Development of Automatic Flame Cutting Equipment for Medium and Large Castings

Mengliang Lu*, Tianying Ji, Kai Lu, Zhilong Chen
Intelligent Manufacturing Division, CRRC Qishuyan Institute Co.,Ltd., 258 Wuyi Road, Wujin District, Jiangsu Province, China
*Corresponding address: e-mail: 011500003384@crrcgc.cc

Abstract: For the pouring and riser cutting process of cast steel, cast iron, and carbon steel parts, CRRC Qishuyan Institute Co.,Ltd. has independently developed an intelligent flame cutting process equipment for castings to promote the greenization, intelligent, and digitalization of customers' casting post-processing procedures. The equipment uses two industrial six-axis robots integrated with two sets of flame cutting devices, integrating key technologies such as laser vision recognition, intelligent control technology, electrical proportional control technology, Dual robot coordination technology, flame recognition and sensing technology, and advanced casting cutting technology. The equipment can autonomously identify the position of the pouring and riser and correct the cutting path,automatically correct the pressure and flow of oxygen, gas or propane. The workpiece is fixed on a dual-position fixture such as a rotary table, and the loading and cutting can be performed simultaneously. It can automatically and adaptively complete the cutting of various sizes, materials, and types of castings pouring and risers. The cutting surface has a smooth and flat surface quality, and it has now formed a demonstration application.

Keywords: dual robot coordination technology; intelligent flame cutting

1 Introduction

The bolster and side frame are crucial components of the railway truck bogie, with a workpiece length of approximately 2,500 mm. The general dimensional tolerance is ±3mm, and the maximum cutting thickness of the pouring gate is around 120mm. These parts are cast using B+ grade steel (ZG25MnCrNi), making it challenging to cut.

Currently, manual hand-held torches are commonly used in the cleaning process for cutting the bolster and side frame, but this approach does not enhance casting quality. The automation level in post-processing remains low, resulting in a heavy workload during cutting operations while demanding high operator skills and quality standards. Moreover, working conditions involve high temperatures, dust, noise, arc pollution, safety risks as well as occupational disease hazards. Therefore, addressing post-processing challenges through automation and intelligent technology represents a key area for future research.

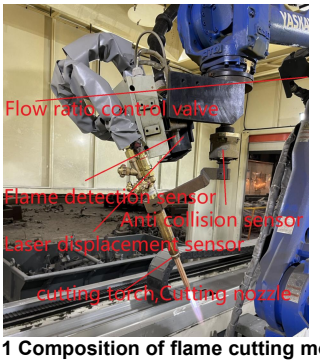

Figure 1 Composition of flame cutting module.

The system utilizes 2 Motoman GP35L robots for coordinated operations (multiple robots can be selected for large workpieces), and is equipped with an equal pressure cutting torch, laser displacement sensor, anti-collision sensor, flow proportional control valve, automatic ignition mechanism, flame monitoring sensor, sheet metal protection room, running mechanism, waste recycling box, etc. The workpiece is secured on the reverse positioner.

The flame cutting task involves a form of target coordination, requiring significant spatial and temporal synchronization between the two robotic arms despite the absence of physical interaction.

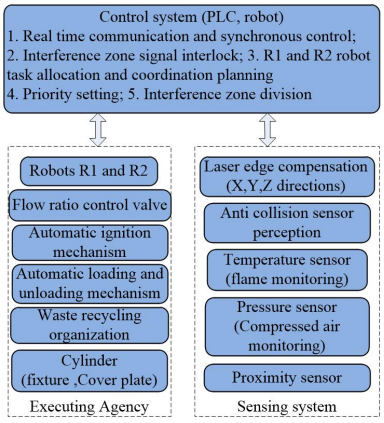

Figure 2 Composition of control module

The robot uses a laser displacement sensor to correct the cutting path. The sensor searches the cutting position in *X*, *Y* and *Z* directions, compares it with the reference position, and automatically corrects the cutting path according to the position deviation.

Table 1. Automatic cutting equipment technical parameters

Type	Configurations
Cutting gas pressure	Efficient natural gas(or propane) ≥0.08 MPa,Oxygen pressure≥0.8 MPa；
Ignition mode	Automatic ignition
Support cutting material	Cast iron, cast steel, carbon steel
Maximum cutting thickness	300 mm
Robot workspace	2,538 mm
Residual height after cutting	Edge cutting：≤3 mm, Non-edge cutting: ≤5 mm
Cutting speed	160-230 mm/min
Gas control system	Automatic proportional control
Flame detection	The temperature sensor monitors the flame in real time
Collision detection	Anti-collision sensor

2 Experimental procedure

Test preparation: Pipeline natural gas (CH4 accounted for 94%) and oxygen with 99% purity were selected as the test gas. The test object was the spout of the bolster side frame, equipped with Jierui isobaric cutting gun and 307-6 cutting nozzle; Gas and oxygen are controlled proportionally through the flow control valve, and the pressure and flow data are monitored during the test.

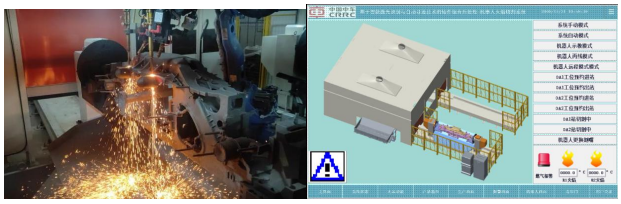

Figure 3 Automatic cutting test platform.

3 Result and discussion

The robot system performs automatic adaptive flame cutting in turn, without manual participation, the root of each pouring gate is cut completely, there is no adhesion after cutting, and the riser can fall automatically. The cutting surface was compared by sample blocks, about 50-500 μm, there was a little hanging slag after cutting, the cutting surface quality was good, the residual height was less than 3 mm, and the consistency was good after cutting.

Figure 4 surface quality of automatic cutting

4 Conclusion

The development of automatic flame cutting equipment for medium and large castings solves the problems such as low degree of automation, poor consistency of manual cutting quality and high labor intensity within the industry for a long time, and provides a solution for speeding up the intelligent upgrading of the cutting process of the head. The cutting surface quality, cutting residual height and cutting precision are better than manual cutting.

References

[1] Li Y J. Cutting technology and application [M]. Beijing: Beijing Industry Press, 2004.
[2] Patricia M E, Maria C P. Analysis and influence of acetylene and propane gas during gas cutting of 1045 carbon steel [J]. Materials Engineering and Perfor - Mance, 2006, 15: 684-692.