NEW MODEL FOR INTEGRATED PRODUCT DEVELOPMENT

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Abstract
The Norwegian Research Council has sponsored a project that aimed to increase the impact of manufacturing concerns in design projects. This should be done without compromising the customers' requirements to the product. Partners were HÅG, a manufacturer of office chairs and SINTEF Industrial Management. HÅG spent four years developing a new chair, and in the same period SINTEF assisted the development of a totally new way of producing the chairs. The experiences from the project are used to develop a new model for considering the co-ordinated development of products and processes.

In the proposed model the manufacturing system and the distribution process are considered to be products as well. Hence, in this particular case we have a sitting product (chair), a manufacturing product and a sales/distribution product. On an aggregated level, they must go through the same stages in their development process, and demands from different design foci (design for X) concerning i.e. the environment or their life after realisation must be included in all three processes. The challenge is therefore to co-ordinate and exchange information between three parallel development paths instead of trying to include all aspects into one. The participants in the product- as well as the manufacturing- and distribution- development processes are highly motivated, and ideas at the concept stage may come from either party. Experiences from the project and preliminary results with regards to the integration of the product and manufacturing development are discussed in this paper.

Keywords: Concurrent Engineering, Integrated Product Development, Case study

1 INTRODUCTION

The core business processes of a manufacturing enterprise are "product to market", and "product to customer". These include product design, manufacturing and sales/distribution. All other processes might be considered as support activities to these core processes. To be able to compete in today's dynamic market, all processes, and especially the core processes, have to be continuously improved and developed. Without attractive products, which can be produced at an acceptable price level and delivered according to customer demands, the business is likely to be in trouble in the long run. In addition to the market demands, the enterprise put up internal demands to the core processes. They must all be highly effective to maximise the profit of the company.

When the core processes are integrated in a development project, the possibility to obtain benefits for the customers as well as the enterprise increases. This is however not always easy to do, due to differences in culture, organisation, competence, tools, methods etc. among the participating departments. In addition, the existing models for integrating these core processes are usually based on a product development project onto which the other subjects (manufacturing and sales/distribution) are added. This may in some cases obstruct the best solutions. For instance, the fact that new ideas might occur in either of the core processes is not taken sufficiently into consideration.

An experience learned at HÅG, shows that after the introduction of new products in the market, a period with improvement and adjustment of the manufacturing system developed always follows. Another experience is that the product itself must be adjusted to be more elegant to manufacture. This becomes more visible when the sales volume of the new product increases and the material flow connected to this particular product gets considerable. In addition, the new product is likely to come in more variants over time, as the product family grows. All these aspects lead to the conclusion that the basis for this should be laid at the design stage.

Customer focus has been the leading trend for industry making goods to end customers over the past years, and the companies are facing ever more stringent demands with respect to time, prices and product variants. However, it is now time to look into the company's core processes also, in order to secure the highest possible revenue, the key to future development projects.

Carl Peter Aaser, developing director of HÅG, states: "When companies in the furniture industry develops new products, one of the goals is of

course to make them easy to manufacture. But, when the production volume reaches a level that could justify automated operations, one often experiences that the manufacturing has not been sufficiently taken care of after all during the development. In this project we wanted the expectations from the manufacturing department to be promoted just as strongly as the expectations to the products functions and aesthetics".

Common for most manufacturing companies is that al lot of their future revenues are depending on today's development projects. Of course the product must be a success in the market, but in addition, the company may influence both expenses and revenues by motivating for;

- shorter development time
- easier manufacturing implementation and product launch
- cheaper production

The goal of this project is not to develop a new overall product development method, but to introduce manufacturing concerns stronger into the existing ones.

2. EXPERIENCES FROM HÅG

HÅG designs, manufactures, markets and sells office-chairs on the European and North American market. The company has its manufacturing plant at Røros while design, marketing and sales departments are situated in Oslo, some 400 km away.

The company introduced JIT techniques in their production management system six years ago. Results from this effort have been discussed as rather successful in Norway, and the company has profited on both the changes and the extra publicity. To become a true JIT enterprise, one also has to design the production processes as well as the products themselves to suite the philosophy of JIT completely. These are long-term activities that must be handled over some years. Hence it is naturally to follow up the first implementation with a project including the topics of new design.

HÅG compares the change from relatively small volume production to large series production of a product with moving from craftsmanlike work towards industrial production. It is when the plant must handle a large number of orders, with considerable variety, the manufacturing task becomes a challenge.

