Magnetic Contactor with Cadmium-Free Contacts

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Mitsubishi Electric Co. has developed magnetic contactors with cadmium-free electric contacts in the smallest case in the industry. To develop such magnetic contactors, taking the 50-A model as an example, the arc runner that decreases the arc discharge has been improved and its performance enhanced by more than 20% compared with the conventional type. In addition, Mitsubishi Electric has developed an original mechanism to exhaust the hot gas generated from the arc discharge, improving the cooling capacity by seven times. The improvements and new mechanism have made it possible to realize cadmium-free electric contacts and reduce the case size of the 50-A model by 40% compared with the conventional model. This development received the 2017 Environment Excellence Prize (sponsored by the National Institute for Environmental Studies in Japan and Nikkan Kogyo Shimbun, Ltd. and supported by the Japanese Ministry of the Environment).

1. Introduction

Magnetic contactors are industrial switches that can open and close (turn on and off) electric circuits remotely based on the behavior of the electromagnets. They are mainly used to automatically control motors for elevators and factory equipment. Recently, they have been broadly used for power conditioners for photovoltaic power generation and storage batteries for household use. Magnetic contactors must be able to interrupt an overcurrent under abnormal conditions to protect the equipment, in addition to current switching under normal conditions, and so require high reliability. They also need to be small to enable installation in a small space.

When a magnetic contactor interrupts (turns off) the current in a circuit, an arc discharge occurs between the electric contacts, which are key parts. To interrupt this current, the discharged arc needs to be eliminated. Silver cadmium oxide has been widely used as the material of electric contacts due to its good performance in eliminating the arc and thus realizing highly reliable magnetic contactors. Recently, however, demand has risen for cadmium-free magnetic contactors in view of environmental protection and the potential effect on humans. For example, the RoHS Directive regulates the use of cadmium even for industrial control equipment. Cadmium for electric contacts is not presently regulated, but its use should be avoided in the future.

To satisfy both the need for reducing environmental risks and for downsizing, Mitsubishi Electric has developed cadmium-free electric contacts and smaller magnetic contactors.

This paper introduces some current interruption technologies that we developed to eliminate the use of cadmium and to downsize the contactors.

2. Current Interruption Technologies to Make Contacts Cadmium-Free and to Downsize Contactors

When the electric contacts in a conventional magnetic contactor were replaced with a cadmium-free material, the performance in terms of suppressing the arc discharge generated between the electric contacts was insufficient and so the case size needed to be increased to ensure safety. This was a major disadvantage given the demand for smaller magnetic contactors. To solve this problem, Mitsubishi Electric developed technologies to efficiently control the arc discharge and realized magnetic contactors with cadmium-free electric contacts in the smallest sized case in the industry. This paper describes the technology developed for the 50-A model.

To quickly eliminate an arc discharged between electric contacts, an arc runner made of magnetic material (iron) is used. Figure 1 shows an arc runner around a contact. The current from the arc discharge magnetizes the arc runner, which attracts and extends the arc. This extension increases the arc voltage. In

