DEVELOPMENT OF PARTS FOR THE WHITE GOODS INDUSTRY BASED ON THE DFMA CONCEPTS – A CASE STUDY

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Abstract: *The classical way to manage product development processes for massive production seems to be changing: high pressure for cost reduction, higher quality standards, markets reaching for innovation lead to the necessity of new tools for development control. Into this, and learning from the automotive and aerospace industries other segments are starting to understand and apply manufacturing and assembly oriented projects to ease the task of generate goods and from this obtain at least a part of the expected results. This paper is intended to demonstrate the applicability of the concepts of DFMA (Design For Manufacturing and Assembly) and the Concurrent Engineering in the development of product parts for the White Goods industry (major appliances as refrigerators, cookers and washing machines), showing one case concerning the development and releasing of a component. Finally is demonstrated in a short term how was reached a solution that could provide cost savings and reduction on the time to delivery using those techniques.*
Keywords: DFMA, Concurrent Engineering, Project Management, White Goods, development of plastic parts.

1. INTRODUCTION

Projects are been deployed faster and faster through time – cost reductions and conceptual changes with shorter time to go into the market are now the way to work in almost any industry – mainly in the White Goods (major home appliances as refrigerators, cookers and washing machines): pressure caused by competent and strong players, reduction in the markets and a costumer that demands more per money is the daily reality. For those highly aggressive conditions, more suitable ways to manage product and component developing to fit the necessities are now more needed than ever.

To match those, and using the example from the aircraft and automotive industries, the DFMA and the Concurrent Engineering show themselves as powerful alternatives to the running design management methods, bringing together some interesting advantages. About those, BOOTHROYD (2001) has affirmed that a winning project can only be developed when the product responsible is prepared to get in to the process and understand the way the manufacturing works and behaves – something close to what HUANG (1996) stated about the good developer, who "must know the manufacturing to prevent unrealizable products due lack of intimacy with the productive process". Agreeing and complementing, according to DEWHURST (2005) project must involve any single part and respect all opinions; else, the lack of participation of one or more groups can mitigate the success of the product and finally, increase unexpected costs and problems.

All them are showing a well known panorama – a project must be accepted and discussed with all responsible: the design area, which is the conceiver of the product, then the project engineering, which will transform the sketched concept into a proposal; after the process engineering that will prepare the factory for the project; forwardly the manufacturing which will release the concept into a tangible product, the quality people that approve the developed parts and processes and so on.

Over that, this paper intends to show a successful product developed under this synergy and also explains how DFMA and Concurrent Engineering have helped teams to reach the target of develop a new part more affordable, with quality improvements, reduced time to assembly and with a short time to enter the market.

2. RESEARCH METHODOLOGY

Regarding to the research method, this can be an explanatory case study – according to TELLIS (1997) – this kind of cases can use pattern-matching techniques and conduct a study to examine the reason why some research findings get into practical use. They used a funded research project as the unit of analysis, where the topic was constant but the design varied (YIN and MOORE (1988) apud TELLIS (1997)).

Since that and based on observations, studies, tests and some literature revision and research an opportunity for application of DFMA and CE was identified and a solution was proposed: the research was divided in phases, driven by events and milestones. Firstly there was the identification of a project that could offer an improvement possibility. Discussions over the deficiency of the recent management methods and practices applied in the design/manufacture/assembly took place based on the literature and cases observation. After that, opportunities to the develop a new part using DFMA and CE methods and concepts were raised and the real application was chosen to be used as a demonstrative example. In the second phase, these methods were presented emphasizing the process and controlling activities. In the subsequent phase the conceptual project was carried out as a product and in details about the proposed methods were given, to share information to support the multiple viewpoints.

3. DFMA AND CONCURRENT ENGINEERING

According to ARAÚJO (2000) apud CANCIGLIERI (2005) communication and information share is important to all design definition and execution phases, but mainly in the conceptual phase. That viewpoint can be defended when is considered the aggregated cost caused by any late change needed by misinformation, an unexpected redesign or reprocess or either a necessity that was neglected due lack of a strong team participation – ANDERSON (1990) apud CANCIGLIERI (2005) evidenced this by affirming that the design determinates the product manufacturability and a significant part of the resources investment (80%) - once these resources have been allocated, it will be very difficult and expensive to make any changes, as shown in Figure 1.

