Breaking with tradition

Staff Report

ABB's new generation of vacuum circuit-breakers has now firmly established itself and is proving very popular with a variety of ABB customers. The new breakers feature innovations that clearly separate them from traditional models. But what is it exactly about them that breaks with tradition? This article explains.

A new generation of vacuum circuit-breakers, launched by ABB, is breaking with tradition. Activated by a magnet instead of the traditional spring, it has less than half as many parts as conventional models. Because they are standardized across the company's other lines of breakers, inventories are more economical and back-orders are less likely. Maintenance is virtually unnecessary and malfunctions are rare.

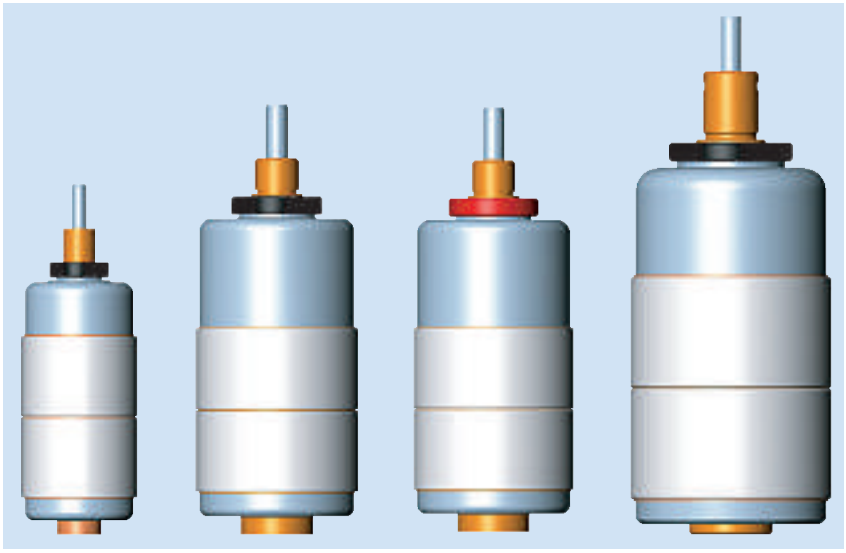
There are simply fewer parts to go wrong.

Milan Milanov, ABB segment director responsible for medium-voltage equipment in Bulgaria, has sold 500 vacuum circuit-breakers in the 12-kilovolt and 24-kilovolt ranges to thermal power and distribution plants in Bulgaria, including 200 of the new magnetically activated breakers. So he has had good opportunity to compare the relative merits. "The new breaker will switch 30,000 times before maintenance is needed. This is a huge improvement over the 10,000 switching operations with the earlier generation motor drive breaker. Also the new breaker has a signal on the box warning you of any problems, but you don't need very many inspections at all."

The new vacuum circuit-breaker is also expected to provide an economical solution in chemical and steel industries, car plants, airports, railways, shipbuilding and building industries.

Yet it is only the latest in a series of engineering breakthroughs that have refined the vacuum circuit-breaker over time and made it a product of choice for medium voltage.

The effectiveness of a vacuum in breaking a current was recognized as early as 1920, when the engineering world was shaken by fires in distribution



VG family of interrupters for embedded poles. Characteristic features are the two short ceramic parts and the long stainless steel cover on the movable contact side, which hides the bellows.

and switchgear installations. But despite a concerted trend away from the use of oil in breakers – and the development of breakers using air pressure, magnets, and gas – the vacuum alternative was virtually ignored for almost thirty years. Quite simply, it took decades to perfect a container that could reliably seal the vacuum for 20 years, the life expectancy of a breaker.

ABB Calor Emag Mittelspannung GmbH has been developing and manufacturing vacuum interrupters since the early 1980s. Its goal was to improve on spring-activated vacuum circuit-breakers with a more reliable technology. Since it was also producing the popular SF_6 gas circuit-breaker, it aimed to cut the cost of its product by standardizing parts across the two lines.

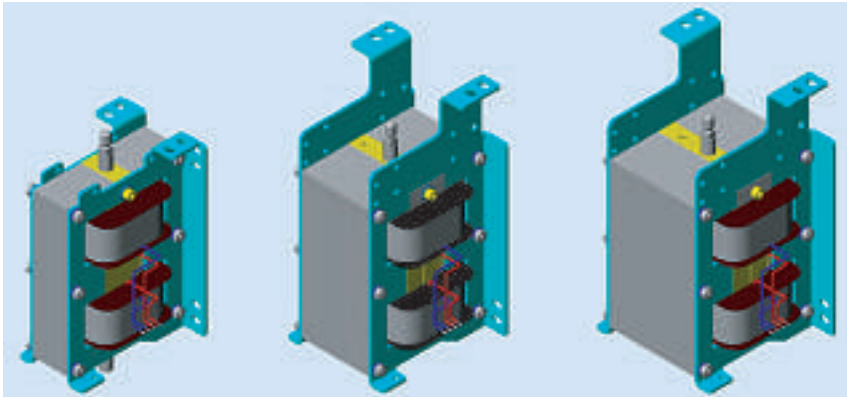
"The magnet technology used in this breaker has emerged from a sounder understanding of power electronics and the development of new magnetic materials over a 20-year period," says Dr. Markus Heimbach, ABB global product manager in Germany. "With the new magnetic materials, the holding force inside the actuator could be increased. You could call it a revolution."

