Precision Control on Development Design of the Injection Plastic Part based on Reverse Engineering

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Abstract. Product development design needs to go through four phases. These phases are construction phase, development phase, emulation phase and assessment phase. The deviation composition of these phases is studied. In the process of reverse development design, emphasizing on phase deviation, taking the injection plastic part for example, the quantitative precision control on the process is satisfied effectively.

1 Introduction

In the development process of products[1-5], the precision analysis is always a crucial technical problem. With reverse engineering technology used in product development increasingly, accuracy control becomes a core technology issue[6-8]. In this paper, a quantitative analysis on deviation distribution of development design and reverse development design is implemented, at the same time, precision control on reverse development design of the injection plastic part is realized.

2 Deviation Distribution of Development Design

2.1 Phase Analysis

Product development design needs to go through four phases. These phases are construction phase, development phase, emulation phase and assessment phase. The phases of development design process is shown as Figure 1. The construction phase includes reconstruction process and appraisal process. The construction phase is shown as Figure 2. The development phase includes analysis process and optimization process. The development phase is shown as Figure 3. The emulation phase includes static process and dynamic process. The emulation phase is shown as Figure 4. The assessment phase includes product process and assembly process. The assessment phase is shown as Figure 5.
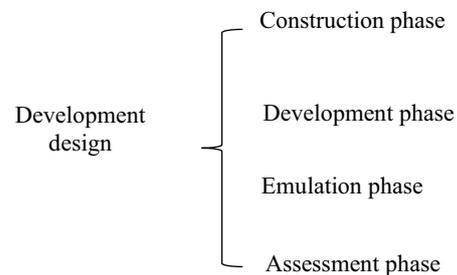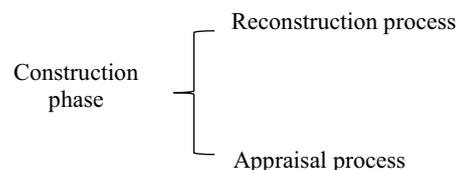

Figure 1. Development design.
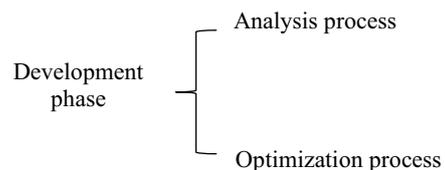

Figure 2. Construction phase.

Figure 3. Development phase.

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Emulation phase
- Static process
- Dynamic process

Figure 4. Emulation phase.

Assessment phase
- Product process
- Assembly process
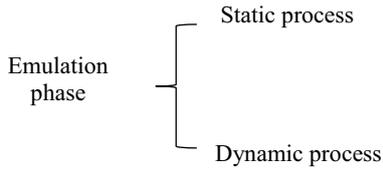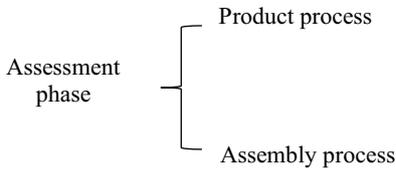
Figure 5. Assessment phase.

2.2 Deviation Composition

Based on the phase analysis, deviation of development design is made primarily from construction deviation, development deviation, emulation deviation and assessment deviation. The deviation of development design is shown as Figure 6. The construction deviation involves reconstruction deviation and appraisal deviation. The construction deviation is shown as Figure 7. The development deviation involves analysis deviation and optimization deviation. The development deviation is shown as Figure 8. The emulation deviation involves static deviation and dynamic deviation. The emulation deviation is shown as Figure 9. The assessment deviation involves product deviation and assembly deviation. The assessment deviation is shown as Figure 10.
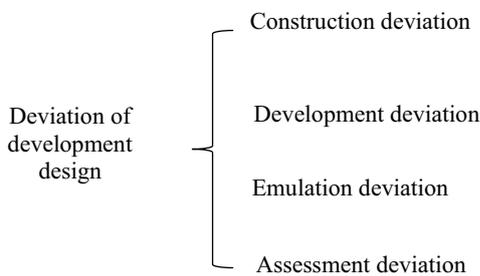
Deviation of development design
- Construction deviation
- Development deviation
- Emulation deviation
- Assessment deviation

Figure 6. Deviation of development design.

