WITH RIGHT STRATEGY AND KNOWLEDGE TO COMPETITIVE ADVANTAGE AND NOMINATIONS FOR THE PRODUCTION OF COMPLEX WELDED PRODUCT

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Abstract: *For companies, rapid prototyping is a powerful tool for conceptualization, form and fit review, functional analysis, and pattern generation. These applications are also relevant to the manufacturing process. The ability of the development, construction and prototype department is today, in a strong competitive field, very important for the development and existence of the company. The paper will present an example of good practice and the use of rapid prototyping technologies in very complex steel components - rear frame of the motorcycle BMW F 800 S. This article will present the use of technologies of rapid prototyping with a view to presenting a prototype to BMW customer at the stage of the decision on the selection of a supplier.*

Keywords: RAPID PROTOTYPING, MOTORCYCLE BMW, PROTOTYPE, REAR FRAME

1. Introduction

Introducing a new product is expensive and needs careful planning. The planning for a new product goes through a number of stages. Depending on the complexity of the product, the time-span from original concepts to the marketing of the final product can vary from a few months to many years. The development phase has been improved by the use the concurrent engineering concepts and wide but very important applications of CAD, rapid prototyping technologies, engineering and manufacturing tools and other techniques. Figure 1 shows steps and well-known procedure methods in Design of Product from Definition to the Manufacturing.

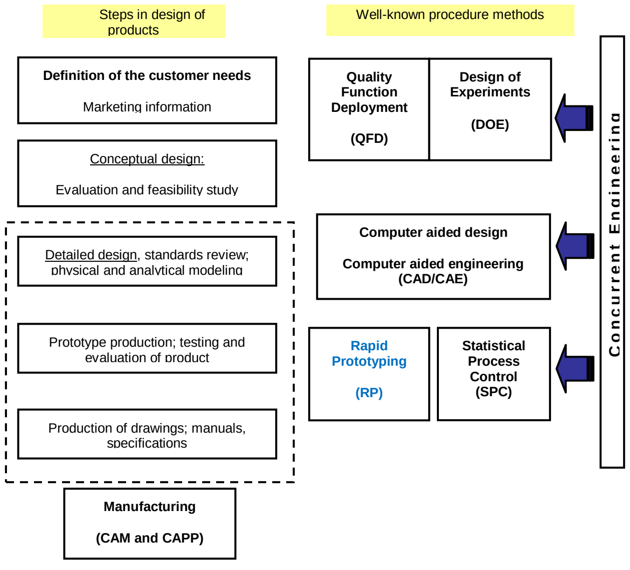


Fig. 1 *Steps and well-known procedure methods in Design of Product from Definition to the Manufacturing* [1].

In its experimental part our paper presents the application of various technologies of rapid prototyping and the importance of their use in the context of the nomination and selection process for the German company BMW project.

For design engineering, rapid prototyping is a powerful tool for conceptualization, form and fit review, functional analysis, and pattern generation. These applications are also relevant to the manufacturing process. Prototypes are often used to answer two types of questions: "Will it work?" and "How well does it meet the customer needs?" When used to answer such questions, prototypes serve as learning tools.

Communication: Prototypes enrich communication with top management, vendors, partners, extended team members, customers, and investors. This is particularly true of physical prototypes: a visual, tactile, three-dimensional representation of a product is much easier to understand than a verbal description or even a sketch of the product.

Integration: Prototypes are used to ensure that components and subsystems of the product work together as expected. Comprehensive physical prototypes are most effective as integration tools in product development projects because they require the assembly and physical interconnection of all of the parts and subassemblies that make up a product. In doing so, the prototype forces coordination between different members of the product development team. If the combination of any of the components of the product interferes with the overall function of the product, the problem may be detected only through physical integration in a comprehensive prototype.

While the industry has had an exceptional track record, it is not without its challenges. The general consensus is that less than 20 percent of the design and product development community use rapid prototyping. In the manufacturing and manufacturing engineering disciplines, the level of use is far less.