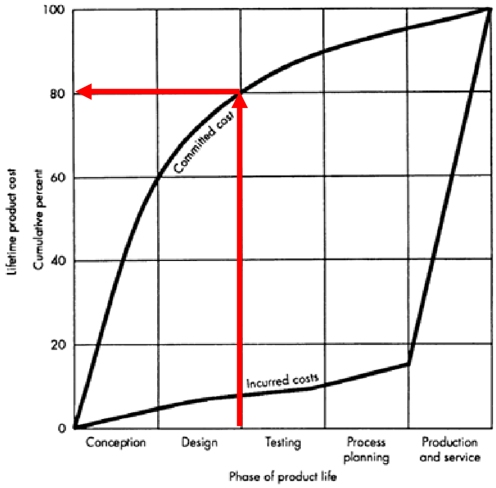


Figure 1: Development costs – process and product
Adapted from: ANDERSON, 1990 apud CANCIGLIERI (2005)

3.1 Traditional Design versus DFMA

Starting a new project has most of the times several inconveniences: CAPUCHO et al. (1997) expressed this saying that generally a project starts some problems caused by misinterpretation of the available data (or low precision, of even complete lack of information) an that could extends to subsequent steps of the project. Also, imprecise communications between involved parts could cause undesirable effects. Those must be added also to other limitations – machine restrictions, low investments, schedules, space and logistics.

That means a conceptual challenge: how to develop a new product trying to find the best cost-effectivity in the shortest time, hearing all different opinions without loosing the acquired knowledge about processes and also fitting the consumer necessity?

The design will determinate the manufacturability of a product, not the manufacture by itself – even considered a very high sophisticated one. In fact, this level of sophistication (maybe considered also as automatization) will reinforce the necessity of a well-elaborated project (CANCIGLIERI (2005)).

Traditionally a productive process has some basic steps (GALDAMÉZ, 2001) – first, the identification of customer needings and desires as a input, last a output represented by product or service to match as most as possible the needing expressed in the input and between them a productive transformation process feeded by information, resources (as materials and machinery) and a demand caused by a possible market as shown in Figure 2.

However, this kind of simple interpretation seems to not consider the information flows from the process to the input and output – information which can show some limitations or can express the necessity of change or improvement. Also, most of the known players do stepped investments and some products are just upgrades of their predecessors, not completely new developments. Finally, it is necessary to maintain (at least for some years) an assembly line, method and machinery to ensure spare parts to the working population of products.

Those apparent undesirable conditions may present a very good opportunity to rethink the development process: experience obtained from previous projects and the knowledge of where are the weakest points can reveal a path to start a DFMA.

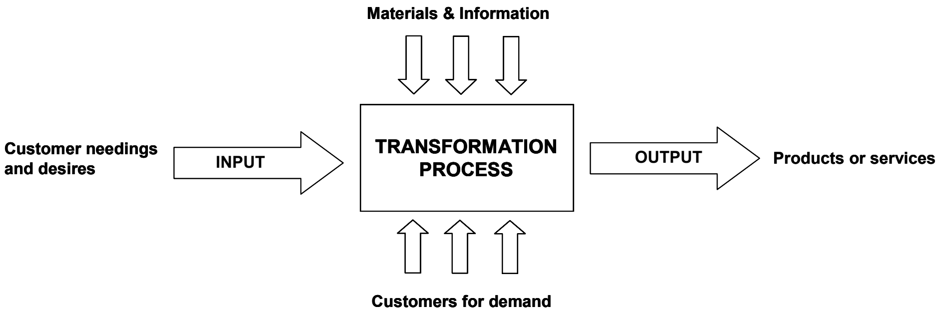


Figure 2: Model of a generic process or productive system
Adapted from: Galdaméz (2001).

3.2 WHY DFMA?

Organizations learn in order to improve their adaptability and efficiency during times of change (BRINK (2003). This idea can effort the use of the experience of previously done mistakes to speed up the development process and also accomplish new technologies and philosophies to ensure that activities which now must be faster and give more precise results can really reach this target.

In this way, DFMA and CE (both Production Oriented Designs "ways") offer a substantial advantage: they permit to run activities simultaneously in a parallel form, in opposition of the tasks sequencing. Also, they allow using simulation techniques and a full synergy between the teams – these make possible to find project failures or deviations and fix them before the development ends – FERNEDA (1999), as illustrated in Figure 3. Bringing to the White Goods industry reality, DFMA and CE permit develop faster, with savings (time, money, work) and mainly with a higher quality level. But how is possible to do this?