According to Figure 6, the overall deviation formula of the development design is presented in Equation1.
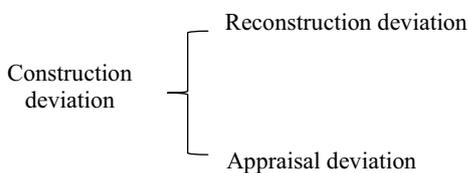
$$\Delta^2_{development\ design} = \Delta^2_{construction} + \Delta^2_{development} + \Delta^2_{emulation} + \Delta^2_{assessment} \quad (1)$$

Construction deviation
- Reconstruction deviation
- Appraisal deviation

Figure 7. Construction deviation.

In Equation 1, according to Figure 7, the construction deviation formula is presented in Equation 2.

$$\Delta^2_{construction} = \Delta^2_{reconstruction} + \Delta^2_{appraisal} \quad (2)$$
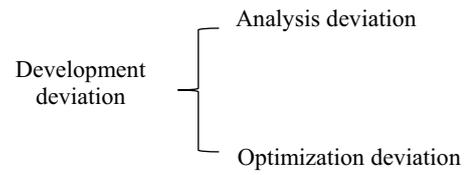
Development deviation
- Analysis deviation
- Optimization deviation

Figure 8. Development deviation.

In Equation 1, according to Figure 8, the development deviation formula is presented in Equation 3.

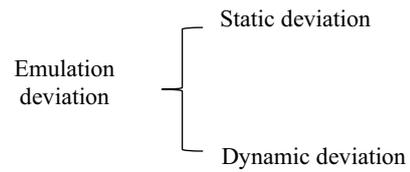$$\Delta^2_{development} = \Delta^2_{analysis} + \Delta^2_{optimization} \quad (3)$$

Emulation deviation
- Static deviation
- Dynamic deviation

Figure 9. Emulation deviation.

In Equation 1, according to Figure 9, the emulation deviation formula is presented in Equation 4.

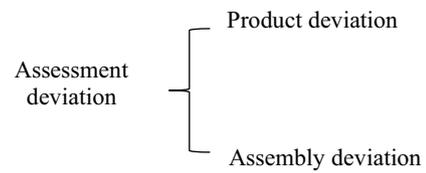$$\Delta^2_{emulation} = \Delta^2_{static} + \Delta^2_{dynamic} \quad (4)$$

Assessment deviation
- Product deviation
- Assembly deviation

Figure 10. Assessment deviation.

In Equation 1, according to Figure 10, the assessment deviation formula is presented in Equation 5.

$$\Delta^2_{assessment} = \Delta^2_{product} + \Delta^2_{assembly} \quad (5)$$

3 Accuracy Study on Reverse Development Design

3.1 Phase Analysis

There are four phases during reverse development design, namely, reverse phase, reverse development phase, reverse emulation phase and reverse assessment phase. The phases of reverse development design is shown as Figure 11. The reverse phase includes rebuilding process and appraisal process. The reverse phase is shown as Figure 12. The rebuilding process covers data process and prototype process. The rebuilding process is shown as Figure 13. The reverse development phase includes reverse analysis process and reverse optimization process. The reverse development phase is shown as Figure 14. The reverse emulation phase includes reverse static process and reverse dynamic process. The reverse emulation phase is shown as Figure 15. The reverse

assessment phase includes reverse product process and reverse assembly process. The reverse assessment phase is shown as Figure 16.
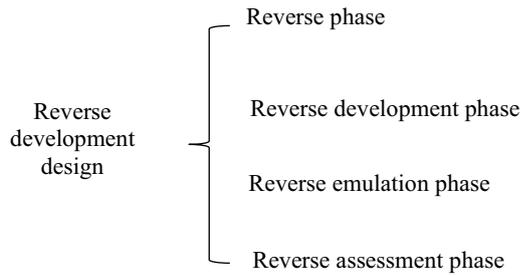
Reverse development design
- Reverse phase
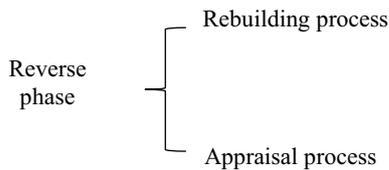- Reverse development phase
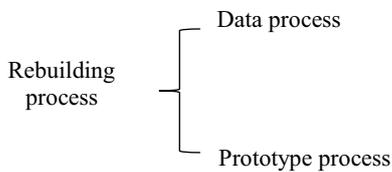- Reverse emulation phase
- Reverse assessment phase

Figure 11. Reverse development design.

