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QFD IMPLEMENTATION IN MANUFACTURING PROCESS OF A CAST PART

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ABSTRACT

Casting is a very flexible technological process which can be used in gross production for a very wide range of parts for automotive industry, aircraft industry and ship-building industry. Improving the casting process is of a great importance for researchers and engineers, because, by this process, can be manufactured very complex parts having very high engineering characteristics which cannot be obtained by other processes. Quality planning of each process represents an important activity in assuring the unimproved quality of the final products. QFD (Quality Function Deployment) is an important tool in production planning, which starts with identifying the customer requirements and prioritization of the steps to be achieved in getting the desired demands. QFD method is recommended to be used for strategic deployment of the aims which refer to product and company market, starting with conceiving phase and analyzing its behaviour on the consuming market.

This paper presents a route of QFD implementation for products manufactured by casting . Due to QFD mechanism itself, there will be returned a product designed with modified characteristics that concern the customer requirements.

KEYWORDS: QFD, casting, engineering characteristics, efficiency, customer requirements.

1. INTRODUCTION

Casting is the most used method for transforming raw materials to final components. Casting process provides the possibility to manufacture near-net-shape castings with high quality level and dimensional accuracy [1, 2].

In automotive industry, hundreds of thousands of engine blocks and transmission cases are manufactured every year and one of the most important research subjects in casting industry is to conceive the most suitable fabrication plan. Casting process provides some advantages, as reducing or eliminating the machining processes for obtaining the final product, manufacturing of parts with very complex geometry, which otherwise would demand assembling of several components and the simplicity for adapting to mass-production processes [3, 4].

Owing to a very strong competition on the market, the companies are forced to develop very high quality products in order to survive and to be profitable. Quality planning is the activity of quality goals identification and the development of products and processes used for attachment the goals. Quality planning includes 6 stages: 1) identification of quality goals, 2) customer identification, 3) determination of customer requirements, 4) development of new product engineering characteristics in order to answer to customer requirements, 5) development of the processes which are capable to manufacture the product and 6) establishing the process control.

Quality function deployment (QFD) is a strong tool of quality planning. It is a structured methodology used to translate the customer requirements to engineer characteristics and manufacturing plans. QFD is a very useful tool but its correctness is given by the quality of data collection from the customers and their correlations with technical requirements. It is also a very complex tool which demands a lot of time to develop the QFD charts [5, 6].

2. CAST PART QUALITY PLANNING

It is known that the process quality planning goal is to develop the processes with enough capability in order to produce the product characteristics in accordance with the customer requirements and needs.

For QFD implementation, a engine block was chosen as a part for which QFD is applied (Fig. 1). In case of this part, casting is the main manufacturing operation, followed by cutting on faces *A*, *B*, *C* and *D* for final machining.

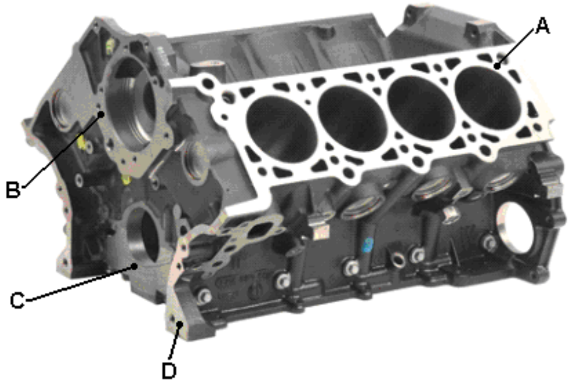

Fig. 1 Engine block used for QFD implementation [7]

The engine block is the resistance system of the engine and has a skeleton function which carries the other engine components. It is rigid fixed on the car frame. It can be manufactured by aluminium alloy in one piece. Due to its role within the motor assembly, the accuracy of its dimensions plays a very important role. In the engine block the bearings and the cam spindle is mount. This means that the high level of fits accuracy should by carried out. The dimensional accuracy for manufacturing this part must be very high in order to fulfil its purpose.

The dimensional accuracy consists in obtaining the parts dimensions between some limits imposed by condition that the values of this limits to comply with the functional purpose. The geometry precision consists in generating with accuracy the entire surface of the cast part. In casting, there are not generated one or more surfaces of the cast part, like in case of other machining processes, but is simultaneously generated the entire cast part surface. In this case, it can be considered that the part has a unique surface, very complex and shut, which is the result of a unique generation process and having a unique set of process parameters [8].

The main question which is posed here is "Why is it necessary the quality planning of the cast parts?". Very often the defects may occur because of the microstructure, casting regime or moulds machining quality. That leads to incomplete shapes (break calliper. – the mould is not adequate filled because there is not enough melt material or the melt material is solidifying to fast because the incorrect feeding system positioning or because of the wrong position of the complex cast parts axes).