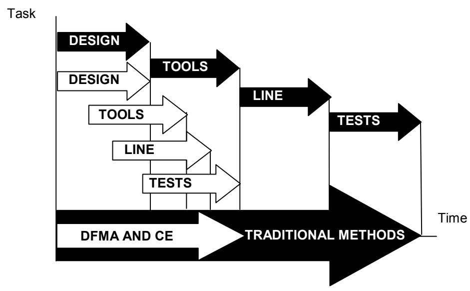


Figure 3: Time to deliver comparison between DFMA+CE and the Traditional Methods.

3.3 HOW DFMA?

Designers do not enter a new design situation as newcomers or novices. Through education and practice they have acquired a vast repertoire of design solutions, which they will carry over the design task at hand (PASMAN, 2003). These experiences are the result of several situations of mistake, improvement opportunities or just real good new ideas acquired due to development and research on design area.

But how to acquire a "high manufacturability level product" experience? HUANG (1996) affirmed that reasons like increasing complexity level of the bundled technologies in the product, stress caused by short time to deliver some output to the market, the pernicious philosophy adopted by some designers of "we design, you assemble" or "we do sketches, you do products", the complexity of some industrial processes (and sometimes even the distances) invalidate the implemented idea of the development people caring about the manufacturing reality.

A good development designer/engineer must know the factory in a sufficient detail level that can permit an assembly to be done and an injected part to be extracted and also must know his job to ensure the assembled parts to be there and the injected material to be in the correct geometry. These means two different and in a first view conflicting conditions: that the designer cannot stay in his area ignoring what is happening around and the designer must know his tasks perfectly to justify his work position.

The question remains: is it possible to be in simultaneously in the factory and in the design office? FERREIRA and TOLEDO (2002) say so and suggested how: using the technique of Design for Manufacture and Assembly is possible to "hear the voice of the production line" and been virtually near to the information. BUSS et al. (2001) agreed with this point of view, saying that the DFMA allows bring to the project area the considerations related to the assembly and manufacturability of the product. Finally FAGADE and KAZMER (1998) defended that the most significant advantage of DFMA is the encouragement of the teamwork between project and production, improving the reliability of the final product and generating the possibility of cost/time to deliver reductions due decreasing in the parts number and/or more productive parts that can accelerate processes.

Now the perspective is clearer: is understood why use a Production Oriented Design and how implement this using the DFMA. The next step is clarifying what to do to "have" DFMA.

3.4 WHAT TO HAVE DFMA?

First of all is necessary to understand well what is needed to drive a project with DFMA techniques. For this is important to define the product conception as a task of multiple responsibility: since the first conceptual sketch to the final packed assembled delivered product many are the necessities and interdisciplinary actions that are needed. CANCIGLIERI (2003) and PERERA apud SACCHELI (2005) mentioned that in a multiple viewpoint manufacturing and project system all opinions must be considered interdependent as shows figure 4. Thus, the accordance over key points must be decided in intelligible form that can allow all the productive chain to express its necessities and limitations in a clear form to any other part connected to it and responsible to provide or receive services/preprocesses.

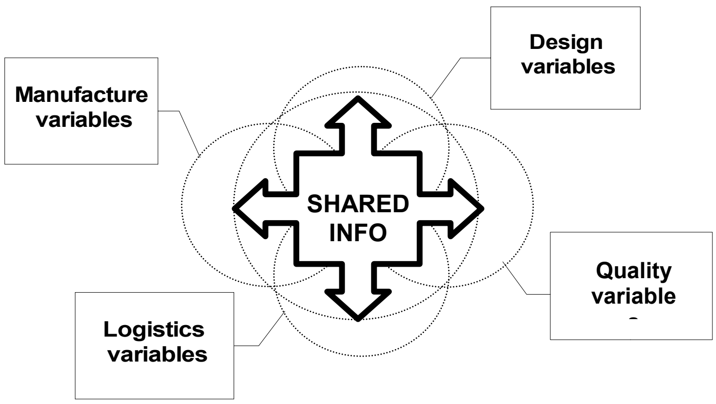


Figure 4: Interdependence of variables (opinions) for a DFMA driven development.

Also is essential to let all teams warned that the project is designed for manufacture and assembly – and this means that all attention is focused in a development for that condition and this means that the manufacture must be heard all time. Process times, workers number, tools for assembly, in-line stocks and other typical variables emerged from the shopfloor are vital for the development and other variables must express themselves as factory improvements or assistances.

To achieve this, the communication has to be constant and efficient: information sharing/translating and data optimization are basic requirements on a DFMA driven development.

