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Operation and Type of Fuses- Review

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Abstract

This paper deals with the concept and functioning of the different types of fuses with a main focus on the protection of power system from or current occurs due to short circuit or over-load conditions. The electrical fuses are commonly used protective apparatus which finds wide applications in domestic as well as in industrial sector. Fuses are compact in size and have high operating time as compare to circuit breaker. The operation of fuses is reliable and economical in low voltage to medium voltage application.

Keywords: Electrical fuse, Electrical protection, Electrical faults, Over-load, Short circuit, Over-currents

Introduction

There are many protective devices to protect the power system against over-current. Fuse is one of them. A fuse is basically a over-current safety device. A fuse is a protective device joined in series with the circuits and operates when a short circuit or overload current flows through it by melting themselves.

Fuses are the cheapest form of protective device as compared to circuit breaker against over-current. The first fuse model invented in 1890 by Thomas Edision. Many advanced feature are incorporated in fuse model from the formation of first fuse model. In present days, different types of fuse are available in the market at reasonable prices and used for low to medium voltage application where frequent operation is not needed and use of circuit breaker become uneconomical.

Fuses are simple in construction and economical and being used over hundred years as a protective device. The operation of fuse is based on the heating effect of the electrical current. Fuses are rated for a particular current level as well as a particular voltage level. The operating time of a fuse is less as compare to the operating time of a circuit breaker. The operating time of a fuse is inversely proportional to the over current i.e. if value of over current is high, fuse operating time is less.

Fuses are commonly used in homes to protect theappliances like television, computers, radios and other devices from over load or short circuits etc. If we do not use fuse at home, then any electrical fault can cause damaged of the home appliances and can also set a fire at home.

Under normal condition of operation, the fuse material temperature remains below its melting point which it melt. Hence it carries current without over heating. Whenever a overload or short circuit conditions occurs in the circuit excessive over-current flows through the fuse element. Hence fuse element blows out and disconnect the circuit. In such way, a fuse protects the machine and home appliances from damaged due to over-current.

The operating time versus over current characteristics of a fuse is shown below-

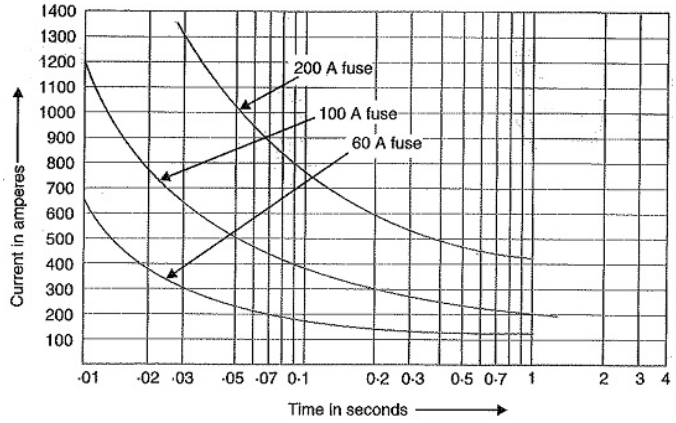

Fig 1: Operating Time Vs. Overcurrent Characteristics

Fuse Element Material

The material used in fuse element has low melting point as compared to material of line conductor. The fuse element wire is joined in series with the circuit to be protected.

The common fuse materials are tin, lead, zinc, copper and silver etc. Tin or an alloy of tin and lead (lead 37%, tin 63%) is employed as a fuse material for small current up to 10A. Copper or silver is employed as a fuse material for large current. In present trend, silver becomes a perfect choice for fuse element despite its high cost because of the following reasons:

- Silver is free from oxidation as compared to other fuse element.
- It does not easily deteriorate in the presence of dry air.
- No critical fatigue occurs because coefficient of expansion of silver is small.
- Silver is vaporizes at low temperature. Due to this reason, excessive current flow in the circuit is quickly Interrupted.

Types of Fuses

Fuses Are Sub-Divided In Two Categories I.E. Low Voltage Fuses And High Voltage Fuses.

Low Voltage Fuses

1. Semi-enclosed Rewireable Fuse

Rewireable fuses are used in place where low values of fault currents is required to be interrupted and commonly known as kit kat fuse.It has two parts basically (i) a base and (ii) a fuse carrier. The base is made of porcelain and fuse carrier consist of fuse element made of tin, lead, copper. When a fault occurs in the circuit, the excessive or over-current flows in the circuit and fuse element is blown out and supply is interrupted. The cost of replacement of fuse element is negligible.

The semi-enclosed rewireable fuse has low current interrupting capacity and are available up to 500A current. Therefore they find limited applications and used in domestic purpose only. Due to this reason, this type of fuse cannot be used in circuit of high fault level. Also the chances of deterioration of fuse element is high. Therefore precise determination of length of fuse wire element is not possible because current flowing through the fuse element is much depend upon the fuse wire length.