In the first stage, quality planning assumes identifying of the most frequent defects which may occur during casting and to transpose these defects into improvements of the technological characteristics which are associated to the casting processes.

There are a few kinds of frequent defects which occur during casting of engine blocks as air gap formation (blow hole or shrink hole), inclusions, cracks (cooling cracks, cold cracks), defects relating with the geometry and the dimensions of the cast part, surface defects and microstructure defects as pores.

Engine block functions are provided with the tolerances assembling way – from which the dimensions are deduced (dimensions, adjustments and structure integrity) and engine performance – from which the microstructure quality is deduced (microstructure integrity, composition and defects admissible values).

3. IDENTIFICATION OF THE CUSTOMER REQUIREMENTS – VOICE OF THE CUSTOMER

During the designing and manufacturing stages of a new product, it is necessary to determine exactly the product final form that fulfils the entire final purpose. Redesigning and remaking the product is a very expensive and time-consuming process [9]. Implementation of QFD in manufacturing process shortens the distance between what the customer requires and what the manufacturer produce. After customer's identification, the next stage is to identify the customer requirements.

In order to gather the whole necessary data for finding out all the requirements, a market research was done using a group of 15 persons, potential clients, among them being engineers, researchers, PhD students and students. The data raw obtained from the customers, also known as *source data*, constitutes what has come to be defined as *voice of the customer* (VoC) – *HOW's*.

In case of the engine block shown in Fig. 1, the customer requirements are:

- To have small tolerances of the dimensions;
- Do not have deviations from the smoothness of the plane machined surfaces;
- To have reduced weight and dimensions;
- To withstand to the mechanical and technical stresses during the relative movement toward other components of the engine;
- Do not produce high noise, during the time the engine is working;
- To operate at normal parameters, even at high temperatures;
- To be provided with a cooling system that would automatically trigger when necessary and do not allow the water to freeze in the cooling circuit;
- To be designed with a recycling device of the water from the cooling system;

- To be designed in order to reduce at the minimum value the vibrations during the engine is operating.

4. DETERMINATION OF THE TECHNICAL/DESIGN REQUIRMENTS

The technical requirements (*WHAT's*) are a structured set of relevant and measurable product characteristics. This is a particularly step because it implies translating the market model as expressed in subjective terms in the *customers needs* , into objective factors of technical nature expressed in the designer's own language (voice of the engineer- *VoE*). The list of technical requirements compiles the technical design requirements, characteristics and parameters or the engineering characteristics (EC) that represent the *hows* determined by the engineer.

The engineering characteristics (EC) for the engine block are determined by the: costs analysis, study of materials, logistic study, design of the product, study of process, trial of weight, study of tolerance, climatic trial.

At least one EC should be identifiable for each customer request, even though each single EC may affect more than one customer request. If an EC does not affect any customer request than it may become unnecessary. Each EC gives a description of the product in measurable terms and affects directly the customer perception concerning quality.

5. HOUSE OF QUALITY

The relationship matrix indicates how the technical decisions affect the satisfaction of each customer requirement. For each element in the matrix, we try to obtain an answer to the question: “To what extent can the technical characteristics of our product affect the quality expected by the customers?”.

The relationships between the requirements and the characteristics are expressed in a qualitative manner as well as a semi quantitative manner, by the factors of correlation intensity r_{ij}, such as strong, moderate and weak. The matrix is filled up with symbols, each representing a numerical value.

A strong correlation between the requirements and the characteristics implies that a small variation in the value of a j-th indicator of the engineering characteristics (EC_j) may produce a considerable variation in the degree of satisfaction of the i-th customer requirement (ca_i).

We consider that the degree of satisfaction of an i-th customer requirement depends on the values assumed by a set of m ec_j, which describes the car block engine in technical terms, we may write say that the degree of satisfaction can be expressed as:

$$gds(ca_i)= f\,(ec_1, ec_2, \ldots, ec_j, \ldots, ec_m),$$

where f is an implicit function of m variables.

Based on the relationship matrix there can be determined the levels of importance assigned to the product characteristics that are evaluated by: the importance of the customer requirements, the level of correlation and the degree of difficulty.

As we can see in figure 2, in the right part there is a planning matrix that illustrates the customer perceptions observed in the market researches. This matrix presents the importance of the customer requirements and the performance of the organization in meeting these requirements.

The roof of the House of quality is the technical correlation matrix that it is used to identify the situations where the engineer characteristics support or impede each other in the product design stage. The technical correlation matrix is filled up with symbols, each corresponding to a numerical value: 9-strong positive relationship, 3- positive relationship, -3- negative relationship and -9-strong negative relationship. As we can see, in our case there are only two kinds of relations between the engineer characteristics, strong positive and positive.

