indian bearing Industry, significant difference does not exist between new product development activities in initial sample development and mass production, as first sample lot developed on manufacturing lines. To develop sample lot on production line major requirements are tooling and to inspect/check the product quality major requirement of gauges at various stages. Here stages mean different process inspection at different development processes i.e. Turning, Heading, Grinding and Assembly. In bearing industry major time consuming process is tool & gauge design, tooling & gauges manufacturing. After complete tool and gauge design, tool and gauge development process started.

III. Methodology

The authors have proposed methodology of identifying critical tooling and prioritizing design and manufacturing efforts towards it. The prioritization is necessarily based on certain parameter which are being explained in a tabularized format as below:

Sr. No.	Parameter	Description
1	Procurement lead time (P_i)	Describes lead time required for procuring raw material
2.	Design lead time (D_i)	Describes lead time required for designing

Table. 1 Parameters for setting up the Priority

Stages and activities of the tool design process:

The tool design process is dependent on Product and Machines under consideration. Moreover it also needs to consider product features to be ensured by manufacturing processes. In case of bearing industry the primary operations are Turning, Grinding & Super-finishing. Thus for all of these operations 2 varieties of tooling is required which are (i) Facilitating manufacturing viz. fixtures, cutting tools etc and (ii) Facilitating Quality assurance viz. gauges. After giving consideration to above categorization we can further categorize Bearing Tool Design in following stages,

- Turning and heading gauge design,
- Grinding gauge design,
- Assembly gauge design,
- Grinding line (includes Inner & Outer face, Outer diameter, Flange, Track grinding and super finishing) tool design,
- Assembly line tool design.

The methodology is explained in brief in following section

Calculation of Total lead time

The total lead time for Tool Design activity can be formulated as

Total Lead Time $\sum_{i=1}^{n} \mathrm{Ti}$

Wherein we have defined tool design activity in “n” stages.

Criticality Ranking

Based on the parameters mentioned in Table (1) the criticality of the component is calculated.

Ti = Pi + Di

Subsequent to this a criticality Rank is awarded starting from maximum Ti to lowest one.

Expedition of Critical components

The top 20% are selected for further expedition.

The selected drawings are looked upon for reducing the Ti by controlling internal factors.

The revised Design lead time (Di) is worked upon by means of expediting on design efforts.

The revised Ti is calculated.

IV. Case Study

A case study based on the proposed methodology is undertaken in a automotive component manufacturing industry. The tool design activity constituting of stages as below,

