

Analysis and research on RP manufacturing precision

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Abstract. In the rapid prototyping technology, the step effect of the data error and the approximation error of the STL format would affect the machining accuracy. In this paper, we have studied the cause of the error and the method of improving the machining precision. Manufacturing precision of rapid prototyping not only has decisive significance but also influences the stability and service life of parts, so the study on rapid prototyping manufacturing accuracy is very important.

1. Introduction

Rapid prototyping (RP) technology started in the 90s, we have used it to shorten the design cycle of new products, make product innovation, and improve product competitiveness in the market. It has played a positive role in industry.

The influence factors of RP manufacturing precision include the error caused by forming process, data processing, post-processing and so on. The following factors affecting the accuracy of LOM rapid prototyping are analyzed and studied.

2. Forming process error

The errors produced in the forming process are mainly due to the following reasons.

2.1. Machine control error

Machine error is hard to avoid, which has a relationship with the machine material environment and the operator. It is obvious that the position error of the x and y plane scanning motion of the forming head and the z direction motion of the worktable can directly lead to the shape and size error of the forming part.

2.2. The surface of the mold is damaged by excessive laser power.

It is difficult to adjust the laser power to cut exactly through a layer of tape due to uneven surface of the laminated block and machine control errors. If the laser power is too small to lead difficult waste stripping. In practice, we increase slightly the laser power, to control the damage to a small extent on a layer of adhesive tape surface. Although the damage is not big, temperature can be controlled as far as possible, but they still have influence on the molding error.

2.3. Thermal warping deformation of the laminate.

The adhesive tape needs to be cooled in a certain environment after hot pressing. In the cooling process, due to the different thermal expansion coefficients of the adhesive tape, the irregular constraint between adjacent layers, and the warping deformation of the laminate, so that certain residual stress is generated in the interior of the workpiece.



2.4. Uneven thickness distribution of the laminate.

Due to the thermal expansion and contraction during the hot pressing process, there is larger deformation, and the adhesive tape may not be in a plane, so the laminated thickness distribution is not uniform, and its thickness can be reached to millimeter error.

3. Post - processing errors

Post - processing errors are mainly due to the following reasons.

3.1. The error caused by environmental change.

After the laminated block is taken off from the worktable, the temperature is reduced. The laminated block is further warped due to thermal expansion and cold contraction. After stripping the scrap and the bezel, the article absorbs moisture from the air moisture and expands, resulting in further deformation of the article.

3.2. The error caused by improper post - processing.

The general molding of the workpiece should be sprayed and polished and other processing. If the post-treatment is not appropriate, the shape and size control is not rigorous, and can lead to errors.

4. Precision inspection of RP parts

Based on the summary of the above theoretical knowledge, we completed the detection of 3D entity figure 4 - 1 (entity is peeling / hot peeling after cooling).