This case-project investigated the product development method in use at HÅG, and found improvement possibilities. Changes might involve topics like organisation, competence, procedures etc., but in this project focus was held on manufacturing aspects. In the following, three potential areas concerning the method will be discussed;

- Use of existing tools
- Importance of the early phases of the development process
- What and when to integrate

2.1 Use of existing tools and methods

Many tools and methods are available for assistance in product development projects, but studies show little use of them in industry. There are several reasons for this, the most important ones being;

- some techniques are not very well known to the engineers
- some methods and tools are just to demanding
- the output is often dependent of the relative uncertain input, and hence not reliable anyway

The case project revealed several other potential improvement areas within the organisation and the working method used in this specific company:

- It seems hard to get full commitment from all departments (especially in the beginning) since the development project is *owned* by the product development department
- Ideas that arise in the distribution- or manufacturing departments sets off internal projects, not integrated ones
- The different departments have, to some extent, different language and focus, and this hinders good co-operation
- The participants take their own knowledge for given, and do not realise that they are hiding relevant information. Others might not know enough about that topic to ask the right questions
- Since time to market is essential, the work on how to manufacture and distribute the new product must start in the early phases of the product development project and not be added to the end as an extension. This has been a challenge for the case company in previous projects

To be able to offer attractive products, one of the leading trends for the past decades have been "Design for X" (abr. DfX). This has resulted in a big collection of different design foci (X's). In DfX the X has two meanings; either X stands for a life phase or phase system for the product such as assembly, manufacturing, recycling, service, etc. or X stands for an *universal virtue* such as cost, environment, time, quality, risk, flexibility etc [1]. These areas are represented by their own set of rules that are supposed to be used during the main design process. There are two comments that can be made based on the experiences from the case-project. First, many of the DfX's consist of *rules of thumbs* to guide the designer. If they are too

general or simple, designers and engineers find them hard to utilise unless he or she is well experienced in that particular *X-field*. It looks like the simple rules are too simple. The other point is related to the definition made in this project, considering the three physical systems (prime product, manufacturing system and distribution system) as products. All three products (sitting, manufacturing and distribution) need to be optimised by these rules, not only the prime product.

In spite of some shortcomings, increased use of existing tools and methods should be encouraged because they often represent more structure and thus a common way of working in the project in addition to serving good results. Next generation computer based tools should be more integrated though, for instance by using the same data sources as input.

2.2 Importance of the early phases of the development process

Often, some departments' impact on the final design is reduced because their expertise is introduced too late in the overall process. Too late refers to that the project will be either more expensive, delayed, or both if more concerns are to be introduced at this stage or later. Several studies have shown that approximately 70% of the costs of a product are determined during the early phases of the design project [2]. According to Andreassen and Hein [3], this seems to be the case for other universal properties as well. Hence, it is crucial to be able to exploit this period in an optimal way.

At HÅG, the same situation was discovered, and one of their clear potentials is to get all departments to start their work in the early phases of the development project. Both the current and the wanted situation for the case company are described in figure 1. At the top of the figure, general phases of a development process are shown. Underneath, the engagement of the market-, technical construction- and manufacturing-departments are shown as full lines. These do not start at the same time, and at least the manufacturing department is engaged too late. The wanted situation is shown as broken lines, and the crossing arrows indicate that information and consequences of decisions must be exchanged all time.

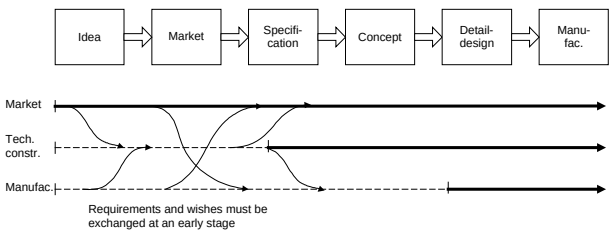

Figure 1: Current and wanted situation in HÅG's development projects

The result of too late introduction of manufacturing concerns into the development process is often focus on downstream activities only, like trimming of components. Such activities can be introduced relatively late in the ongoing project.

The company tries to involve all departments early, as they are well aware of the benefits obtainable if achieving this. It seems, however, that it is not easy for the manufacturing department to participate without a clear definition of what to do. This is discussed in section 2.3.

By introducing more aspect in the beginning of the development project, it is likely that the process gets even more complicated. The challenge is to find a simple but still useful overall method for integrated product and process development projects.