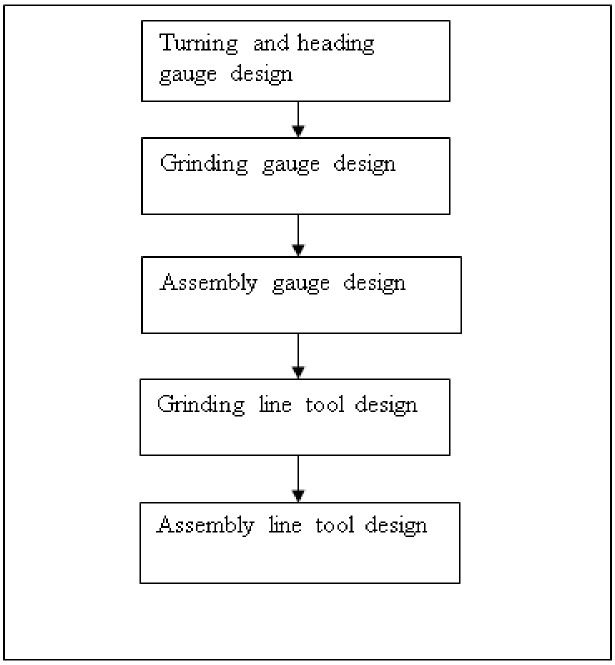


Figure 1. Design Process

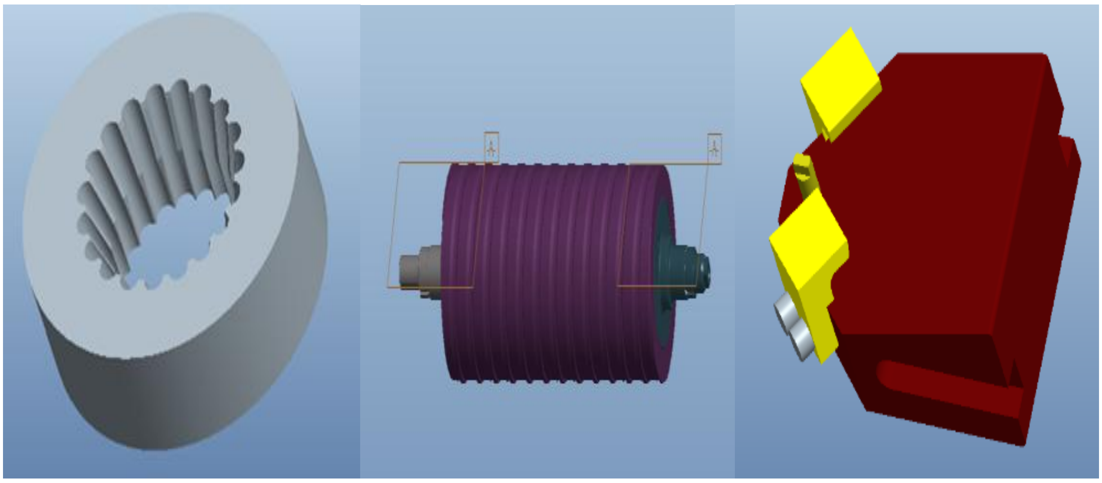
The tooling and gauge development time is averaging 120 days for the activities of design and manufacturing of the s specific bearing. However this can be generalized to other variants as well.
In the study we identified tooling's and Gauges which are critical and are more time consuming in development.

Description	Design Time	Manufacturing time	Total Lead time	Criticality ranking
Turning & Heading gauge	1	90	91	3
Grinding gauge	1	90	91	3
Assembly gauge	1	90	91	3
Grinding Toolings	11	120	131	1
Assembly Tooling	5	120	125	2

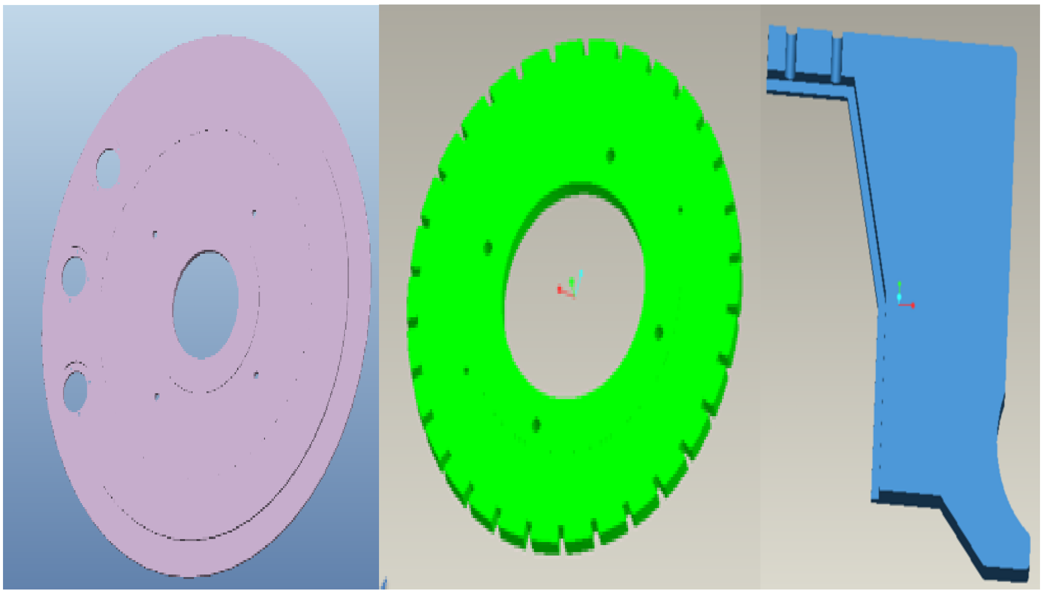
Table 2 Activity based lead times

For the expedition purpose the critical components are studied further. Firstly identified critical tooling's whose development time is more. Major time consuming tooling's are as follows.(Illustrated in Figure 1)

- Close in die for cage assembly operation in assembly
- Feed rollers for super-finishing of rollers on super-finishing machine
- Flange checking gauges of cone flange in grinding and turning stage
- Face grinding plates of cone and cup face grinding on grinding machine
- Carrier plates of roller end face grinding on grinding machine
- Work guide of cup grinding on grinding machine



Close in die　　Feed roller　　Flange Gauge



Face grinding plate end face grinding　　Carrier plate roller　　Work Guide Outer (Cup) Grinding

Figure 2. Tools and gauges crucial for the study.