The obstacles that rapid prototyping faces are not unique. As with any new technology, there is a resistance to change and a reluctance to work through the challenges of a developing technology. However, there are other factors that are unique to this industry. Since rapid prototyping requires 3D digital definition of the part, its growth rate is limited to that of CAD solid modelling, an application that is far from being used by the majority of design professionals. Additionally, rapid prototyping has been burdened with a negative perception that the parts are "brittle." While true many years ago, this is no longer an appropriate generalization. Yet, many use the belief that rapid prototypes are brittle to justify not evaluating or using the technology.

While rapid prototyping may not pose a competitive threat to those who do not use it, many who have implemented the technology have discovered powerful advantages in applications that range from product development to manufacturing to sales and marketing.

While the various rapid prototyping technologies each have their own unique methodology and process, there are common elements that apply, at least in part, to each of these technologies. Although not specifically stated in the following process description, the unique factors of rapid prototyping, when compared to other manufacturing processes, are that there is minimal labor required and there is little requirement for thorough consideration of part design or construction techniques.

2. *Experimental work with a real case study for BMW Company*

The beginnings of the cooperation between a prominent motorcycle factory, Slovenian company Tomos, and the world-renowned motorcycle manufacturer BMW date back to the late 19-ies. With competitiveness in the manufacturing and supply of welded components for BMW, Tomos gained precedence over other companies, which enabled the growth of the company and its new owner Hidria, not only in the segment of welded components but also in the segment of smaller aluminium castings. The value of the successful supplier increased when BMW entrusted Tomos the task to enter the competition with other companies in the segment of complex welded components.

Soon after my arrival in the company I was entrusted with the management of the project named BMW K71 with a large format drawing containing dimensional and technological requirements, as we can see in figure 2. We entered the nomination process with the rest of other major companies whose aim was similar to ours: to become manufacturers and suppliers of the complex welded product.

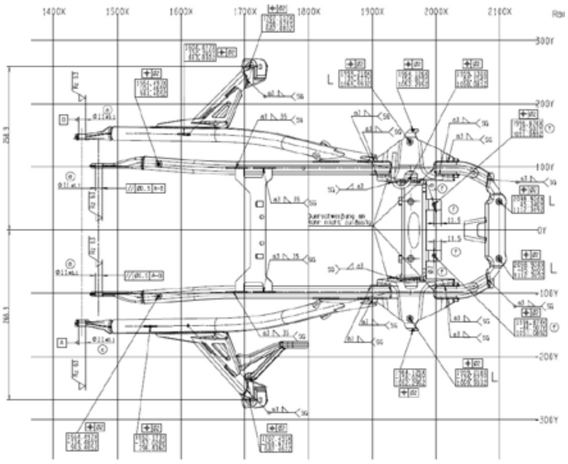


Fig. 2 *Drawing of the product rear frame K71.*

The product is the rear frame of the motorcycle BMW F 800 S/ST made from steel structure, secured to the aluminium front frame with four mounting points, as indicated in the figure 3. Both frames serve as a bridge for mounting the chassis, seat and safety components.

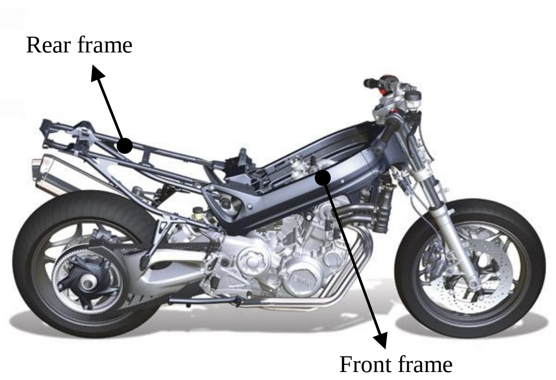


Fig. 3 *BMW F 800 S/ST* [2]

An F marked motorcycle is powered by a parallel twin engine manufactured by the Austrian company Rotax. Although the parallel twin-cylinder motorcycle is not very common in the world of motorcycling, BMW Motorrad opted for this model. A four-cylinder engine would have been more expensive, heavier and larger. BMW, however, aimed at a powerful unit with more torque, and a parallel unit is much more aerodynamic. S stands for "Sport", ST for "Sport Touring". There are not many differences between those two quite similar motorcycles. F800 tends to be slightly sportier with angled front armour, a lower windshield, a lower position of a steering handlebar, grips instead of a rare tailgate, different wheel rims, a black front fender and an aggressively designed seating position.