Reverse phase
- Rebuilding process
- Appraisal process

Figure 12. Reverse phase.

Rebuilding process
- Data process
- Prototype process

Figure 13. Rebuilding process.

Reverse development phase
- Reverse analysis process
- Reverse optimization process
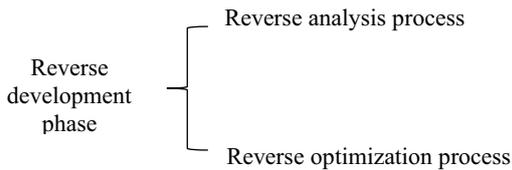
Figure 14. Reverse development phase.

Reverse emulation phase
- Reverse static process
- Reverse dynamic process

Figure 15. Reverse emulation phase.
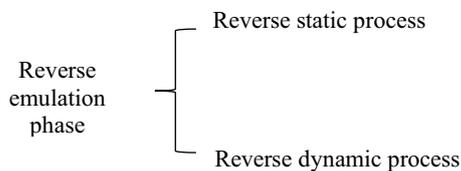
Reverse assessment phase
- Reverse product process
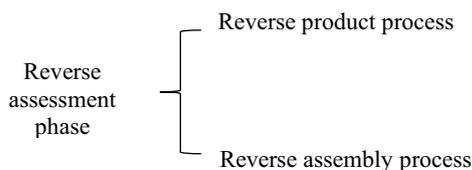- Reverse assembly process

Figure 16. Reverse assessment phase.

3.2 Deviation Research

Based on the phase analysis of reverse development design, deviation of whole process involves reverse deviation, reverse development deviation, reverse emulation deviation and reverse assessment deviation. The deviation of reverse development design is shown as Figure 17. The reverse deviation covers rebuilding deviation and appraisal deviation. The reverse deviation is shown as Figure 18. The rebuilding deviation incorporates data deviation and prototype deviation. The rebuilding deviation is shown as Figure 19. The reverse development deviation covers reverse analysis deviation and reverse optimization deviation. The reverse development deviation is shown as Figure 20. The reverse emulation deviation covers reverse static deviation and reverse dynamic deviation. The reverse emulation deviation is shown as Figure 21. The reverse assessment deviation covers reverse product deviation and reverse assembly deviation. The reverse assessment deviation is shown as Figure 22.
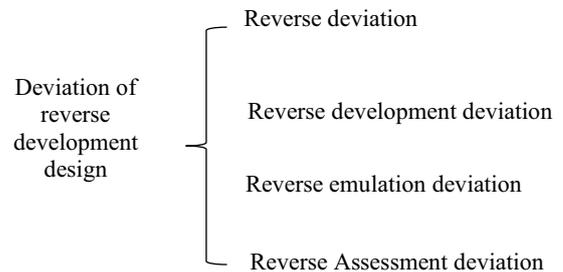
Deviation of reverse development design
- Reverse deviation
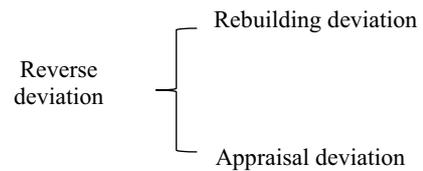- Reverse development deviation
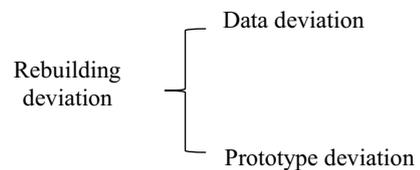- Reverse emulation deviation
- Reverse Assessment deviation

Figure 17. Deviation of reverse development design.

Reverse deviation
- Rebuilding deviation
- Appraisal deviation

Figure 18. Reverse deviation.

Rebuilding deviation
- Data deviation
- Prototype deviation

Figure 19. Rebuilding deviation.