V. Results and Impacts

After identifying critical tooling's using Concurrent Engineering process and releasing drawings of tooling i.e. Close in die for cage assembly operation in assembly, Feed rollers for super-finishing of rollers on super-finishing machine, Flange checking gauges of cone flange in grinding and turning stage, Face grinding plates of cone and cup face grinding on grinding machine, Carrier plates of roller end face grinding on grinding machine, Work guide of cup grinding on grinding machine …etc. which require more development time in first three days of tool design and release drawings for manufacturing. Adopting concurrent engineering between tool design and tool manufacturing will save more than 10% development time. This will overall reduce New Product development time. As depicted in the Figure 3

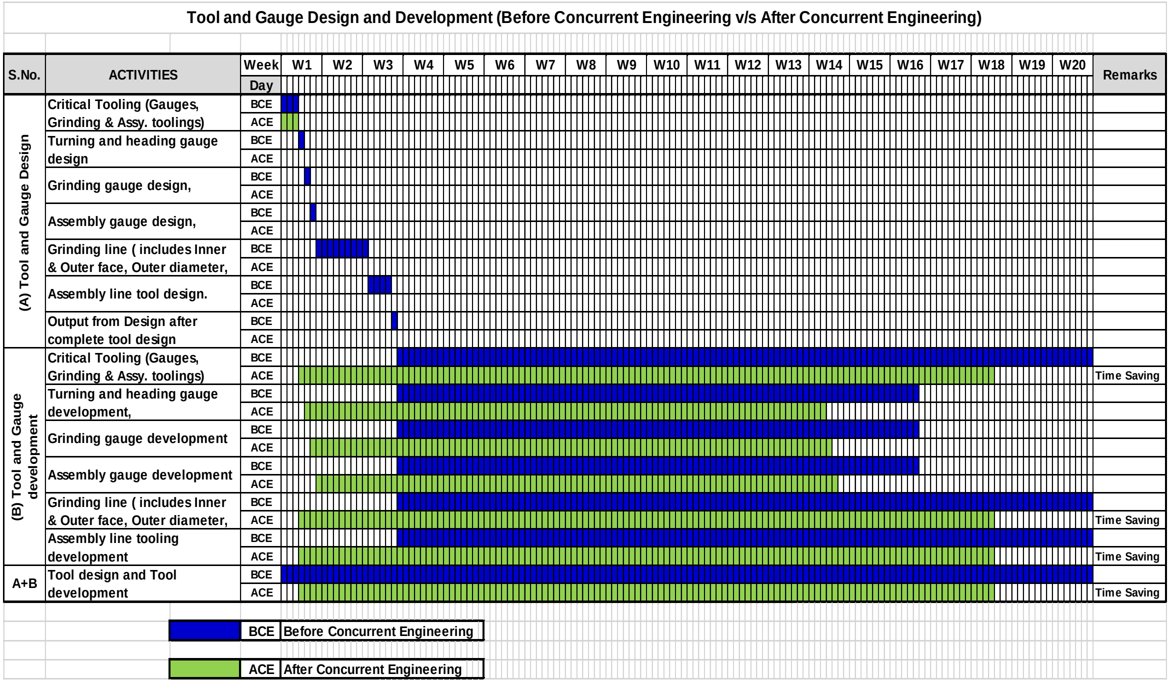


Figure 3. Tools and Gauges design and development

(a) Impact: Organization

Using concurrent engineering in tool design and development the following goals are achieved:

- Tooling development time reduction
- New product development time reduction.

Following are the reasons for time reduction by Concurrent Tool development:

- Parallel running activities (Tool design and Tool development),
- Tool Design release in stages,
- Longer development time tooling design released in first stage,
- Longer development time tooling development starts first,
- Team members have regular meetings for information exchange,

(b) Improvements and Exceptions

Concurrent Engineering between tool design and tool manufacturing required proper Co-ordination and management between two different resources. To develop faster new products in organization, develop and maintain system for regular meeting between tool design and tool manufacturing.

VI. Conclusion

This paper presented a literature review of the CE implementation for the product development activity in Indian bearing Industry. It is found that the CE helps in improvement of tool development time in Indian bearing industry. Indian automobile market requires short new product development times and so Indian bearing industries are also moving into transition to concurrent product development from conventional one. The basic element of the concurrent product development is parallel working, team working, so the article focuses on the design and development of tooling and gauges by formation of teams. In Indian bearing industry the research has helped the bearing industry achieve time saving by concurrent engineering.The proposed concept of concurrent engineering between design and development has been tested in Indian bearing industry. First, the complete design process steps defined and then design release started in phased manner. In the design planning phase identified critical tooling and gauges and design released on priority. Tool development in-house and on vendors started in phased manner. The concurrent development implementation of activities, possible interconnections of activities and times of overlapping activities saved development time of new product development in Indian bearing industry.

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