Research on product quality optimization of H steel based on QFD and FMEA

--A case study of Laiwu Steel group

WanLi Ma[1, a], Mengzhi Wang[2, b] and Ningning Wu[3, c]

[123] College of Economics and Management, China Jiliang University, Hangzhou, China

[a]mawlrq@126.com, [b]313095664@qq.com, [c]982339381@qq.com

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Abstract: In this paper, we select H-beam products as the research object and use the integrated QFD and FMEA to improve the product quality. First of all, we obtain customer demand through a variety of ways, using QFD convert customer demand into the technical characteristics of the product, then calculate the importance of technical characteristics and the target value of quality improvement. Secondly, the FMEA theory is introduced to analyze the reliability and the key technical characteristics of the house of quality, so as to avoid and control the quality risk effectively. QFD and FMEA are integrated for product quality optimization, which can quickly get the corresponding improvement program and complete the whole quality optimization of H-beam products for the enterprise.

Introduction

In recent years, H-beam has been widely used in industry, construction, bridges and other related industries, the market demand is quite large. Faced with severe market competition, improving the quality of H-beam through a series of quality optimization methods products to speed up the domestic H-beam market development has become a very important proposition [1]. Through the relevant research at home and abroad ,we find that QFD and FMEA as individual quality tool has been widely applied in a variety of quality research [2-5], but if using these two tools separately is not good enough to achieve the purposes of comprehensively optimizing product quality. At present, few scholars integrate QFD and FMEA into optimize the quality of a new type of H-beam according to information research and paper retrieval. Therefore, this paper tries to apply QFD and FMEA to H-beam's quality optimization.

Construction of H-beam Product Quality House

Acquisition of Customer Demand for H-beam Product

In the process of designing product quality optimization, understanding the customer demand accurately is the primary task. After obtaining the original information of customer demand for H-beam product through interviews and literature research, we use the scenario method to translate, convert, consolidate the original data, then investigate the data by "5W1H" (Who, Where, When What, Why, and How) , imagine the case scenario, extract the demand items, and transform and express the needs. The KJ method was used to systematically sort out the original customer demand to get the customer demand expansion table of the H-beam product. As shown in Figure 1, the leftmost column. Next， we use AHP to determine the importance of customer demand of H-beam products.

Market Competitive Assessment and Quality Planning

Through the investigation and analysis of H-beam products enterprises, we choose Ma Steel Group and Pan Steel Group as major competitors. We use Likert Five Scaling Method to understand product characteristics through setting the optimization goal. Comparing each customer demand within competitors, quality table is formed as the rightmost column in Figure 1.

Establish Customer Demand - Technical Characteristic Correlation Matrix

(1) Determine the h-beam product technical characteristics

By converting the customer demand to the technical characteristics expressed in the technical language, we can carry out the productization of the abstract customer demand. The author discusses with the relevant technical personnel of the R & D department of Laiwu Steel Group and refers to the related technical parameters and industry standards to determine the technical characteristics of H-beam, seeing the top line of Figure 1.

(2) Correlation meter of customer demand and technical characteristics

After finishing the above work, it is necessary to evaluate the relationship between each customer demand and the corresponding technical characteristics. We draw the conclusion through discussing with experts of Laiwu Steel Group. When evaluating the degree of correlation, a set of symbols are used to indicate the degree of correlation. ◎ for strong correlation, ○ for correlation, ⊿ for weak correlation, seeing the middle part of Figure 1 (room of the house of the quality).

(3) Conversion the important degree of technical characteristics

After completing the quality scale, in order to transform demand into technical language. Each importance degree of technical demand needs to be calculated. The results are shown in the bottom of Figure 1 (basement of the house of quality).

The Determination of Design Quality

According to the product technical level and competition demand, Laiwu is compared with Ma and Pan to determine the target value of product quality, combining with the importance degree of technical characteristics. The results are shown in Figure 1: the last two lines.

We get the information about the customer demand information and technical characteristics of the H-beam products through the above work, and construct the house of quality of h-beam product planning, as shown in figure 1.

The Application of FMEA Theory in H-beam Product

FMEA can find solutions to avoid or reduce potential failures and improve continuously. In order to benefit the quality assurance of h-beam product production process, this paper uses FMEA theory and field investigation to understand the production process of H-beam. After analyzing the important technology of quality optimization , all the potential failure modes are found in production process, there are lanking plate, CNC cutting, submerged-arc welding, H-type correction and secondary assembly. Then we analyze its possible consequences so as to take necessary measures to improve the quality and reliability of products in advance. In table 1, the maximum value of RPN in the failure mode is selected, and we get the control points of the larger RPN value in the FMEA, take measures to improve product quality.