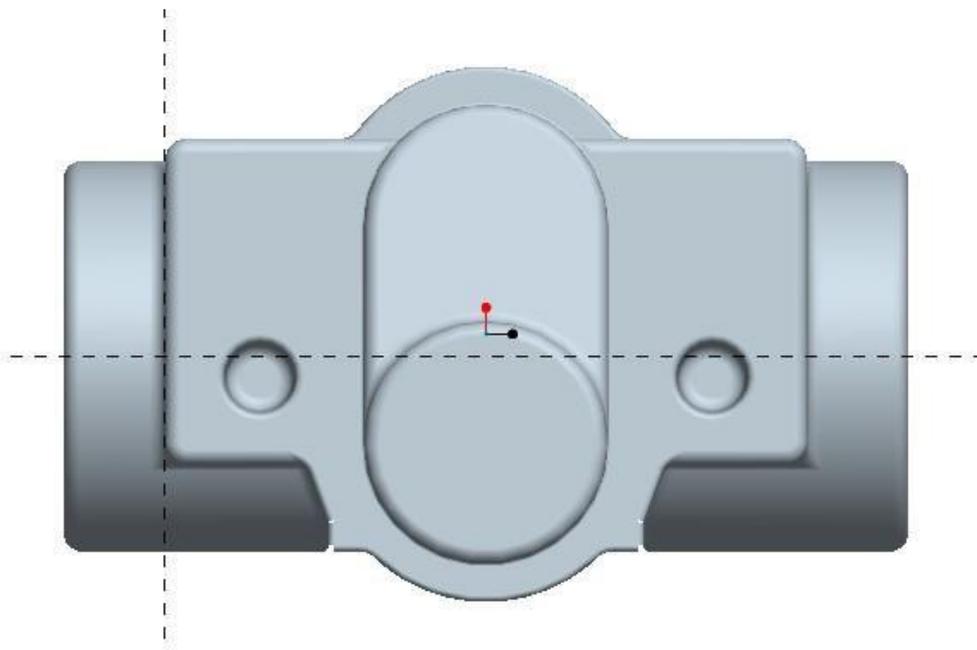


Figure 4 - 1 pro/e entity diagram

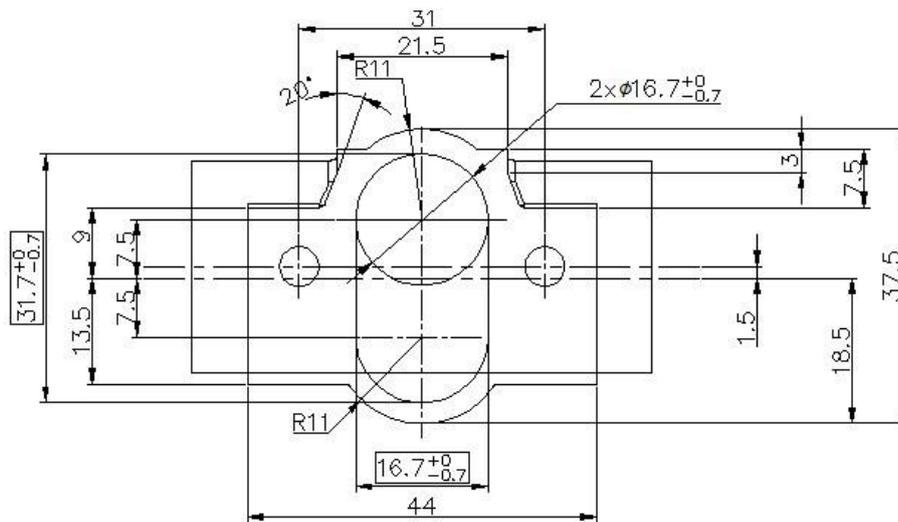


Figure 4 - 2 size diagram

During the internship by the company's measuring tool such as digital vernier caliper, depth scale, angle scale we got the measurement result after the post - peel was cool. The difference of thickness is generally reduced. The blanks produced for GI-A using the rapid prototyping system is shown in figure 4 - 3.



Figure 4 - 3 rapid prototyping roughcast

GI - A rapid prototyping machine system running environment is win XP, file input format is STL, molding precision is plus or minus 0.2 mm / 100 mm. Molding space is 250 x 302 x 330 mm, the thickness of the direct pressure double nozzle is 0.15 - 0.4 mm. According to the above processing parameters we made the rapid prototyping entity, and we can clearly see that the precision difference between the entity and pro/e prototype is too big.

- The error with the naked eye we can see a layer of small cylinder.
- With the hand to touch we can know that it is a regular polygonal cylinder.
- The counter bore on the drawing model would not be formed.
- Because of the influence of the supporting liquid, it is obvious that the supporting liquid is adhered to the molded part.

What is the difference between rapid prototyping and die forming error size as shown in table 4 - 1:

Table 4 - 1 size comparison table of die forming and rapid forming

Measuring position	Drawing Size/mm	Measuring size/m		Dimension error/mm
		mould	roughcast	
Outer circle diameter	Φ 27	Φ 26.93	Φ 30.31	3.38
Excircle length	58	57.76	60.28	2.52
Mounting surface length	44	44.02	46.12	2.1
Mounting surface width	22.5	22.45	24.68	2.23
Surface thickness	4	4.08	4.82	0.47
Boss length	31	31.01	34.25	3.24
Boss width	16	15.98	18.18	2.2
Boss angle	8 ⁰	7.9 ⁰	8 ⁰	0.1 ⁰
Positioning surface size	21.5	21.55	23.67	2.12
Upper diameter of hole	5	5.03	5.83	0.8
Hole lower diameter	4.5	4.45	5.46	1.01
Hole depth	5	5.18	6.05	0.6

According to the size of table 4 - 1 it can be seen that the accuracy of the mould still has a lot of room for improvement. There are many reasons for error difference, such as the proportion of the set on the rapid prototyping machine, or different cooling way. To avoid such size error is to control the temperature of the cooling environment of the moulded parts. To sum up, in order to make a good moulded parts we should improve the moulding system and the function of the moulding equipment, which can greatly improve the accuracy, but the cost is too high. In figure 4 - 3 the weight of the roughcast is 29.2 g, required time of production is 2 hours and 9 minutes, plus preheating time is almost 2 and a half hours, so the processing efficiency is very low.

5. Conclusion

The application of 3D RP technology makes the product design cycle shorten greatly. But the accuracy and strength could not fully meet the requirements of engineering design, so we should consider the combination of the 3D model design, parameter transformation, hierarchical cutting and other aspects and improve technical conditions to reduce the loss of precision. It makes the technology more effective and efficient in product development.

References

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