The sharing of information has its own reason: system variables are quite complex when analyzed locally, but once put together are virtually different forms to observe the same necessities.

3.5 WHEN DFMA?

When is time to carry over a task in a DFMA 'driven' project?

Answering this question CAPUCHO et al. (1997) adopted after observe the behavior of multidisciplinary teams that the local rework caused by an activity with adverse results is much smaller then a global restructuring of a project – also, a global reproject may be impossible due costs (according to HARTLEY and OKAMOTO (1992)) the inclusion of a change in a running project is more expansive as more is close to the project end or due other factors as time and market expectations.

So, once defined the project main activities and tasks start doing them is a good option, respected the order of the development – as mentioned before mistaken actions and adverse results can less compromise the project running timetable and budget as first they are identified.

4. DFMA and CE in the White Goods industry – a case study

Applying the concepts of DFMA to a new part development, a local White Goods industry could illustrate the advantages of a multidisciplinary part development. The task was substitute a complex assembly of different parts made of press worked metal and plastics by an aggregated function single solution with cost reduction, short-time tooling payback, quality improvement and mainly ease to assemble in line.

4.1 Which technology?

According to BOOTHROYD (2001) the rising sophistication in the use of molded injection plastics is an important tool to win the battle of reduce parts to save costs and create an elegant design.

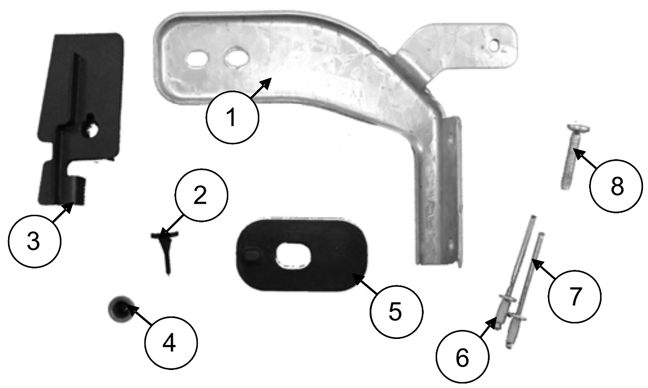
Also, BEALL (1997) said that plastic injected parts could consolidate several different other parts – plastics or not – in a complex geometry what can be obtained in an injection process with relative ease and with this save sub-assemblies and mounting operations. Finally, GAUTHIER et al. (2000) shown that is possible not only find saving using plastic multifunctional parts, but also improve the general quality of the product by reducing the probability of defective parts in the assemblies and the possibility of a mistaken coupling.

Based on the literature mentioned and other articles researched by the groups and considering the expertise of the teams on plastic injection acquired by work and development in other lines (refrigerators and washing machines), where plastics are used in a very large scale, was decided to try a solution using injection of thermoplastics.

This was a risky decision: first of all the temperature limitations on a plastic material are more severe than in a press worked metal – limits also include the possibility of deformations, flowing and resistance downgrade. After that, a running and deployed solution give some comfort to the project designers and all of other teams: the new idea was offering a possibility of assembly improvement and a bundled possibility of fail – this means that for some parts of the workgroup the manufacturability advantages were not good enough to release the change – in short words that was the paradigm: develop a substitute part to improve a good working assembly to give some help to line and to reduce costs, with a low, but existent, possibility of further problem.

4.2 The substituted assembly

The original assembly composed of plastic parts and pressworked (figure 5) metal lead to nineteen attaching, two riveting and one screwing sequential operations - the assembly condition demanded two working positions and needed specific equipment and care. Also, the attaching manipulation was fully manual and highly sensible to errors due the complexity of join together all parts in a moving line. Finally, the riveting operation had its own difficulty – in the case of an imprecise attachment, the rivets could not be placed properly causing an off-line rework call and stopping the production flux.



(1) Main bracket; (2) Glass spacer; (3) Upper cover; (4) Bush; (5) Internal spacer; (6) Steel rivet; (7) Steel rivet; (8) Screw.

Figure 5: Original assembly.

To avoid these inconveniences and fit the high level of reliability required, a new injected component was designed to aggregate in an single plastic construction the maximum as possible original single parts and a error free mounting. This component was conceived under the DFMA philosophy and was expected to result in one high manufacturability development made from a productive low cost heavy duty material and projected to join six other components resulting in the maximum possible exclusion of intermediate operations.