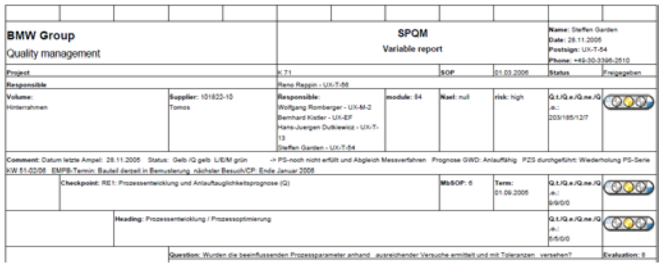
The parallel twin-cylinder motorcycle with a capacity of 800 cubic centimeters provides high compression and produces more than one hundred horsepower per liter of displacement. A toothed belt means less weight, quieter operation and longer service life if compared with the chain transfer. Its most striking feature though is fuel consumption. Despite revving the engine at high RPMs, we will not significantly exceed five liters per hundred kilometers.

2.1 From calculation to the first prototype

The deadline for making the calculation was predetermined by BMW. BMW's development department in Munich acceded to our request and soon we acquired a 3D model of the product, made in the program Catia 4.0. The product was disassembled to single elements and the indicative value for each of them was determined. The calculations of technological processes of welding, painting, inspection and delivery were followed by the final price and its entry into the BMW system. Our manufacturing costs turned out to be interesting to BMW assessors and we came to a shortlist of suppliers.

The project team was given a month to prepare for the visit and assessment by BMW, in the areas of development, industrialization, quality and logistics. Assessment is carried out using SPQM system Supplied Parts Quality Management.

SPQM is predestined to develop the questionnaire. At the end of each question assessors appropriately labeled the adequacy of the response to the "traffic lights", as we can see in figure 4.


BMW Group
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Volume: Hinterrahmen | Supplier: 101822-10 Tomos | Responsible: Wolfgang Romberger - UX-M-2, Bernhard Kistler - UX-EF, Hans-Juergen Dutkiewicz - UX-T-13, Steffen Garden - UX-T-54 | module: 84 | Nael: null | risk: high | Q.t./Q.e./Q.ne./Q.e.: 203/185/12/7
Comment: Datum letzte Ampel: 28.11.2005 Status: Gelb /Q gelb L/E/M grün -> PS-noch nicht erfüllt und Abgleich Messverfahren Prognose GWD: Anlauffähig PZS durchgeführt: Wiederholung PS-Serie KW 51-02/06 EMPB-Termin: Bauteil derzeit in Bemusterung nächster Besuch/CP: Ende Januar 2006
Checkpoint: RE1: Prozessentwicklung und Anlauftauglichkeitsprognose (Q) | MbSOP: 6 | Term: 01.09.2006 | Q.t./Q.e./Q.ne./Q.e.: 6/6/0/0
Heading: Prozessentwicklung / Prozessoptimierung | Q.t./Q.e./Q.ne./Q.e.: 5/5/0/0
Question: Wurden die beeinflussenden Prozessparameter anhand ausreichender Versuche ermittelt und mit Toleranzen versehen? | Evaluation: 8

Fig. 4 *SPQM questionnaire, example in Tomos, 2005.*

This is based on the development process of vehicles and components, where BMW Group engineers and suppliers share responsibility for achieving challenging goals. The 'Supplied Parts Quality Management' (SPQM) has been created with a number of purposes in mind,

• to ensure that the quality standards of all components and material used in all BMW Group products continue to please our customers;

• to create a common group-wide operational standard for this very important activity;

• to ensure that all the responsibilities concerning this activity are fully understood throughout BMW Group and throughout our supply chain;

• to help all those involved complete their tasks in a professional manner and in line with the project timetable / BMW Group Production Materials Purchasing Division © 09/2000/.

