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# Research of a New DC Breaker Based on the Electromagnetic Forming Technology for Battery Power Supply of Long Pulsed Magnet

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## I. Introduction

The new DC breaker switch consists of pulsed magnet (EMF coil), aluminum tube (the main contact of DC breaker) and its supporters. It uses pulsed magnetic field to apply repulsion produced by induced eddy current to expand the aluminum tube, which can be broken at the weaknesses of V-shaped slots in a very short time. Both simulation and primary experimental results show that the design of the new DC breaker with compact volume and easy maintenance is feasible. In addition to the pulsed high magnetic field facility, the breaker can also be applied to other potential industrial fields.

## II. Working Principle and the Structure of DC Breaker

### A. DC Breaker System Structure

The system structure of DC breaker is shown in Fig. 1. It consists of Upper electrode, Lower electrode, spring assembly, EMF coil, isolation explosion bucket, aluminum tube and its supporters.

### B. Working Principle

As the main circuit is in serious fault, the charged capacitor will be discharged into the EMF coil, and a pulsed magnetic field is rapidly built around the coil, as shown in Fig. 2. According to Lenz's law, the inner surface of aluminum tube will produce an induced eddy current. The aluminum tube will be subjected to the radial Lorentz force under the interaction of pulse magnetic field and the eddy current. When the radial Lorentz force exceeds the yield stress of the aluminum, the aluminum tube is easy to be broken at the weaknesses of the V-shaped slots under the help of supporters so that the DC breaker is switched off and the main circuit is disconnected.

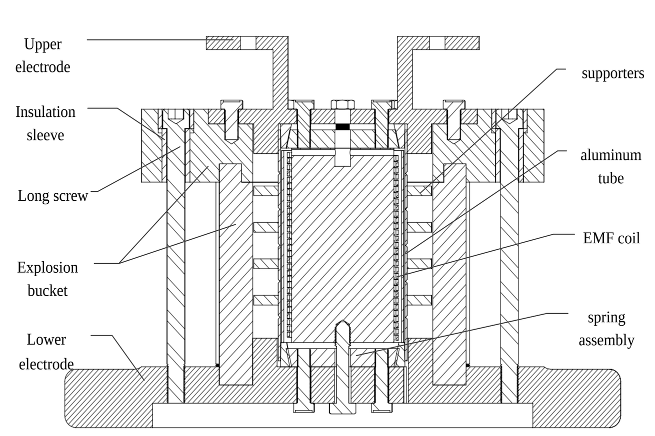


Fig. 1 The structure of DC breaker

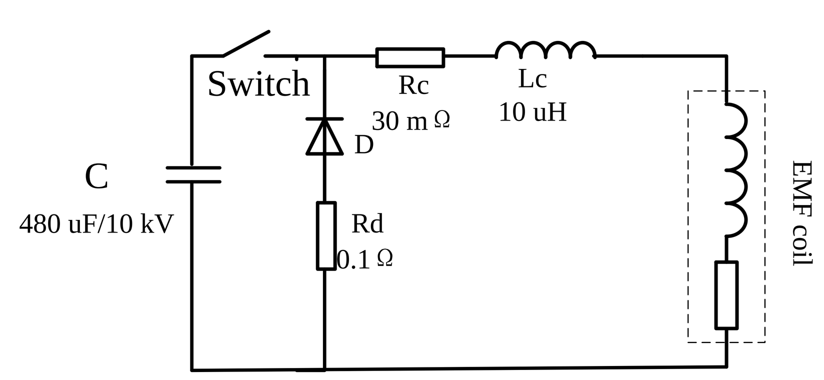


Fig.2 The principle circuit of DC breaker

TABLE I
Parameters of EMF coil and aluminum tube

| Name | Item | Parameter |
|---|---|---|
| EMF coil | Height | 132 mm |
| | Out Diameter | 103 mm |
| | Turns | 32*2 |
| Aluminum Tube | Height | 188 mm |
| | Inner Diameter | 113 mm |
| | Thickness | 2.0 mm |

## III. Simulation and Analysis of Electromagnetic and Stress

Comsol Multiphysics is used to simulate the DC breaker by sequential coupling method. The initial magnetic field forces are calculated, and the results are used as the input load to calculate the deformation and fracture of the aluminum tube. According to the deformation, the magnetic field model is updated. Finally, the transient magnetic field forces are calculated again based on the updated geometry of tube until the simulation ends.