The multifunctional part was able to permit the exclusion of seventeen of the original nineteen attaching operations and took out one of the riveting tasks due the substitution of one rivet by a pivot (figure 6, item 6) directly emergent by the structure of the multifunctional part. This pivot, which is normal to the foundation of the part, was projected to be one partial anchorage and lock to the structure, ensuring the right placement of the whole assembly.

Another anchorage is offered by the upper cover (figure 6, item 3) 90° cross-phased from the pivot and grooved to fit the construction of the column where the part is mounted on which by its geometry reduce to almost zero the possibility of a wrong assembly. Finally the bush (figure 6, item 4) is also 90° cross-phased from the other two attachments, ensuring the full locking of the component to the environmental geometry, causing a full compliant assembly even when the other components (not treated by this development) present variations out of the tolerance levels.

All these and the extreme easiness to produce an injected part this means 80% reduction in the assembly and 15% reduction in the composition of costs, and a short term payback of the injection mould.

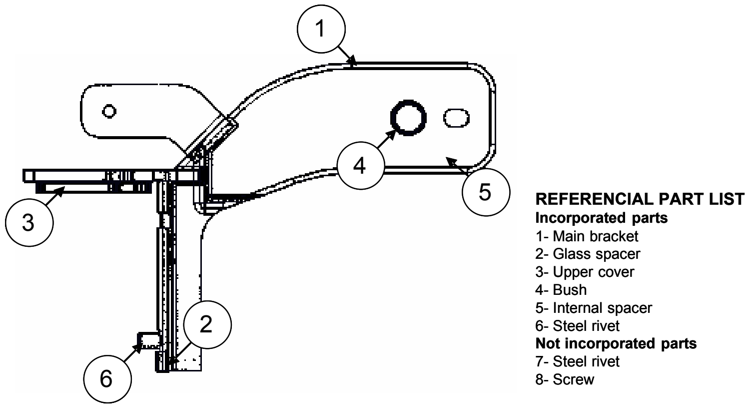


Figure 6: New part design

(a) Original set of parts (b) new component developed under DFMA concepts

Figure 7: Final comparison between the original set of parts and the new component developed under DFMA concepts.

5. DISCUSSION AND CONCLUSION

In this article has shown an application for the concepts of DFMA inserted in a Concurrent Engineering collaborative context for the development of a new part for the white goods industry (home appliances) focused in low-cost, high manufacturability, long-term reliability and resistance to severe working duty. The article presented either some guidelines for development using in DFMA, based in the industry-level bibliography. Also, was shown the application in the steps of the development since from the conceptual idea to the final implemented project. Finally were presented advantages that can justify substantial savings of time and cost in the development of high manufacturability products when using DFMA and the CE methodologies as production-oriented guidelines.

As could be justified, the development of a new part in any industry (mainly in the analyzed case of the white goods industry) speeds up substantially when working in a collaborative-concurrent engineering environment – when teams work together and simultaneously the results of the development can be faster and furthermore, cheaper. Using the Concurrent Engineering as the main guideline, in addition with DFMA as methodology of work, results can be presented faster and with increases in the level of control, investment application and rightfulness.

Concerning the development of the part, the value added by DFMA and CE was also very important: more than only the development process, the part itself needed special care due its own special heavy-duty working environment – have reliability of a structural part came from the steel and passed to plastics is delicate, mainly when high temperature and aggressive humidity, chemical and use collaborates in the mechanical stress of the part. There, in the concept of the part and the using position DFMA and CE where specially useful because they permitted a better communication between all involved teams and this philosophy helped in pass from the Product Engineering the product conditions to the Industrial Engineering that developed the tooling and the Manufacturing Area, that was warned exactly about what expect from the part.

That was decisively important: the advantages of this communication could save time - the mould was made as expected by the product developers and manufacturing people have determined, avoiding rework. Furthermore, saved money – the part was designed more then one time, but the final component only was made once – this was money saving in prototypes, tests and working time. Finally, the component was designed for the production line – fewer parts and assembly-line speeders as fast locks, pins in place of rivets or screws, pre-assembled features, self-positioning parts and adaptable robust-design made more productive teams, saving money. Also, fewer parts finally decreased 15% the whole assembly cost directly in the materials prices – with the advantage of logistics, shop-floor space and avoiding sourcing from more than one supplier.

In the last, the main advantage was the application of a newer way to work – working in teams that can do engineering concurrently and designing for the last part of the production chain results were sensively more precise and most of the time, faster and cheaper.

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7. RESPONSIBILITY NOTICE

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