The Application of FEMA and Error-Proofing Equipment on the Shell Drawing Line of G Company

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Abstract. This paper systematically analyzed the production situation of the shell drawing line of G Company, and utilized FMEA and fish-bone diagram to identify weak links in the production line as well as the cause of failures. On this basis, we formulated several error prevention plans to reduce defects. After that, the workers could avoid errors even without particular attention.

Introduction

It is generally known that the quality of product is the foundation of a company to survive, and many companies have realized that error-proofing is an effective way to improve the productivity levels. That have also helped FEMA and error-proofing equipment to be used in more and more fields. G Company is specialized in the production of various kinds of vehicles stamping parts and plastic parts. This paper mainly studied the product, which is called 980 Shell, that produced by the shell drawing line of G Company, and illuminates the application of FEMA and error-proofing equipment to identify and reduce errors of the line.

FMEA and Error-Proofing Equipment

Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all potential failure modes within a system. Failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones [1,2].

Error-Proofing, also known as poke-yoke and Mistake Proofing, is the use of any automatic device or method that either makes it impossible for an error to occur or makes the error immediately obvious once it has occurred [3,4].

The Original Production Process

The 980 Shell is a sort of hollow cylindrical part, and it is 168.5mm high, 92mm diameter, and 100mm additional side diameter. Figure 1 is a structure schematic drawing illustrating structure of the 980 Shell.

On the basis of field real-time data, the workers could use FMEA to identify failure modes and effects of the original production process, as shown in table 1. S (Severity) is used to determine how serious each effect is, and O (Occurrence) is used to estimate the probability of failure occurring for that reason, and D (Detection) is used to estimate how well the controls can detect either the cause or its failure mode after they have happened but before the customer is affected. These three indicators are usually rated on a scale from 1 to 10. Then risk priority number (RPN), which equals \( S \times O \times D \), could be easily calculated to rank potential failures in the order they should be addressed [5].
Table 1. Failure modes and effects analysis.

| Process | Failure Modes | Effects | S | Cause | O | Precaution | Detection | D | R | P | N |
|---------|---------------|---------|---|-------|---|------------|-----------|---|---|---|---|
| 1 stock | bend and corrosion | influences production seriously | 8 | breakage of packages | 2 | improve storage conditions | 2 | 32 |   |   |   |   |
| 2 blanking | chipped edge | insufficient stretching height | 3 | size over tolerance | 3 | repair and maintain the mold | 3 |   | 4 | 36 |   |   |
| 3 the first stretching | a. stretching height over tolerance b. sheel surface folding | product disqualification | 4 | a. die misalignment b. uneven die clearance | 2 | repair and maintain the mold | a. 3 pieces per two hours b. point inspection | 4 | 32 |   |   |
| 4 the second stretching | a. insufficient stretching height b. sheel surface folding | product disqualification | 4 | a. die misalignment b. uneven die clearance | 2 | repair and maintain the mold | a. 3 pieces per two hours b. point inspection | 4 | 32 |   |   |
| 5 the third stretching | a. insufficient stretching height b. sheel surface folding | product disqualification | 4 | a. die misalignment b. uneven die clearance | 2 | repair and maintain the mold | a. 5 pieces per two hours b. point inspection | 6 | 72 |   |   |
| 6 levelling | a. inner diameter over tolerance b. surface folding | product disqualification | 7 | a. punch wear b. insufficient pressure | 2 | repair and maintain the mold | a. 5 pieces per two hours b. point inspection | 4 | 56 | 3 | 24 |
| 7 molding | size over tolerance | product disqualification | 4 | insufficient size | 2 | repair and maintain the mold | 3 |   | 4 | 48 |   |   |
| 8 trimming | size over tolerance | product disqualification | 7 | die wear | 2 | repair and maintain the mold | 5 |   | 4 | 56 |   |   |
| 9 spraying | a. misses b. size over tolerance | a. spraying again b. product disqualification | 4 | a. uneven spraying b. inaccurate measurement | 2 | 3 pieces per two hours | 4 | 32 |   |   |