*The aluminum alloy is chosen as the material of tube for machining, and after all machining is finished, the aluminum alloy tube is annealed to soften so that it is easy to be broken.*

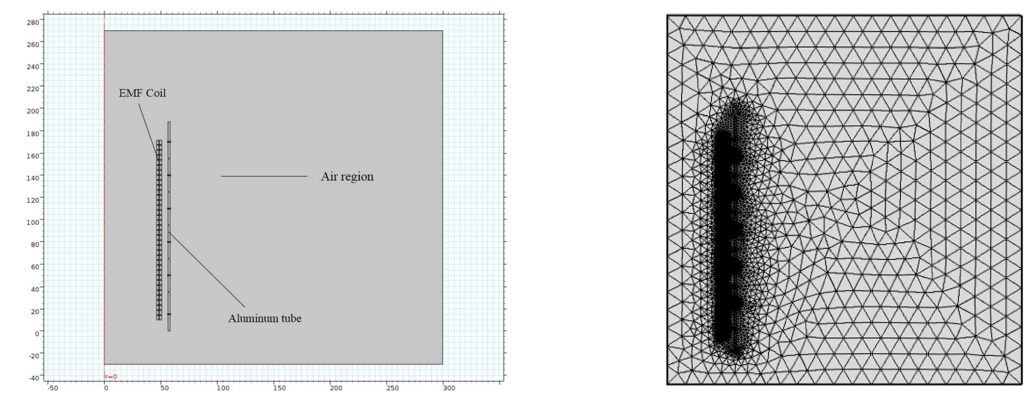


Fig. 3 The Model and dynamic mesh

TABLE II
Circuit Parameters of EMF coil

| Item | Parameter | Item | Parameter |
|---|---|---|---|
| Capacitor | 480 μF/10 kV | Coil material | Copper |
| Coil inductance | 189 μH | Coil resistivity | 1.67e-8 Ωm |
| Line inductance | 10 μH | Line resistor | 0.03 Ω |