Reverse development deviation
- Reverse analysis deviation
- Reverse optimization deviation
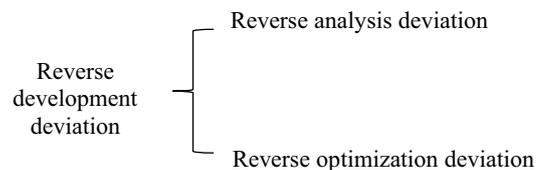
Figure 20. Reverse development deviation.

Reverse emulation deviation
├─ Reverse static deviation
└─ Reverse dynamic deviation

Figure 21. Reverse emulation deviation.

Reverse assessment deviation
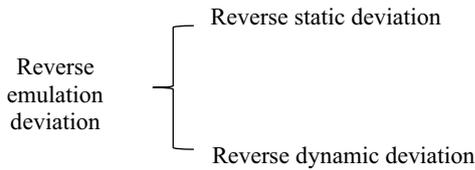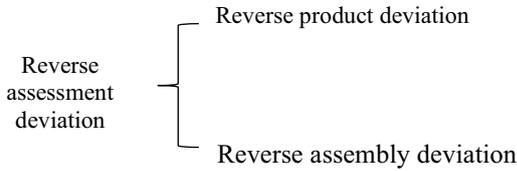├─ Reverse product deviation
└─ Reverse assembly deviation

Figure 22. Reverse assessment deviation.

On the basis of the whole deviation analysis, the overall deviation formula of the process is presented in Equation 6.

$$\Delta^2_{reverse\ development\ design}=\Delta^2_{reverse}+\Delta^2_{reverse\ development}+\Delta^2_{reverse\ emulation}+\Delta^2_{reverse\ assessment} \quad (6)$$

In Equation 6, the reverse deviation formula is presented in Equation 7.

$$\Delta^2_{reverse}=\Delta^2_{rebuilding}+\Delta^2_{appraisal} \quad (7)$$

In Equation 7, the rebuilding deviation formula is presented in Equation 8.

$$\Delta^2_{rebuilding}=\Delta^2_{data}+\Delta^2_{prototype} \quad (8)$$

In Equation 6, the reverse development deviation formula is presented in Equation 9.

$$\Delta^2_{reverse\ development}=\Delta^2_{reverse\ analysis}+\Delta^2_{reverse\ optimization} \quad (9)$$

In Equation 6, the reverse emulation deviation formula is presented in Equation 10.

$$\Delta^2_{reverse\ emulation}=\Delta^2_{reverse\ static}+\Delta^2_{reverse\ dynamic} \quad (10)$$

In Equation 6, the reverse assessment deviation formula is presented in Equation 11.

$$\Delta^2_{reverse\ assessment}=\Delta^2_{reverse\ product}+\Delta^2_{reverse\ assembly} \quad (11)$$

4 Instance

Point data of a injection plastic part is shown as Figure 23. The deviation of reverse development design is limited within 0.1mm.

Figure 23. Point data.

The reverse deviation is restricted in about 0.08mm. The reverse development deviation is restricted in about 0.01mm. The reverse static emulation is shown in Figure 24. Generally speaking, the reverse emulation deviation

and the reverse assessment deviation are restricted in about 0.02mm. On the basis of Equation 6, the overall deviation of the reverse development design is 0.085mm, which satisfies the deviation need of less than 0.10mm. Therefore, the precision control of the reverse development design is realized.
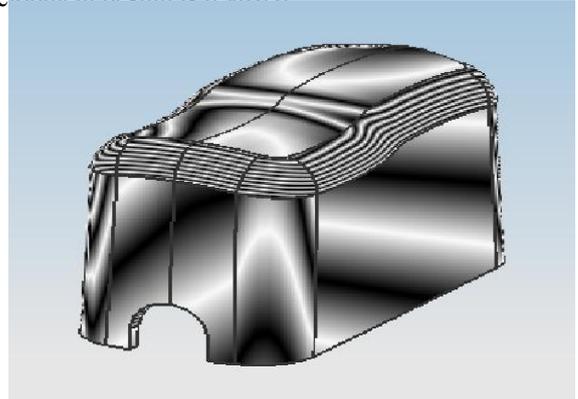

Figure 24. Reverse static emulation.

5 Conclusions

In this paper, precision on development design of the injection plastic part based on reverse engineering is under control. Analysis on the deviation composition of reverse development design is very significant for accuracy control.

Acknowledgements

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