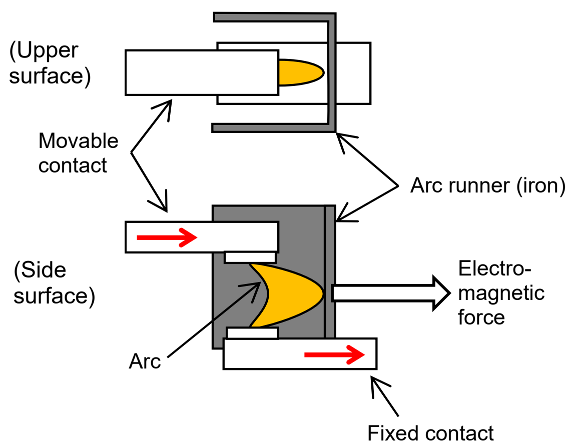

Fig. 1 Schematic diagram of arc attraction by arc runner

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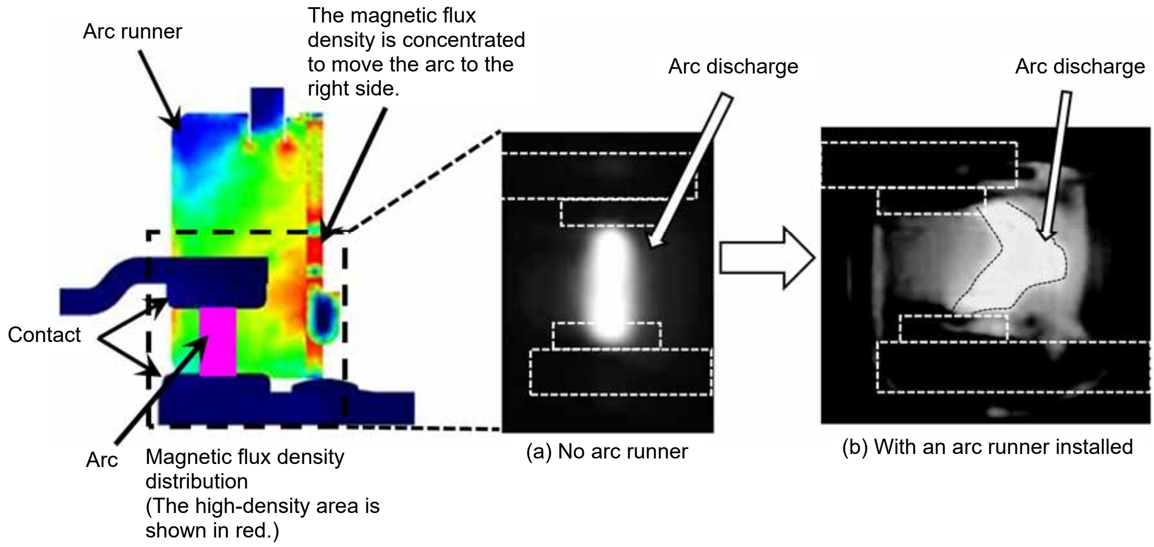

Fig. 2 Analytical results of the magnetic flux density distribution of an arc runner and photographs of arc behavior by a high-speed camera

addition, the extended arc is cooled more easily, which also has the effect of increasing the arc voltage. Further, the arc reaching the arc runner is discharged again to the contact, whereby the cathode-fall voltage is generated in the vicinity of the arc runner. These factors increase the arc voltage, which makes it easier to interrupt the current.

We optimized through electromagnetic field analysis to reduce the leakage of magnetic flux. As a result, the magnetic flux efficiently passes the arc runner, increasing the magnetic flux density in the arc runner. This mechanism has increased the electromagnetic force (Lorentz force) that attracts the discharged arc to the arc runner by 20% or more compared with the conventional model. Figure 2 shows the magnetic flux density distribution in the arc runner along with photographs of the arc behavior taken by a high-speed camera. Two photographs are provided to show the effect of an arc runner: one shows the behavior when there is no arc runner and the other shows that when an arc runner in the optimized shape has been installed.

The temperature of an arc discharge is high, and the interruption performance deteriorates in the high-temperature environment. In addition, the generated hot gas damages the electric contact and resin case. To prevent these problems, the case needs to be made larger or instead, large vents need to be provided to exhaust the hot gas. However, larger vents allow dust to get in, which causes additional problems. Therefore, through thermal fluid analysis, we studied a structure that prevents dust from getting in and efficiently exhausts hot gas, and developed a new exhaust structure. This structure has improved the arc discharge cooling capacity to seven times that of the conventional model (Fig. 3 and Fig. 4).