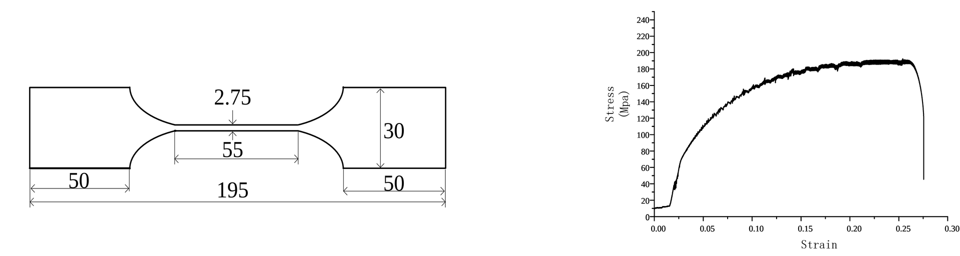


Fig. 4 Stress-Strain of the annealed aluminum alloy sample

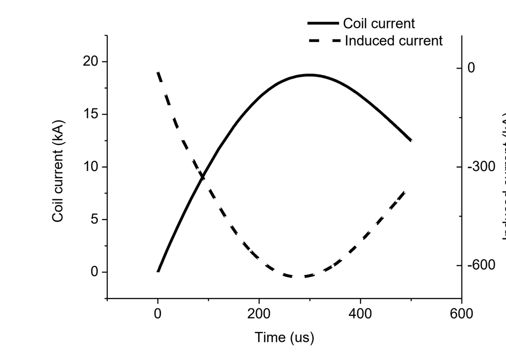


Fig. 5 Currents of EMF coil and induced in tube

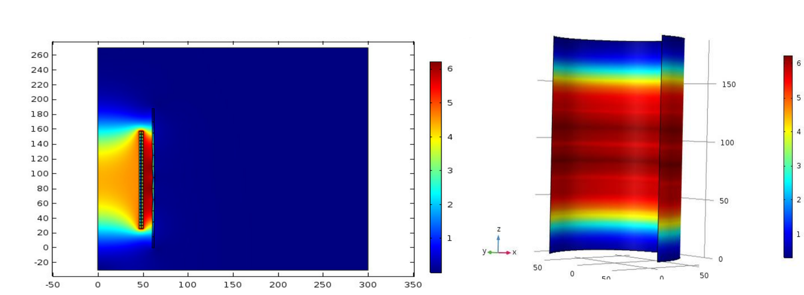

Fig. 6 Magnetic field distribution

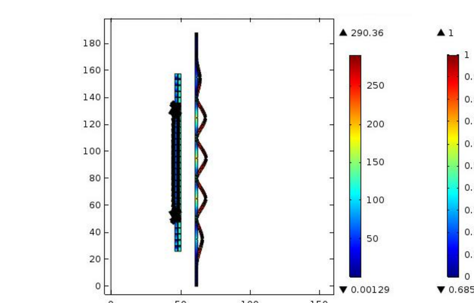

Fig. 7 Deformation of tube

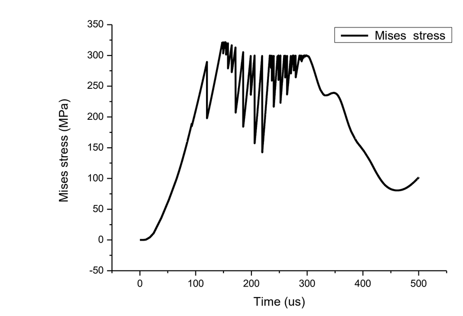


Fig. 8 Stress in the middle of tube

## IV. Experiment and Results

The structure diagram of the new DC breaker is designed by Solidworks software as shown in Fig. 9. The experiment results are shown in Fig. 10 11.

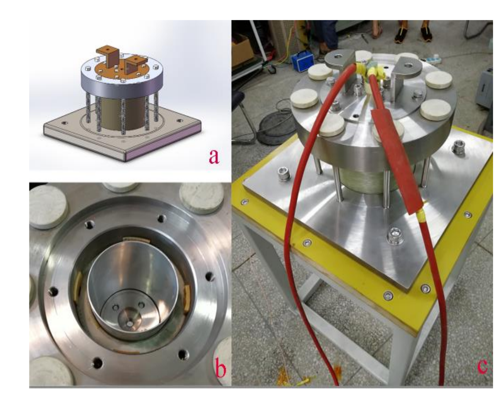

Fig. 9 The prototype of the EMF DC breaker

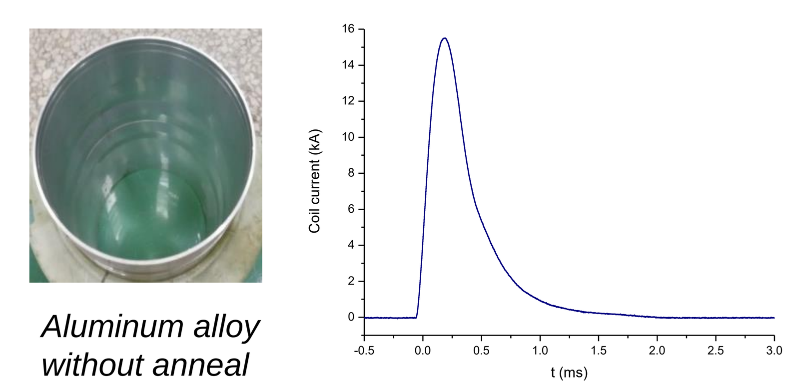


Fig. 10 Deformation of tube and Current Waveform of coil

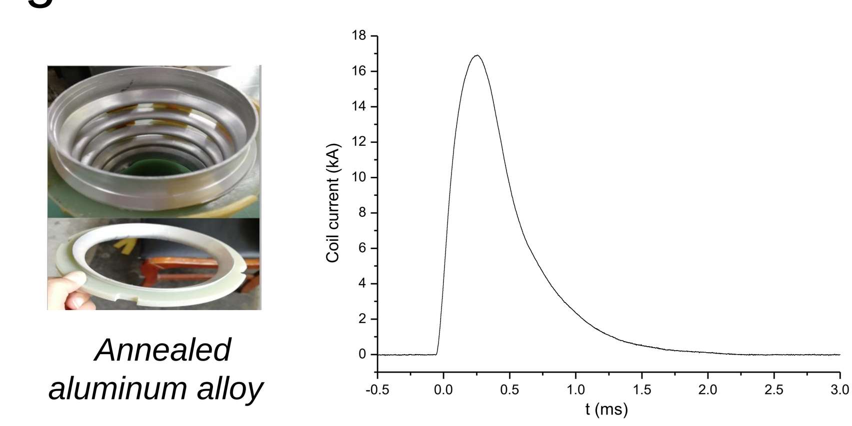


Fig. 11 Deformation of tube and Current Waveform of coil

## V. Conclusion

The experiment results show that the design is feasible. The new switch has a great deal of advantages such as simple structure, easy to maintain, small volume and compact power supply and control systems(no need of high current (>60 kA) vacuum Tube).

The switch will be improved and connected to the DC current to study the arc extinguishing performance.