Figure 1. The structure schematic drawing of the 980 Shell.
As shown in Figure 2, there are several main failure modes, including insufficient stretching height, size over tolerance, inner diameter over tolerance, chipped edge, bend and corrosion, and shell surface folding. Then analyze those failure modes from the aspects of man, machine, material, method, environment and monitoring by applying 5W1H method. According to that, we can draw the fish-bone diagram of the failure modes (see Figure 3) [6].

Through the analysis it can be found that:

(1) there are several problems within the aspects of material and environment, including unqualified parts, damaged parts, and inappropriate storage conditions, which result in chipped edge, bend, and corrosion. These issues can be solved by improving the sanitary conditions of working environment, replacing damaged parts in time, and so on.

(2) there are several problems within the aspects of man and method, including inexperienced personnel, distraction, and deficient training system, which lead to the failure modes that stretching height and size can't meet the requirements. These issues can be solved by improving the training of staff, generating standard operation procedure scientifically and reasonably, and so on.

(3) there are several problems within the aspects of machine and monitoring, including poorly maintained equipment, and positioning devices that can not assure adequate precision, which lead to the failure modes that stretching height, inside diameter, and the surface of the shell can't meet the requirements. These issues can be solved by applying error-proofing equipment.

**Error-Proofing Equipment**

The error-proofing equipment would terminate the process and give a warning when the workers encounter some drawbacks and problems, so that, unqualified parts would not be transported into the next step, and it will be useful to reduce many defects [7]. In the production process of 980 Shell, the
errors in the aspect of machine exist mostly in the phases of the first stretching and leveling. Then design detailed plans based on error-proofing:

(1) In process of the first stretching, workers should put work-pieces on the convex die, and make appropriate adjustments. If workers can not fast and exactly position the work-pieces, the quality of products will be influenced greatly, which will lead to severer consequences, such as product disqualification, reworking, and even scrapping.

Workers used to adopt two-point location method, and they only utilized two positioning pins to fix work-pieces. After improvement, we install proximity switch on the positioning pins, and the machines will run normally only when the work-pieces firmly contact with the positioning pins. Otherwise, the machine can not be started to complete this process.

(2) In process of leveling, the product adopts the structure of the hollow cylinder, and it is difficult to firmly fix the work-piece to the convex die. In addition to that, there are many wrinkles in the flange part, so that, the products quality is not steady.

![Figure 4. The original die.](image1)

![Figure 5. The improved die.](image2)

1- upper die base 2,4,10,11,12- bolt 3- column
5- concave die 6- convex die 7- blank holder
8- lower die base 9- positioning block 13- support pillar

The workers had installed rigid blank pressing device to alleviate the problem, but the problem still exist. As shown in Figure 4, the convex die and the blank holder are fixed on the lower die base by a bolt, and the concave die is fixed on the upper die base by another bolt. On the basis of the original die, we add two extra bolts to connect the work-piece with column and positioning block, and enhance connection strength. The improved equipment utilizes column 3 and positioning block 9 to fix the work-piece, and keep the uniform clearance between the convex die and the concave die (see Figure. 5).

**Conclusions**

On the basis of production situation of the shell drawing line of G Company, this paper applied FMEA to identify failure modes and effects of the production process, and utilized 5W1H method and fish-bone diagram to analyze those failure modes from the aspects of man, machine, material, method, environment and monitoring. At last, we design detailed plans based on error-proofing, and G Company should:

(1) improve the sanitary conditions of working environment, and replace damaged parts in time;
(2) improve the training of staff, and generate standard operation procedure scientifically and reasonably
(3) Increase several error-proofing equipment. They can install proximity switch on the positioning pins during the process of the first stretching, and add two extra bolts to enhance connection strength during the process of leveling.

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