In the bottom part of the House of quality there are the technical priorities, the benchmarks and the targets, that are used in order to record the priorities revealed by the relationship matrix and to measure the technical performance achieved by the competitive products. This matrix also determines the degree of difficulty in fulfilling each requirement of each customer in order to obtain a much more competitive product. The last line in the bottom part shows a set of target values for each technical requirement to be met by the new design of the product.

6. CONCLUSIONS

In a competitive market, the success of a product depends on not only its performance, but also on its competitors. With the rapid developments in technology, customer needs regarding our product are constantly changing. In such a competitive market, the system designers have to be live updated on each and every second with everything that is new in order to be ready to fulfil al the customers needs. Accurate analytical methods are discovered in order to help the engineers understand the customer requirements and to obtain the future prediction requirements. This paper presents a case study of the Quality function deployment applied on a car engine block, in order to help the designers understand better the customer needs. Also, the Quality function deployment tool also helps in decision-making at organizational level in order to improve the sales and become a much more competitive organization in a constantly changing market.

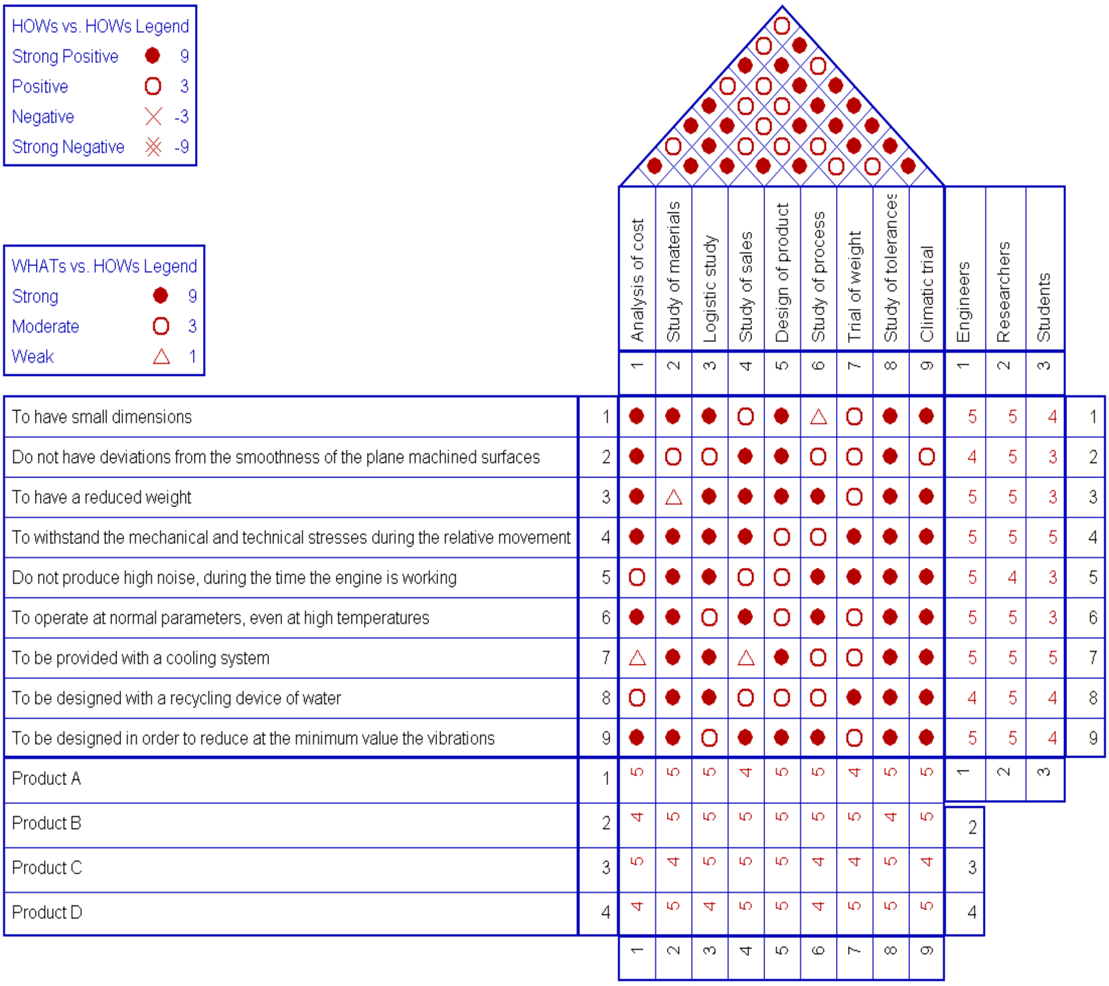

Fig. 2 House of Quality: mapping the customers requirements and the EC for the car engine block

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