According to table 1, in each process of the h-beam corresponding fault and risk may appear. Therefore, enterprises should observe technical specifications and standards in produce. The application of FMEA provides reference for implementing of product quality optimization, reminds the staff should consider and coordinate all aspects to improve product quality.

Conclusion

In this paper, we select H-beam products of Laiwu steel Group as the research object and use the integrated QFD and FMEA to design and improve the product quality. We obtain customer demand through a variety of ways, using QFD to convert customer demand to the technical characteristics of the product, then calculate the importance of technical characteristics and the target value of quality improvement. Then FMEA theory is introduced to analyze the reliability and the key technical characteristics of the house of quality, so as to avoid and control the quality risk effectively. QFD and

FMEA are integrated for product quality optimization, which can quickly get the corresponding improvement scheme and complete the whole quality optimization of H-beam products for the enterprise.

Figure 1 The House of Quality of the H-beam Product

Technical characteristics of quality housing / H customer requirements	Rolling temperant	Mixing proportion	Cleaness	Length of the weld zone	Axis rack	Compressive pre-stress	Flexural carrying capacity	Bi value of the rolling mill	Leg thickness of the work piece	External dimension	Materials	Weld time	Protective layer thickness	*Important degree*	*The company*	*Ma steel group*	*Pan steel group*	*Target value*	*Horizontal uplift ratio*	*Product characteristics points*	*Absolute important degree*	*Relative important degree*
Few pockmark	○	●	●											1.6	3	4	3	4	1.33	1.2	2.6	1.9
Good fastness		○	●		◢									2.3	4	4	4	5	1.25	1.2	3.5	2.6
Uniform color	●	●	○			◢								1.1	4	4	3	5	1.25	1.2	1.7	1.2
Strong loadbearing capacity			◢	○		●								4.3	5	5	4	5	1	1	4.3	3.1
Strong anti-bending capacity	○	●	◢		●									0.6	4	3	4	4	1	1.5	0.9	0.6
Strong pressure	○	●	◢		●	●								0.5	3	3	4	4	1.33	1.5	1	0.7
Suitable throat sizes	●						○		◢					15.6	4	5	4	5	1.25	1	19.5	14.2
Web thickness three points thickness deviation on widthwise reach the standard	◢						●	○						9	4	4	4	4	1	1.2	10.8	7.8
No cooling bellows	○						◢	●	●					3.4	3	4	4	4	1.33	1.5	6.4	4.7
No web decentring	○		●					◢	◢	○				30.3	4	4	5	5	1.25	1	37.8	27.6
Suitable width-thickness ratio	●								●	◢	○	◢		17.4	4	4	4	4	1	1.2	20.8	15.2
No leg wave	●								●	◢	◢	○		6.6	3	3	4	4	1.33	1.5	13.2	9.6
Strong corrosion resistance	●		◢		◢								○	7.3	3	4	4	4	1.33	1.5	14.6	10.7
Importance of technical characteristics	216.1	16.6	82.9	9.3	15.9	8.8	62.9	83.3	86.6	107.6	55.2	44	10.7									
The company	5	3	5	5	4	3	3	3	3	4	5	3	3									
Ma steel group	4	3	5	5	4	3	3	4	4	4	4	4	3									
Pan steel group	5	4	5	5	4	4	4	4	4	4	5	4	4									
Target value	5	4	5	5	4	3	4	5	5	4	5	4	4									
Keep or improvement	K	I	K	K	K	K	I	I	I	K	K	I	I									

◎： strong correlation；○： correlation； ⊿： weak correlation；K： keep；I： improvement.

Table 1 FMEA Analysis of H -beam Product

Number	Failure Process	Failure Mode	Severe Degree	Failure Cause	Frequency	Difficulty of Detection	RPN Coefficient	Improvement Actions
1	Blanking plate	Waist size is too small	6	Blanking plate s temperature is too high when it's rolling	5	3	90	Increase the flange thickness
1	Blanking plate	Waist size is too large	5	Blanking plate's temperature is too low when it's rolling	4	2	74	Reducing roll gap of vertical roll
2	NC cutting	Web thickness is not up to standard	6	Each unit of finish rolling in the severe leg pull waist or waist pull leg	5	2	60	Adjustment scale
3	Submerged-arc welding	Cooling ripple	5	The extension of the previous frame is slightly deformed	4	4	48	Increase the cooling rate of the legs and add cooling water to the mill guide
4	H-type correction and secondary assembly	Web eccentricity	3	The thickness of the metal materials are uneven	4	2	32	Adjust the axial direction of the corresponding frame
5	Paint	Leg wave	3	The rolling reduction of E1 edge mill is less, so that the amount of metal in the legs excessive increase	4	2	24	Increase the rolling reduction of E1 edge mill, so that the amount of metal in the legs in the E1 control

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