Improvement in Subsisted Product Delivery Process of Manufacturing Organization using Concurrent Engineering

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Abstract: There is a strong market demand to develop product quickly, according to customer requirements at lower cost. To fulfill this demand, it is essential to develop product in such a way which is quicker and improved than traditional sequential way of product development. This can be achieved by replacing existing practices of product development with a collaborative approach of Concurrent Engineering (CE), which explores the opportunities of removal of design errors at initial stage. In this paper an attempt has been made towards exploration of implementation of CE. An existing Product Delivery Process (PDP) of local manufacturing organization has been closely observed and analyzed on the basis of Concurrent Engineering principles. Possible areas of improvements have been identified and prioritized for improvements. A comparison is made between the traditional and concurrent approaches and based on analysis; comparison has been made for bringing the current Product Delivery Process (PDP) of a manufacturing organization closer to the Concurrent Engineering (CE) concept. The recommendations advocate user companies to implement CE as a tool in manufacturing organization which is justified after comparison that the approach is valid and implemented in similar organization.

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Key Words: Concurrent Engineering; Discrete parts Manufacturing Industry; Product Delivery Process; Supply Chain; Program Approach

1. Introduction and Literature Review

The objective of a manufacturing company is to make use of resources efficiently to maximum profit. In the new era, the paradigm is shifting from mass production to mass customization. There is a demand by the companies to launch the product with minimum possible product development time with existing recourses. The new product is launched to the market early to earn profits. The existing industrial environment is a form of sequential process. These activities include design process. planning. manufacturing, QC, packing etc. Theses activities may increase in number in different industrial sectors depending upon the complexity of the products and processes. The engineering changes and production impediments is quite high in existing setup. This is considered a slow approach and time to launch new product is high which added cost of the product. In order to cope with this situation, concurrent as a tool is a likely approach which is a collaborative approach. This paper is an application of the Concurrent Engineering (CE) tools used to improve the existing product delivery process of a manufacturing Company.

The Integration of team, empowerment of team, training & education will be more thoroughly discussed in the topic of cross functional teams [1, 2]. The product development process is from concept design stage to the delivery of the product and is important for

product development [3]. The product design is checked with respect to manufacture, assembly, QC, packing or cost [4, 5], following design strategies may be used in the process design, Design for Manufacturing (DFM); Design for Assembly (DFA); Design for Quality (DFQ); Design for Cost (DFC). One of the important areas in this regard is to use the latest CAD/CAM Techniques and to share the data between design, manufacturing and other departments [6, 7, and 8]. All these requirements demand a strong communication infrastructure which is required for the effective implementation of concurrent engineering. The main component of Concurrent Engineering studied by [9] is also beneficial in this regard. The papers related to the new directions of CE from cross functional teams, multi agent distributed systems is significant [10, 11 and 12]. The work of reworking in CE has been reviewed in order to include it within the company [13]. Some suggested using simulation based tool for performance optimization and embedded the concepts of CE for the organizations, the related work of [14, 15] is important too. The expanded form of managing CE has been adopted in this case study and work of [16] approach is followed for implementation. The following section describes a case study of a local surgical company. The company exports surgical instruments and facing with problem of late delivery and high cost of the products. To cope with the above

problems application of Concurrent Engineering principles are explored, investigated and compared in the selected case company. To Achieve the above purpose, various persons in the company were interviewed, existed design process was thoroughly checked, design phases were analyzed, manufacturing was studied, design and manufacturing system department communication was studied, quality checks and various data was collected (thus as a whole the Product Delivery Process was studied). This all was done by observing the whole process followed in design and development of a product which is in early design phase. CE has following four major advantages. a) Reduction of product launches time; b) Reduction in product cost, c) High quality of the product; d) Team work Environment. Four area of the Concurrent Engineering consists of following components are organization, product development, communications and requirements.

