# MAGNETIC TECHNOLOGY SPURS QUANTUM LEAPS IN CIRCUIT BREAKER PERFORMANCE

By Bob Fesmire

For decades, medium voltage circuit breakers have used stored energy spring mechanisms to operate moving contacts for the purpose of electrical power interruption. While the electrical interruption technology has significantly improved over the years (from minimum oil to air magnetic to SF6 gas to vacuum), the circuit breaker operating mechanisms have remained largely unchanged. Now, with the introduction of magnetically actuated mechanisms, medium voltage breakers are making a quantum leap forward in both reliability and lifespan.

## 'SPRING' TIME

Stored energy spring mechanisms come with a host of limitations. First, they employ many moving parts, which must be maintained — and eventually replaced — over the life of the product. Also, in arc-quenching media, these parts require a high amount of stored force for proper switching, particularly during fault conditions, and that means even more wear. Precise manufacturing tolerances and frequent maintenance are required to meet even modest reliability goals, making spring mechanisms more costly over the lifetime of the breaker.

The advent of vacuum interrupters greatly improved the interrupter process. They shortened the distance contacts must travel (as much as 15 mm less), and they drastically reduced the energy and velocity with which parts are required to move (75% less vs. minimum oil type breakers). In addition, lower-mass parts could be used, further reducing the amount of wear within the actuator mechanism. Even with these advances, though, the same spring mechanism design was still being used.

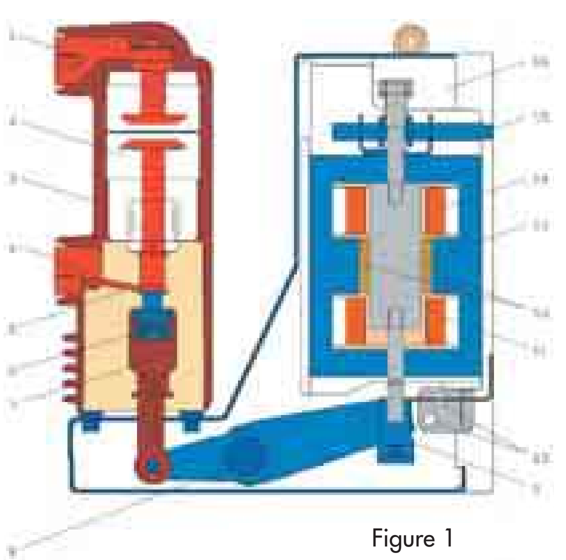

Figure 1

## A BETTER MOUSETRAP

The rotating camshaft represented the first major breakthrough in actuator technology. With 60% fewer moving parts, the new design optimized contact travel and greatly reduced wear. It was also easier on the vacuum bottle and surrounding components. This represented a significant improvement on traditional stored energy spring devices, and set a new standard for circuit breaker performance. But the pressure for further advances continued. Longer service life, lower operating costs — these twin objectives, pushed ever higher by the demands of power system economics, drove the search for an alternative to spring mechanisms.

Magnetically actuated circuit breakers offer the first major advance in mechanism technology in over 50 years. With its simplicity of design and drastically reduced number of moving parts, this new technology offers virtually limitless

**Continued on page 30**

| ANSI Requirement | Industry Standard* | Magnetically Actuated Capability |
|---|---|---|
| No-load mechanical endurance | 10,000 no-load operations | 100,000 no-load operations |
| Operations between servicing | 2,000 no-load operations | Limited only by environmental conditions |
| Continuous current switching | 1,000 load operations | 30,000 load operations |

* These are ANSI/IEEE endurance requirements for breakers rated at 15 kV or less, 31.5 kA or less symmetrical interruption, and 2000 A or less continuous current. Endurance requirements for higher voltage, interruption, and continuous current ratings are considerably lower.

**Continued from page 29**

mechanical endurance with almost no maintenance over the life of the device.