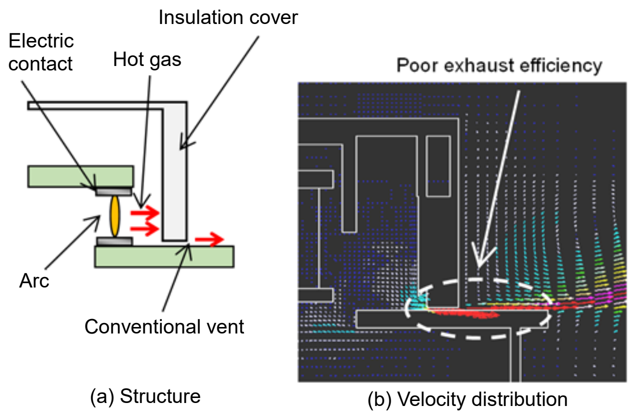

Fig. 3 Analytical results of the conventional exhaust structure and velocity distribution

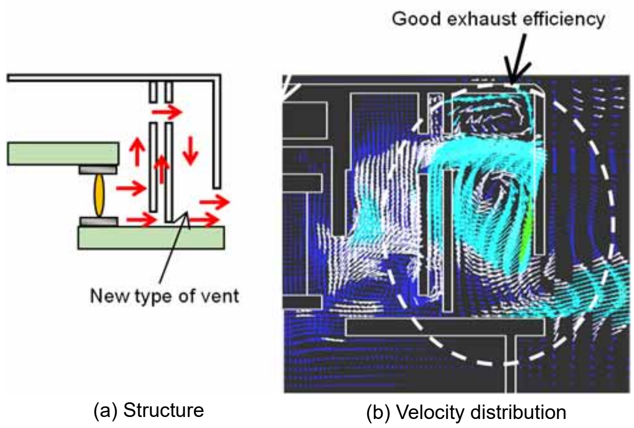

Fig. 4 Analytical results of the developed exhaust structure and velocity distribution

Thus, the width of the new model was reduced by 13 mm and the volume was reduced by 40% compared to the conventional model. Figure 5 compares the size of the conventional S-N50 and the newly developed S-T50.

This development received the 2017 Environment

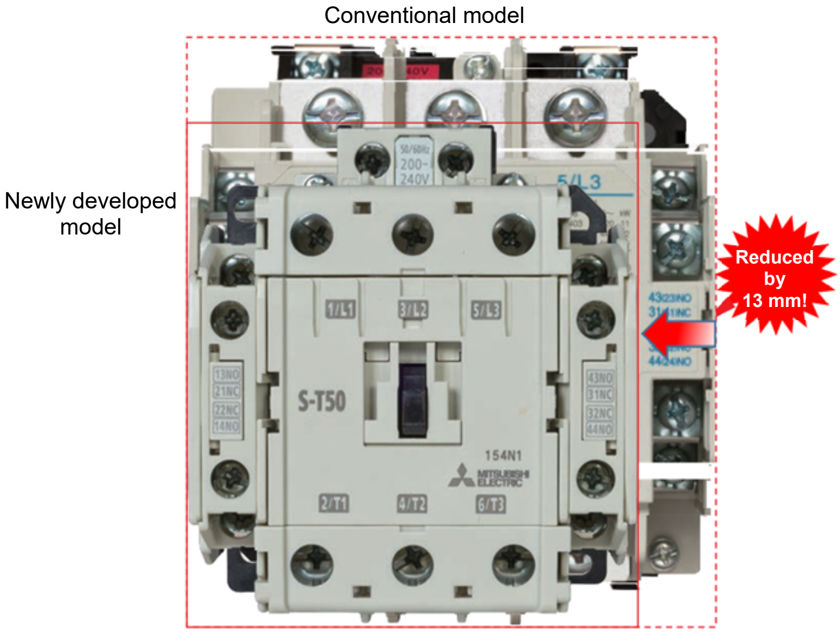

Fig. 5 Comparison of size of conventional product and developed product (50-A model)

Excellence Prize (sponsored by the National Institute for Environmental Studies in Japan and Nikkan Kogyo Shimbun, Ltd. and supported by the Japanese Ministry of the Environment).

3. Conclusion

Magnetic contactors are widely used for automatic control in industry and for power conditioners. Mitsubishi Electric has developed magnetic contactors with cadmium-free electric contacts in the smallest sized case in the industry. We will expand the application of cadmium-free magnetic contactors to various fields to reduce environmental risks.