2. Existing Product Delivery Process: A Case Study

The organizational structure employed in case company is somewhat similar to functional structure and is shown in figure 1



Figure 1 Organizational Structure (Existing case)

Mainly 11 departments are working in this organizational and sole proprietorship organization is Managing Director of the company. Marketing Department accesses the Market demands by taking part in different exhibitions held in different occasions of Europe. The design function will take the idea and specification gathered by marketing department and then translates them into drawings and detailed manufacturing specifications. After detailing the drawings are thrown over the wall into the production planning department and after scheduling, planning take place and subsequent to which manufacturing department become responsible to manufacture the required part. If needed some parts are subcontracted and then checked by the QC departments. The rejected parts are either scrapped or sent for further reworking. Engineering changes were usually not raised because the manufacturing department thinks it's the point of "EGO" for them to raise engineering change .They took it as challenge and cost of manufacturing goes

on increasing. There were certainly barriers amongst the department. The team approach and the communication infrastructure is not well organized .The existing product delivery process is shown in figure 2.

The customer Requirements; Overall Length = 202mm; Over all width =22 mm; Over all depth = 62mm. It consists of handle which is used to pull that device along with jack assembly and also consists of mechanism by which it can be attached de-attached from the Jack Assembly easily. It can withstand the load of hand jerk made during pulling process of the tissues along with the jack and product should not have sharp edges as it can cause injuries during operation. The tool used is Auto-CAD and final Assembly consists of four components: T-Bar; Post; Clamp Block and Screws. In existing case, total time required for manufacturing is 2.5 hours and this is shown in figure 3 as lead time of existing product delivery process.



Figure 2 Existing Product Delivery Process



Figure 3 Lead Time Summary of Existing Product Delivery Process

3. Concurrent Engineering Assessment in the Case Company

If few individuals take part in the development of product which is relatively simple then the approach will be 'task approach'. This is the lowest level of concurrent Engineering. If personals from same engineering department are involved in the development of fewer numbers of parts then this type of approach is called 'project approach' (which also includes task approach). If cross functional team or teams from different departments are required for the development of the product the approach is called 'program approach' (this includes task and project efforts). If along with the mixed discipline or cross functional team third part or vendors are also involved in the development of the product then the approach used is called '*enterprise approach*' (which includes task, project, and program efforts). The assessment includes the Assessment Questionnaire as given in figure 4. This assessment questionnaire will be used to identify the current status of company in which it is operating. All the questions are presented here in the form of four groups as four Areas of CE. The answers of the questionnaire will be given in "Yes" (Y) and 'NO" (N) form. From matrix chart it is identified that the required approach of concurrent engineering is 'program approach'. The next step is concurrent area map, which consists of four steps: **Step 1:** Area map has four quadrants for four major areas of concurrent engineering, which are further subdivided into components of each area. There are four rings representing the task, project, program and enterprise approach. According to the CE approach and area of concurrent engineering, the question numbers are plotted on the map, **Step 2:** The dots under "*Yes*"

Organization

answers of assessment questionnaire are filled red and then the outer most-red dots are connected with the red line, **Step 3:** CE approach necessary to develop the product is refined from matrix of method. This will appear as thick line on the circle corresponding to program approach on the CE Area Map. Now some points *(Yes answers)* are at the thick line and some points are below the thick line.

