

# Influence of Voltage and Current on Arc Duration and Energy of DC Electromagnetic Contactor

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**Abstract**-- In this paper, experimental results were described for a general DC electromagnetic contactor switching under a permanent magnet for arc extinguishing. The experiment circuit was a series circuit of source voltage  $E$ , resistive load  $R$  and DC electromagnetic contactor. The closed contact current  $I_o$  was adjusted by  $R$ . The influence of  $E$  and  $I_o$  on arc duration  $t_a$  and arc energy  $E_a$  of break arc were experimented. The  $E$  had been changed within range of 50 -- 500V DC and  $I_o$  was set from 5 to 30A at each voltage  $E$ . Arc voltage and current waveforms were measured with a digital oscilloscope.

When  $E$  was high, arc duration  $t_a$  became long. However, in 300V or more,  $t_a$  shortens when  $I_o$  is increased. In 200V, influence of  $I_o$  on  $t_a$  was not seen and arc duration became almost constant. In 50V,  $t_a$  became long along with  $I_o$ , it is clarified that permanent magnets doesn't influence for arc. However, shortening of the arc duration with permanent magnet was seen in 100V or more. We think that effect of Lorentz's force on the arc was different according to  $E$  and  $I_o$ . In addition, when  $E$  and  $I_o$  are high, it was found that arc energy  $E_a$  became large.

**Keywords** -- DC electromagnetic contactor, arc discharge, arc duration, magnetic blast, arc energy, permanent magnet

## I. INTRODUCTION

Electromagnetic contactors are widely used as a switch of a motor circuit and other applications. Many reports have been published for AC applications [1]-[3].

Recently, solar photovoltaic power system and hybrid vehicle have been getting popular. Therefore, it is important to make and break high voltage DC circuit. So, DC power circuits of high voltage and large current will be more and more used in commercial and industrial power systems. More than 20 years ago the DC switchgear for low voltage applications was predicted to be more important from the above viewpoint [4], but the voltage becomes higher in the present applications [5].

The authors have been examining the electrode mass change under various normalized contact loads with DC resistive circuit [6]. Further, influence of source voltage to the arc duration, contact resistance, and electrode mass change is examined. As a result, the consumption of the stationary contact of the cathode has increased in proportion to total arc

energy [7]. Consequently the relation between cathode loss per unit arc energy and contact loads have been made clear.

In this paper, experimental results are reported for a general DC electromagnetic contactor switching under a permanent magnet for arc extinguishing. The source voltage  $E$  had been changed within range of 50 -- 500V DC and closed contact current  $I_o$  is set from 5 to 30A at each voltage  $E$ . Arc voltage and current waveforms were measured and arc duration time  $t_a$ , arc energy  $E_a$  were obtained. We found that effect of Lorentz's force on the arc is different according to  $E$  and  $I_o$ .

## II. EXPERIMENTAL PROCEDURE

### A. Experimental apparatus

A test apparatus in this experiment was shown in Figure 1. "K" means tested contacts. This system consists of test apparatus and measuring devices such as power supply, controller, digital multi-meter and digital oscilloscope. It enables us to investigate the contact resistance, the arc duration, the arc voltage and the arc current. Figure 2 shows the structure of a tested contactor. This structure is called plunger type, widely used in the electromagnetic contactors. The advantage of this structure is the double break design, which increases the breaking capacity. Table 1 shows experimental conditions.

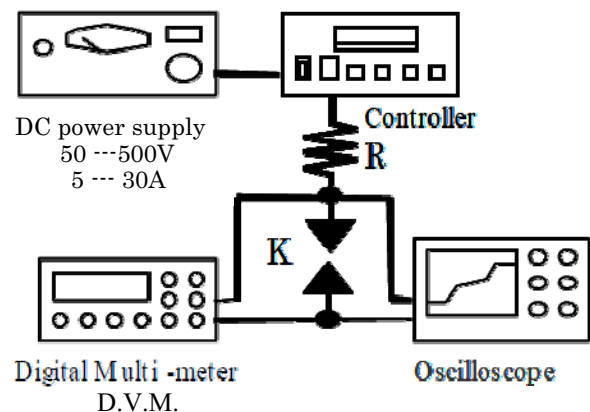


Fig.1 Experimental apparatus.