Figure 1 shows a side view of the magnetically actuated vacuum circuit breaker. A single actuator drives a common jackshaft (8), which couples the actuator energy to the moving contacts of the vacuum interrupters (2) on all three poles through insulating pushrods (7). The actuator consists of a bistable magnet system, in which switching of the armature (13) to the relative positions is effected by the magnetic field of two electrically excited coils (11 and 14).

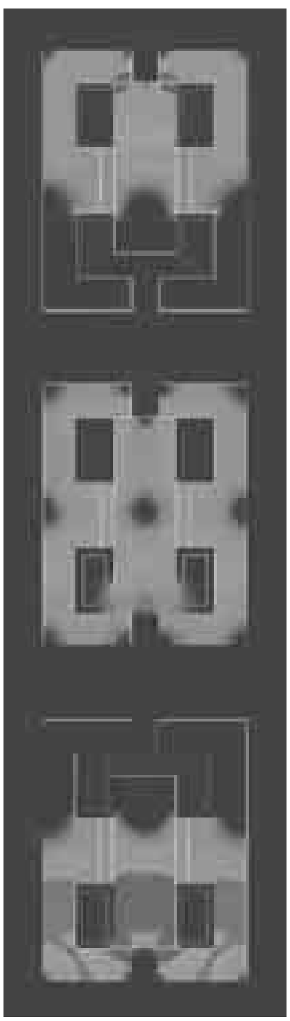

Figure 2

The jackshaft is basically the only mechanically stressed part. Two permanent magnets (12) hold the magnetic armature in one of the two limit positions corresponding to OPEN and CLOSED. Neither mechanical latching nor a constant electrical current supply is required. Figure 2 illustrates the functional principle of the actuator.

Other features of a magnetically actuated circuit breaker significantly reduce auxiliary power requirements and shorten charge time after operation. A single electronic unit controls all input/output functions for the circuit breaker, and requires only a fraction of the auxiliary power used in conventional circuit breakers.

The electrical energy needed for energizing each of the two coils and operation of the breaker is stored in two electrolytic capacitors, which together draw less than 1.5 A at 120 V.

The stored energy of the capacitors is capable of performing the standard Open-Close-Open duty cycle, and the capacitors are charged and ready for operation in less than 2 seconds after a duty cycle operation. The energy stored allows emergency operation up to 200 seconds following a loss of control voltage.

The breaker can also be opened manually, utilizing a special manual operation tool (15 of Figure 1). In order to increase the reliability and operational abilities of the magnetically actuated circuit breaker, inductive proximity sensors (10 of Figure 1) are used to detect the OPEN and CLOSED limit positions, thus eliminating the need for standard auxiliary switches.

The universal electronic control: uses any voltage 24-264 volts AC or 24-280 volts DC; is tested for operational integrity for the extended life of the circuit breaker; and consumes only 8 W of steady state power. The electronic unit controls the electrical impulse directly to the operating coils, greatly reducing power loading on the control circuit. Circuit breaker operation can also be electronically defeated during racking operations, in addition to standard mechanically defeated racking interlocks, further enhancing operator safety.

## MORE BENEFITS OF MAGNETICALLY ACTUATED DEVICES

The following table demonstrates the virtually limitless mechanical capabilities of magnetically actuated technology. The magnetic actuator, pole and position sensors are all completely maintenance free over the breaker's 100,000-operation lifetime.

Magnetic technology has elevated circuit breaker performance to new heights, but further advances are sure to appear. Today, epoxy molds are being used for all current carrying parts and vacuum interrupters. The encapsulation of components eliminates the need for phase barriers; allows for reduction of pole center distances; protects the vacuum interrupters from mechanical damage and outside agents like dirt, moisture or animals; and equalizes temperatures across all current carrying parts, making higher continuous currents possible with less conductive materials. Like magnetic technology, improvements in materials and design will continue to be driven by the need to increase product life and reduce operating costs. ET

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