Components	Task Approach	Project Appreach	Program Approach	Enterprise Approach
Integration of team	There is very small interaction	Project perspectives is used by the	Program mension is used by a	Mixed discipling rear have members from
THE BUILDER OF FEMAL	monget individuale	individuals of a single-discipline	mined discipling team (Cross furctional	the entire enterprise encluding
	Alexia Viera Tadicida la base	man radars of a single-discipline	in sec-uscipline team (Cross functional	me entre enterprise, enclosing
	disciplines individuals have	team. Data is	ream).	innagement,
	specific task and data	not easily accessible	Data is easily accessible	Suppliers, manufacturing.
	is controlled by	by other disciplines.	by other disciplines.	purchasing, customers,
	Individuals.	· · · · · · · · · · · · · · · · · · ·		Service
Empowerment of	Individuals have rechonsibility	One of the member of single discipline	There is a leader of Mixed discipline or	Mixed discussing teams involuing
team	mhile arts and a larr	taxes is asked as taxes to the her the	Crace funder and team. The themelar	sustamer and third party colort a loader
team	while chanagement putys a	team is selected as team leader by me	Closs and chonar leans. The realistics	customer and unit party select a reader.
	dending fole.	management	the authority to make	The teams have authority
	Rewards are given	Decisions are a team	Decisions. Rewards	to make decisions and
	 to individuals. 	Responsibility.	are given to the mixed-	to carry them out .
		Rewards are given to	Discipline team.	Rewards are given to
		the single-discipline		mixed-discipline
		Team		Tame
Tesising	To discussion in the second	1 Colli.	Testanda and testa and	An entermine term (Creek functional term)
Training and	Individuals receive		framing on tools, procedures and	An enterprise team (Cross functional team +
Education	Specialties.	Single discipline team receive training on	 standards used in mixed discipline 	Supplier or third party) receive training on
		Procedures, tools, and standards.	environment is given to mixed	procedures, tools and standards.
	1	•	discipline team (Cross functional team)	
<u> </u>				
Communicatio	n			
Components	Task Approach	Project Androati	Program Antroach	Enterprise Approach
Product Menant	4 month and a service of the service	Disciplinad and consistent	Class communication mathe and and	Manmary Crace functional term
Froduct Management	Appropriate reviews are doneear	Disciplined and consistent project	Ciear communication paths are used for	mangers, Cross functional team, customer
	pre defined review stages.	 approach is used for product management. 	all aspects of product management and	and third party are informed about the
			system requirements.	problems occurred.
Product Data	Individuals are responsible for	Individuals of single discipline team can	Mixed-discipline data in the product	Mixed discipline team has access to product
	controlling and storing the	access and control the data	development database is accessible by	development data as well as third party and
	product development data		the mixed discipline teams (Cross	customer sumplied data
	product act cropatent and		fundianal team)	currouse supplied data.
			iuncumum team).	
Feed Back		Feedback from the customer is handled by	Feed back is handled by the members of	The feedback from the customer is
		the individuals of marketing and design	single discipline team (Design	discussed by the cross functional team as
		department.	Department).	well as the third party.
Description of the				
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requirements				
Key Factors	Task Approach	Project Appreach	Program Appreach	Enterprise Approach
Key Factors	Task Approach	Project Appreach	Program Approach	Enterprise Approach
Key Factors Requirements	Task Approach	Project Appreach Obstomer requirements are partitioned	Program Appreach Bunctional specifications are traced back	Enterprise Approach Costumer requirements are traced back to
Key Factors Requirements formulation	Task Approach Offstomer expectations are converted into custome	Project Approach Assomer requirements are partitioned into functional requirements and	Program Approach Butchonal specifications are traced back to the customer by the cross functional	Enterprise Approach Costumer requirements are traced back to the customer by the cross functional team
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Figure 4 Assessment of Questionnaire (CE approach)

Step 4: In this step the area between the selected level of the concurrent engineering approach and the

line joining the outer most circles of the "Yes answers", is filled with gray color.



Figure 5~8 CE Radar Mapping (four steps)

3.1 Improvement Areas Priority Setting

This part is used to set the priorities of the lacking areas to be improved to balance the four major areas of concurrent engineering. In this part firstly

priority is set to improve the four major areas of CE and then component within each area is prioritized. This is shown in figure 9 as priorities in the product development.