2.3 What and when to integrate

Integration in development projects has been a research topic for many years. The goals are also well known; shorten time to market, add more qualities into the product, and develop the production facilities in parallel to ensure a good match between the product, production and market demands. But often integration is synonymous with parallelism. Doing things in parallel however does not necessarily mean they are sufficiently integrated.

HÅG has internal competence on most of their kernel business areas, but uses to large extent external resources in project work. Examples hereof are external designers, engineers, consultants on production planning and control, marketing, ICT etc. This increases the challenges related to integration between different disciplines in developing projects.

Traditionally the marketing department has most influence in development projects. A product with no customers is meaningless to develop. The challenge is therefore to pay consideration to manufacturing arguments at the same time as the market is satisfied. For instance, not all manufacturing concerns are related directly to the shape or material of components. Studies in industry shows that only 10-15% of the lead-time through the manufacturing plant is actually value-adding activities. The overall production philosophy is important with regards to the rest of the lead-time. Two companies with similar equipment and products can be exploited differently due to different configuration, planning and control philosophies, size of buffers etc. How the new product and its corresponding processes influence the existing production must also be considered.

The JIT philosophy focuses on flexibility, simplicity, decentralisation, cross-functional improvements and time effectiveness, and is suitable in special situations with repetitive manufacturing orders. It

does not have the answer to all problems, nor does it have a lot of flexibility to adapt to them. On the contrary, the theory states that if your premises are not compatible with the philosophy, then you must alter them to be more suitable. This is part of the reason why it is necessary to design products, or even better, family of products, in a modular way and share the components with as many other products as possible to smoothen demand curves and reduce total number of components.

To ensure that the new product is suitable for the manufacturing philosophy of the factory, processes and products must be developed in a concurrent and integrated way. This is not easy however, partly because the employees in production are not used to formulate demands to the product in the early stages of the process. There is therefore a need for a method describing both *what* and *when* to integrate.

3 PROJECT APPROACH AND STATUS

The Research Council categorised the project as user-controlled, implying that the case company should participate in managing and controlling the activities and focus of the project. This resulted in a solution-oriented approach. Whilst HÅG developed the new office chair (four years), SINTEF Industrial Management had three functions: First the researchers were engaged to help in the development of the new and corresponding manufacturing system. Second, to use Design for Manufacturing techniques on parts of the new product for test purposes and to achieve ease of manufacture. Finally, the last and perhaps most important role was to observe the whole project in order to discover process potentials and develop new solutions for integrated product- and process development. In this aspect the project still serves as a case.

HÅG also engaged their main suppliers to secure reasonable solutions in the interface between the companies. Machinery suppliers where invited to participate in the development of the detailed solutions. The project group first decided which concept to elaborate, and then several suppliers of transport equipment participated with their expertise by submitting tenders. This unveiled large differences in how they understood the job and how they worked and co-operated in the detailing. Also the experience of the supplier and their ability to serve both the installation phase and future maintenance tasks was evaluated. Finally a decision was made regarding which supplier to prefer.

Currently the physical development of both the new chair and the manufacturing facility are finished. The new model for working in integrated product development projects is still under development based on experiences gained in the real case. Previous development projects have also resulted in competitive and profitable products for the company, and the best aspects from their existing practice is also included in the new model.

When designing products and processes future expenses are defined to a great extent. Customer demands, and even forecast of future demands, should influence the targets set for the development process. In the market of the case company, the individual treatment of every order is crucial, hence the job was to create a system that would allow this and still be time- and cost- effective. The well-known method of Andreassen and Hein [3] and the results from the VSOP for CONCENSUS project [4] are used as a foundation for the development of the model.

4 PRELIMINARY RESULTS

Besides the physical products (office chair and manufacturing installation) the most important result is, as mentioned earlier, the experience gained to help develop a new way of working within integrated product development, focusing on manufacturing.

Four basic changes are necessary to improve the performance in developing projects at HÅG;

- create interdepartmental ownership to the project
- exploit the early phases of the process
- introduce a multilevel model for all kinds of development projects, and
- use more tools like i.e. Design for X (logistics)

The project team found that the development of the office-chair and the manufacturing system on an aggregated level followed the same process. This is however also shown in existing models of integrated product development, where the development tasks are drawn as parallel processes [3], [4]. To get more engagement from the manufacturing department, and hence an early start of their development process, in the prototype model the manufacturing system is considered a product as well, to strengthen motivation. The same goes for the distribution system. One way of illustrating this is shown in figure 2.