As in conventional breakers, power flows as long as the current is within an acceptable range, but a surge that is more powerful than the approved setting will trip the breaker and pull apart the contacts through which the current was passing. The current is then interrupted.

In a vacuum breaker, the rupture of the last metallic bridge between the contacts causes a metal vapor arc to form. This arc, which consists of the vaporizing contact material, moves over the contact surface at 70 to 150 meters per second, until the current is spent. It is a sine wave that, within milliseconds, passes through zero, at which point the arc is extinguished and the vacuum interrupter can be reset to work again.

The special interrupter contact design causes the current to create a magnetic field which sweeps the arc across the contact in a way that ensures more of the surface is covered. This prevents overheating and uneven wear. A further

Actuators used in the new magnetic vacuum circuit-breaker
From left to right: A1 (20 kA), A2 (25 kA) and A3 (31.5 kA)



contact design feature guarantees better efficiency at the highest currents: the magnetic field works in another way to diffuse the arc and speed up its dissipation, thereby minimizing contact wear.

The attraction of magnets

Magnetic forces do more than diffuse the arc, they also operate the contacts. Any circuit-breaker – gas or vacuum – must move contacts from closed to open or from open to closed, as the situation requires. The part that moves the contacts is called an actuator, and, for years, a mechanical spring did the job.

But new developments in power electronics have led to a magnetic actuator which moves the contacts through a specially designed combination of electromagnets and permanent magnets.

The contacts in state-of-the-art gas and vacuum breakers are held in place – open or closed – by the force of the permanent magnet, without the need for any external energy. An internal spring provides just enough tension to align the contacts perfectly when the breaker is closed. To open, contacts can be separated by changing the direction of the magnetic field, which is done by energizing the electromagnets, the control elements of the actuator. The force has to be adjusted for breakers of different types and with different ratings. This is done by varying the actuator's basic components – the number of iron laminations that make up the permanent magnetic material.

Embedding the vacuum interrupter in a substance that can be easily shaped, like epoxy resin, means the same interrupter can be used for all ranges and the creepage path can be extended. Exposure to dust and moisture is also reduced.

A spring-operated actuator has 159 different parts. Its new magnetic counterpart requires only 66. The big attraction of the new actuator lies in its higher reliability, which is due to its simple and robust design.

A drastic reduction in the number of parts leaves fewer to stock-pile and lessens the chance of malfunction. Maintenance is reduced to a bare minimum.

Spark of genius

Engineers at our research and development headquarters use state-of-the-art tools and powerful computer software to optimize design and function. The most recent fruits of those labors include an innovative process for in-house production of contacts as well as a new family of vacuum interrupters for contactors and switches.

They speak with excitement of ongoing efforts to refine the magnetic vacuum breaker for use with high currents. And of their modular family of actuators and interrupters, with fewer parts than any other on the market, and yet serving the complete range of short circuit and dielectric ratings.

They say only minor design modifications are needed to use the same technologies in special-purpose breakers for synchronous or high-speed switching.

The engineers' "top priority" at this time, says ABB physicist Edgar Dullni, is developing a magnetic actuator for a 50-kA current vacuum circuit-breaker. The top rating for magnetic vacuum circuit-breakers today is 40 kA. Higher currents have been available with springs.

Heimbach, who is responsible for bringing the latest ABB vacuum breakers to market, said the 50-kA magnetic vacuum circuit-breaker should be on sale very soon.

And a "new generation" of 63-kA vacuum breakers, for up to 4000 amps,

VMI magnetic vacuum circuit-breaker

should follow a few months later. That version will be spring-operated at first.

"It is really a niche product," to expand the range of products available to ABB customers, Heimbach said.

Less is more

ABB's focus on standardizing parts across product lines has probably come about because it produces the two most popular breakers in the world – not just vacuum breakers for medium voltages, but also SF_6 gas breakers for medium to high voltages.

The sheer quantity of production, coupled with ABB's equal investment in both major markets, made standardization of parts a natural priority.

The new actuator with permanent magnets can be used to operate vacuum as well as gas breakers. Both make use of proximity sensors to indicate the breaker position. The user faces an easier choice. While many factors may influence which type of breaker is selected, structural factors are no longer a major factor in the decision.

Vacuum breakers are also standardized across various types and ratings. Vacuum interrupters, considered the heart of the breaker, are embedded in an epoxy resin, a method that allows the same interrupter to handle different voltage ratings simply by selecting the relevant rated short-circuit current. The cast resin provides further insulation.

Thanks to the embedding technique, any additional mounting elements are unnecessary, the current-carrying parts being secured by the surrounding cast resin. In this way, the number of interrupter parts is reduced considerably.

And the ABB line of electronic control devices can be adapted, with integrated intelligence, for use in diagnosing problems in the power system. Actuators can be adapted to higher voltages simply by replacing the plunger and coils.

These developments in ABB technology have produced a smaller magnetic vacuum breaker with fewer parts, fully sealed and protected from moisture and dust for easier maintenance and longer product life. The shape of the new interrupters has also been changed gy the latest improvements, with features like shorter ceramic parts and a smaller diameter.

And that should add up to attractive benefits for the ABB customer.

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