Development (of Product

component	Action Item	Priority
Component Engineering	1- Establishment of multidiscipline data library system.	03
Design Process	1- Establishment of Standard Design Process	01
	 2- Definition of appropriate design review stages. 3- Early involvement of representatives of manufacturing, assembly, planning 	
	and people (Cross Discipline or Cross functional team) in design process right	
	from concept design stage.	02
	4- Use of design for manufacture/Assembly & QC concepts	01
Computer Integration	1- Provision of centrally used CAD /CAM System.	01

Organization

component	Action Item	Priority
Integration of Team	1-Understanding of product development process.	01
Balance and the statement of the second s	2-Presensence of decision making mechanism.	02
Empowerment of Team	1-Creation of mixed discipline team (Cross functional)	01
	2- Decision making by mixed discipline team	02
Training & Education	1- Provision of cross functional training for procedure, tools and standards.	01

Requirements		
component	Action Item	Priority
Requirements Formulation	1- Traceability of requirements back to the customer	01
Standards	1- Use of Standards for manufacturability, testability, assembly (Design for manufacture, assembly & QC)	02

Communication

Communication		
Component	Action Item	Priority
Product Management	1-Diciplined & Consistent Product Management.	03
	2-Definning the clear communication path.	03
Product Data	1- Making access of cross function team members to each others data.	03

Figure 9 Actions and Priorities (scale 1 to 3)

3.2Oorganisation and Product Delivery Process

On the basis of the CE based assessment new CE based product delivery process is suggested. Time and cost of the T-frame is recalculated using suggested product delivery process. The proposed organizational structure is shown in figure 10 and 11 as organizational structure and product delivery process of case company respectively.



Figure 10 Proposed Organizational structure (cross functional team approach)



3.3Design and Development of T-Frame

Since different review stages are defined and it is suggested to have two to three models at concept design stage. Out of three, one has been selected by the cross functional team. The suggested software tool used for modeling is Del CAM Power Shape. This has better modeling capability and can be used with Del Cam Power Mill for generation of G & M-Codes. The CE based documented design process is shown in figure 12. The detailing are a) the tolerance are now given using ISO 2768-1 medium grade Standard which is one step in using standards, b) instead of threads on the clamp block side of the post, laser welding will be used to join it, c) using the system of fits wherever there is hole and shaft fitting requirement.

The lead time or product launch time is calculated using the standard operational information and consists of 62.692 days. The lead time summary of CE based product delivery process is shown in figure 13.





Figure 12 CE Based Documented Design Process



Figure 13 Lead Time Summary of CE based Product Delivery Process

The costing of the T-Frame Assembly is computed using the standard costing techniques used in industry and labor rate of Rs. 72 / Hr is used; direct labor cost Rs 536.856, indirect cost Rs 362.293, which gives total cost equal to Rs 899.149 (1 US\$= Rs. 98).

4. Comparisons and Results

The improvements in the overall times are given in figure 14. Increase in design time is due to the introduction of design process model. This will increase the product launch time, but manufacturing time will be reduced by the removal of unnecessary operations due to tight tolerances and due to better design of the product. This resulted in time savings of about 198 hrs (lead time).Planning time has reduced by one hour. The comparative values are given in table 1 and 2.



Figure 14 Improvements in Overall Times

In design and planning times comparison, most of the manufacturing cost is committed at the design stage; an improvement in design process (one part of "development of product" CE area) results in large saving in manufacturing times which is a step towards implementation of required approach of CE based on 'program approach' and values given in table 1.

Table 1 Design & Planning Times Comparison

Time Type	Existing (Hrs)	PDP	Times	Improved (Hrs)	PDP	Times
Design	24			32		
Planning	16			15		

These times are reduced due to the removal of extra operations on T-bar & Post is due to relaxation in tolerances as result of use of technical standards. However this reduction in manufacturing time is also contributed by technological advancement in manufacturing and given in table 2.

Table 2 Manufacturing Operation Times Comparison

		<u> </u>	1	
Part Name		Existing PDP	Improved PDP	
		Times (Hrs)	Times (Hrs)	
T-Bar		52.3	39.5	
Post		91.1	34.1	
Clamp Block		401.6	258.3	
Extra Operated	T-Bar	5.6	0	
Time	Post	4.2	0	

The company was lacking in "organization and development of product" areas of CE as per CE based analysis. As a result of improvement of these areas (particularly use of standards, new esign process consisting of review stages and cross functional teams and technological advancement (computer integration plus CNC) an overall improvement in manufacturing operation times is witnessed. The improvement of manufacturing operation time is shown in figure 15.