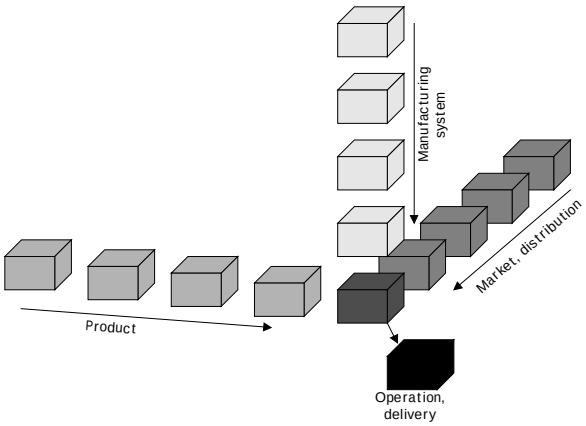

Figure 2: The Development process includes three physical systems.

With this way of thinking, it also follows that an idea might occur in either of the product streams. Regardless of the origin, the other two products are immediately challenged with respect to their ability to adapt. The company must check the total cost effectiveness of every idea. For instance, one might find that a process development project influences the product and challenges its conceptual structure. Then the company must consider redesigning the product to gain benefits on company level. Or, a breakthrough in the distribution process might cause adjustments in both the chair- and the manufacturing system.

In the case project, focus was on the integration between the primary product and the manufacturing system, by nature a two-dimensional configuration. Considering only the *sitting* and *manufacturing* products, the model in figure 2 might be drawn as follows.

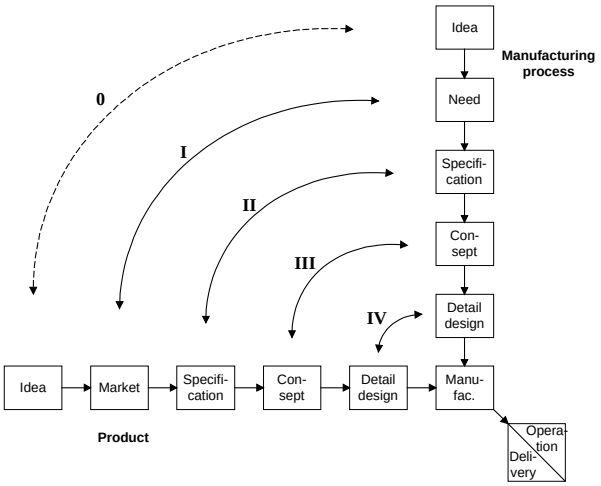

Figure 3: Development of two products with focus on integration.

The goal of figure 3 is to indicate a way of working in developing projects. The boxes on both axes are just examples of an overall development process, and might be adjusted to fit any company's existing model. The goal is not to develop a new overall product development model, but to introduce manufacturing concerns stronger into the existing ones.

Referring to the previous discussed problems, this prototype model is representing improvements compared to the model in use through stimulating early phases by increased commitment and indication of what and when to integrate. Following the topics of integration, existing tools and methods will be referred to at the proper stages. It is also an improvement that the different departments easier can relate to what the others are working on.

The links between the developing paths are considered the most important parts in the new model, and they all have specific integration tasks. The work on the description of what to integrate when has started, and a first listing is printed in a SINTEF report [5]. This work is however in the very beginning, and is not included here.

5 CONCLUSION AND FUTURE WORK

The project revealed potential improvements in the product developing process in use in the case company. Expected improvements with the proposed work model are shorter time to market, easier manufacturing implementation and product launch phase, more integration between the product and process development, and hence higher profit in the future.

Among the tasks necessary to finish this work are;

- Finish the model with a description of the integration based on the case project
- Generalise to be more useful in industry
- Describe in sub levels the details of the process
- It will be crucial to be able to calculate the consequences decisions have on the total expenses and revenues for the company
- Computerise. It follows that the model will have little or no use if the information is not accessible to all participants all the time. The model should be used to structure the information concerning the product, the manufacturing system and the interface between them.

In addition, these features would be preferable in a new model:

- A new model should be scalable to suit different types of development projects.
- It would, also for teaching purposes, be desirable to have several levels in the model. This makes it possible to allow a relatively

simple upper level while the details necessary to perform the work are hidden underneath.

- A new approach should stimulate information availability and be a tool in *continuos* consequence analysis

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