

Research on Intelligent Casting Process Design of Rail Transit Steel Castings

Guoxiang Wang^{1, 3},*,, Jun Wang^{1, 3}, Jianzhong Li^{1, 3}, Xianzhi Li², Song Cao²

 School of Materials Science and Engineering, Shanghai Jiao Tong University, No. 800, Dongchuan Road, Minhang District, Shanghai 200240, China
CRRC QiShuYan Institute Co.,Ltd., No.258 Wuyi Road,Changzhou City, Jiangsu Province 213011, China
Jiangsu Zhongchao Aerospace Precision Casting Technology Co., Ltd., No.16, Changxing Road, Yixing City, Jiangsu Province 214241, China

*Corresponding address: gxwang@sjtu.edu.cn (Guoxiang Wang)

Abstract: Due to the complex structure, large size, lightweight design and economic requirements of key steel castings in rail transit, high-strength casting materials are accompanied by a decline in casting processability, however the casting quality requirement is much higher, which greatly enhances the difficulty of casting process design. On the other hand, there is a relative shortage of experienced foundry process designers. Therefore, the intelligent design of casting process of rail transit parts is the only way to solve this problem. CRRC QiShuYan Institute Co.,Ltd has gradually applied digital casting technology since the 1990s, The integrated application of CAD/CAE/CAM greatly improves the accuracy and efficiency of casting process design. We study the application of AI on steel casting process design, step-bystep, we use while building, on the basis of expert system, we have built a core knowledge database. We study intelligent defect detection of castings. Then tracing the defect results to the corresponding process parameters used through the MES system and AVI system. The next step is to study the combined technology of AI+CAE.

Keywords: Al; rail transit castings; steel castings; casting process design

1 Introduction

As a safe, green, efficient and large-volume mode of transportation, rail transit has been booming in recent years, and the scale of the global rail transit market continues to expand, especially in China, where the rapid growth of the rail transit market is maintained due to the government's strong investment in infrastructure construction. With the implementation of "One Belt, One Road" strategy, rail transit equipment has gradually been applied globally. Rail transit is characterized by safety, reliability, comfort and high-speed. With the demand for higher speed, the safety and reliability of rail transit equipment are facing more difficult challenges. Rail transit casting products, especially key steel castings, are generally more complex in structure, complex and variable in use conditions, and play a key role in equipment, so their castings have more stringent technical requirements.

Due to the complex structure, large size, lightweight design and economic requirements of key steel castings in rail transit, high-strength casting materials are accompanied by a decline in casting processability, however the casting quality requirement is much higher, which greatly enhances the difficulty of casting process design. On the other hand, there is a relative shortage of experienced foundry process designers. The working environment of foundry enterprises is poor, and the salary is relatively low, resulting in fewer employees; Since the 1990s, China's colleges and universities have moved from professional education to general education, and most colleges and universities have canceled casting, and casting is only a part of professional courses. Limited by school hours, casting knowledge cannot be taught systematically and comprehensively, so that graduates have shortcomings in solving technical problems. Therefore, the intelligent design of casting process of rail transit parts is the only way to solve this problem.

2 Result and discussion

CRRC QiShuYan Institute has gradually applied digital casting technology since the 1990s, the application of casting simulation and optimization improves the production efficiency and casting quality. The integrated application of CAD/CAE/CAM greatly improves the accuracy and efficiency of casting process design. With the development of network technology, digital equipment, information management, such technologies improve the automation degree of casting production, improve efficiency and quality. But casting is a complex process, it include the casting process design, modeling, melting, pouring and other processes, involving the process, alloy, equipment, testing and many other aspects. Casting process need to consider metal metallurgy characteristics, mold composition, the heat and mass transfer of the high temperature liquid metal in the cavity, involving metallurgy, mechanics, fluid, thermodynamics, etc., also you need to avoid casting deformation and cracks caused by the complexity of the casting structure. Therefore, the casting process design still has to rely on semi-empirical mode, and the design quality depends on the designer's experience, so the efficiency is low, and it is more often to have errors.

Large Language models (LLMS) can already use deep learning models trained on large amounts of text data to generate natural language text or understand the meaning of language text. Processing multiple natural language tasks, such as text classification, question and answer, conversation, etc., is an important path to artificial intelligence. We can introduce artificial intelligence technology into the casting process design, carry out casting process identification, understanding, thinking, learning, reasoning, rationality judgment, and finally achieve the best process plan given by artificial intelligence.

CRRC QiShuYan Institute, together with Shanghai Jiao Tong University, carry out intelligent exploration of steel casting process design, take a step-by-step approach, has initially built the core knowledge data base, and classify the products according to the material and structural characteristics. The data include the drawings, technical elements, process design and corresponding defects. All these works help to optimize the subsequent process designing.

Due to the rapid development of the information industry, big data has become a major subversive technological. Among them, Data is the foundation, Data is the food of AI. We collect data from the following three aspects, collect it into the enterprise big data center, organize it, and add it into the enterprise core database of rail transit steel casting parts.

1. Casting defect results, we carry out research on AI identification of casting defects, we have a large number of X-ray, CT, ultrasound, metallography, fluorescence, coloring method detection results, the use of large models to accurately identify the defects.

2. The application of casting tracking technology, MES system (manufacturing execution system) and AVI

system (casting automatic identification system) are adopted at the workshop to accurately correspond the casting defects and the process parameters used.

3. Casting simulation, we study the causes of casting defects via the casting simulation; contrast the defects of castings, than the simulation boundary conditions are finetuned to make the simulation results more accurate and closer to the reality. Through DOE technology, multiple gating systems are automatically generated to find out the optimal process method. The next step is to study the combined technology of AI+CAE.

3 Conclusion

We study the application of AI on steel casting process design, step-by-step, we use while building, on the basis of expert system, we have built a core knowledge database. We study intelligent defect detection of castings. Then tracing the defect results to the corresponding process parameters used through the MES system and AVI system.

References

- [1] Ye Maolin, Yan Dengkun, The Latest research and Exploration on the application of AI in Foundry industry [J]. Foundry Equipment and Processes, 3, 2024.
- [2] Xu Jianlin, Wang Zhiping. Artificial Intelligence Technology in Foundry production [J].China Mechanical Engineering, 2002 (12):4.
- [3] Liu Dongmei, Sun Runchao, Wang Yunxia, Zhang Jin, Zhang Chunyan, Current Situation and Prospect of Casting Profssional Talent training in China [J]. Casting, 4/V68,2019
- [4] Guojun macro: artificial intelligence to assist people, replace people, become "people". Finance [citation 2023-04-13]