Figure 15 Improvements in Manufacturing Operation Times

Increase in assembly time is due to addition of laser welding process to join post and the block. This has resulted in reduction in manufacturing operation time. However polishing, QC and packing times are improved up to 5%. This improvement is due to reduction in rejections shown in figure 16.



Figure 16 Improvements in QC, Packing and Assembly Times



Figure 17 Lead Time Comparison

As a result of improvement in weak areas of CE ("organization and product development") an improvement is observed in all most all the areas of product delivery process (which is actually required to reach 'program approach' of CE). However in few

areas an increase in time is observed, but this increase has resulted in large improvement in manufacturing times, the lead time comparison is shown in figure 17.

Reduction in cost is mainly indirect and this shows the reduction in overheads. These costs are

mainly contributed by the reduction in times of manufacturing operations shown in figure 18. These reductions are observed due to overall improvements in product delivery process of the organization.



Figure 18 Improvements in major costs

Reduction in rejection is due to improvement in education and training (organization area of CE), while reduction in extra operated part is due to relaxation in tolerances due to use of standards and miscellaneous comparison as shown in figure 19.



Figure 19 Miscellaneous Comparison

5. Recommendations

- It is found that manufacturing companies particularly in local surgical instruments manufacturing companies are surrounded by typical problems worst are product delivery time and cost of the product. To cope with these problems, it is recommended to implement CE concepts using CE based modified analysis tool. One of the weakest areas is Design Process (One Part of Development of Product CE area). As improvements in design process, following measure are recommended a) Input from representatives of Design, Manufacturing, QC, and Marketing and Assembly department before the start of design, b) Selection of Concept by Cross Functional Team, c) Design Intermediate reviews of Design and d) Design review after the completion of Design activity.
- It is found that due to walls between the departments the company was lacking in Team Integration (which is one of part of organization

CE area). To cope with this problem, it is recommended that multidisciplinary team or cross functional team should be formed to carry out the whole design process as well as development process.

- The use of standards in the case company is very limited as found from CE based analysis. Initially following two standards are recommended to be used: i) ISO 2768-1 Medium grade Standard" for tolerance and ii) ANSI B 4.1 for Limits and Fits.
- There is another area known as Computer integration (which is one of the part of "Development of Product" CE area) is found weak during CE based analysis. This area is also highlighted as top priority for improvements. For computer integration it is recommended to model the product in Del-CAM Power SHAPE and use Del-CAM Power Mill for tool path generation.
- Training and education (which is one of the part of "Organization" CE area) is also marked as weakest area during the CE based analysis. It is recommended that two types of training & education of the employees is required; a) the training on software (Del-CAM, Power SHAPE-MILL) and training on machines of the workers. b) the training of multidisciplinary team or cross functional team is required.
- The technological up-gradation of the company to be done in phases. In first phase use of Del-CAM Power SHAP and Power MILL software may be adopted and CNC Lathe and Milling Machines may be introduced. However in future CNC Wire cut, five axis milling machines etc may be introduced.
- The first assumption which we have done that reworks are also considered as rejections. This area can be more explored and this assumption can be removed by separately calculating time and cost for rework and for rejections. This area can be used for future work in this regard.
- The work is done using the concept of batch production and formulas used for calculation of lead time are from batch production environment.
- More effect of "Simultaneous working" can be added if parallel working of all departments can be done by using the concept of mass customization. This means high variety high volume production (HVHV).
- A Single product has been selected to test CE, however work can be expanded to entire product and this paper focuses only to surgical manufacturing company and work can be

expanded to other similar companies. It will be equally beneficial to other manufacturing organization as whole and surgical instruments manufacturing companies particularly.

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