While waiting for the arrival of the assessors from the company BMW, the project team decided to manufacture the first prototype of the 3D model, which we had received from the R&D department in Munich. The steel frame is composed of 35 parts. Into 4 support tubes, two from the square and two from the circular cross-section, four welded pressed parts are inserted, which serve for mounting of the steel frame on the front aluminium frame.

On each side of the support round tubes two short round and die-cut pipes are welded, which allow the location of the welded foot pedals for the passenger and the exhaust mounting bracket. In serial production, the pedal brackets and the exhaust bracket must be made by forging technology. The connection between the support tubes is provided by six different and technologically complex parts from sheet metal, on which 14 nuts for the installation of additional elements and security on the motorcycle are spot-welded. Four steel bushings inserted and welded into the support tubes enable the attachment of the lateral trunks and rear retaining brackets for the passenger.

In its first phase, the future plan included the purchase of the material, all the tubes and sheets of suitable dimensions, and also the material on the basis of the drawing of the frame. Simultaneously with the purchase of all the materials, from which we had to manually manufacture the individual frame components, we focused on components manufacturing via prototyping technologies.

According to the technologies of rapid prototyping known and available at that time in Slovenia, we decided on the technology of laser sintering, DMLS – direct metal laser sintering, to manufacture both pedals and the exhaust bracket. The device for direct metal sintering of metal powders was owned by the company RTCZ Izlake, which agreed to manufacture all three components. The device enabled a good shape accuracy and mechanical property of the sintered products, which were later welded together. And what was then the most important; we received all three parts three days after sending 3D models to the company RTCZ. The remaining four, production components – pressed parts – were manufactured on a lathe and a milling machine in the tool workshop in Tomos.

Figure 5 presents the exhaust bracket, which is made by rapid prototyping technology DMLS and its position on the bike.

Fig. 5 *The exhaust bracket, made with DMLS rapid prototyping technology and its position on the bike.*

A lot of knowledge and experience were invested in the manufacturing of the complex metal sheet components. There are many ways to manufacture a product by reading a drawing. However, due to the time limit, we decided to develop all sheet metal components in 2D shape using the program Catia. This was followed by the cutting of sheet metal with a water-jet technology, which, unlike the technology of laser cutting, maintained the cutting edge without excessive heat load and consolidation of the material. Consolidation of the material could later in the prototype workshop complicate the process of bending and adjusting the products to the requirements of the steel frame drawing.We managed to purchase and manufacture all the subassemblies needed to build the frame in time. In the prototype workshop a colleague manually shaped all prepared sheet metal parts and other profiles into elements according to the accompanying drawings.

Figure 6 shows the process of manufacturing the element, support steel sheet from 3D model to 2D cutting, welding and shaping into the required structure.

Fig. 6 *Process of prototyping the complex element.*

3. Final prototype

This was followed by the required phase of adjustment and welding of all components to get the final product. The frame was welded manually using MIG procedure, with 3.5 m of welded joining parts between all the elements.

Prototype required a lot of knowledge in the different welding processes between the different materials that we use. Construction of such prototypes is a unique process. Masters of producing such prototypes need a lot of experience, ingenuity and knowledge of modern technologies.

Figure 7 shows the first prototype, successfully and timely implementable with the project team.

Fig. 7 *First prototype.*

4. Conclusions

The design of products and customer satisfaction is crucial to success in today's global competition. The R&D project team responsible for the first calculations was aware of the fact that the buyer needed to be offered some added value in the first phase already, which resulted in the voluntary manufacturing of the first prototype, thus expressing our strong desire to become the supplier of the complex product.

The product – the first prototype – made with different technologies of rapid prototyping was presented to a group of BMW assessors. The effort we had invested into creating the prototype and the successful completion of the assessment SPQM brought us BMW's assurance and official nomination for the serial production of the steel frames BMWF 800 s and BMW F 800 ST. The nomination for the manufacturing of this complex product still guarantees the company the serial production of complex steel components and welded components made from aluminium alloys not only for BMW but also for other well-known motorcycle manufacturers.

5. References

1. Kalpakjian, S. Manufacturing Engineering Techniques, Addison-Wesley Longman, Incorporated, 1995, p.12

2. www.moto-magazin.si/moto-testi/bmw-f-800-sst/galerija/1_2jpg-25/