2. D-Types Cartridge fuse

This type of fuse cannot be interchanged. The main components of this fuse are fuse base, adapter ring, cartridge and a fuse cap. The cartridge is a movable part and moved over the fuse cap. The circuit becomes complete when tip of the fuse is touch to the fuse element. The main advantage of this fuse is that operation of the fuse is reliable.

3. High-Rupturing Capacity (H.R.C) Cartridge Fuse

HRC cartridge fuse is an extension of semi-enclosed rewirable fuse. It consist of a fuse element usually made of silver or copper. The fuse element is welded to fuse link contact made up of ceramic. The space between the fuse element and the cartridge body of the fuse is filled with chalk, marble dust or quartz. This filling material acts as an arc quenching medium and absorbs the heat when excessive current flows in the circuit. After this quartz is converted into lead and act as a barrier for the re-striking voltage.

The main advantage of this fuse is that they are adequate to interrupt low as well as high value of fault current and speed of operation of fault current and speed of operation of fault clearing is high.

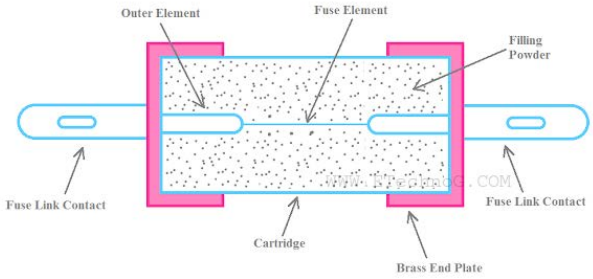

Fig 2: HRC Cartridge Fuse

HRC Fuse with Tripping Device

It consists of a tripping device to operate the circuit breaker. It consist of a plunger, chemical charge, tungsten shunt and silver fuse element. When a fault occurs, silver fuse element is blown out and entire current is transferred to the tungsten wire. Due to this weak link is blown and chemical charge exploide and plunger experience a force which in turn operates the circuit breaker. In this way fault is cleared.

A. High Voltage Fuses

Low voltage fuses have low current rating and low breaking capacity. Therefore low voltage fuses are not applicable in high voltage circuits.

1. Cartridge Type HV HRC Fuse

This is similar to the low voltage HRC fuse except some construction features. In this type of fuse, the fuse element is wound in the form of helix to avoid corona effect. On some designs to fuse elements are used which are connected in parallel to each other. One fuse element is made of silver wire having low resistance and other is of high resistance made of tungsten wire. Under normal operating conditions, the silver wire carries normal load current. When a fault occurs in

the system, the silver wire is blown out and tungsten wire reduces the short circuit current because of its high resistance and finally opens the circuit.

High voltage HRC Fuse are available with breaking capacity of 8700A. Rating of the HV HRC fuse is of the order of 200A at 6.6KV and 11KV and 50A at 33KV.

2. Liquid Type HV HRC Fuse

The liquid type HV HRC fuse is frequently used in the high voltage circuit having a current rating higher than 400A. It is normally used for the protection of transformer.

This fuse consist of a glass tube filled with the carbon tetra-chloride. The fuse element is kept inside the glass tube. The fuse wire is welded at one end of the tube and the other end of fuse wire is kept constant with the help of phosphorous bronze wire. When a fault occurs in the system, the over current flows through the fuse element. Therefore fuse element is blown out. A small quantity of gas is generated. The arc produced is quenched by the liquid used in the fuse. The short circuit capacity of the circuit breaker increase with the help HV HRC fuses.

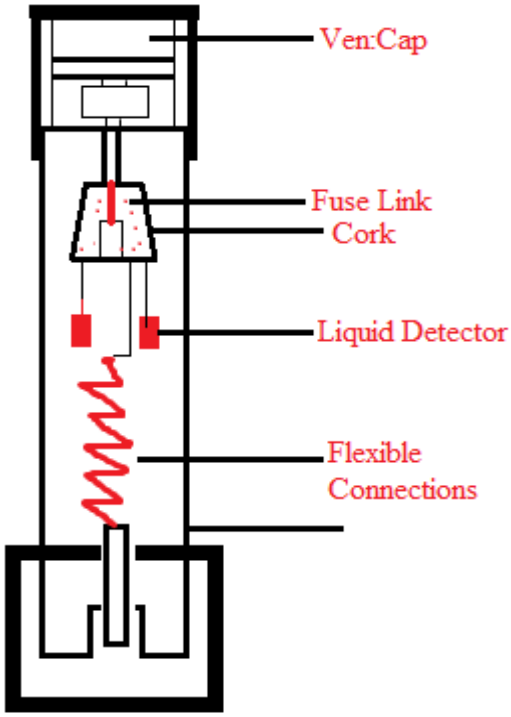

Fig 3: liquid type HV HRC Fuse

3. Resettable Fuses

Resettable fuses are also known as self resetting fuses. The primary advantages of this fuse is that replacement of fuse element is not required after a short circuit fault. The fuse element is basically a thermocouple conductive type thermistor also known as polymeric positive temperature coefficient (PPTC) thermistor. The resistance of the fuse element is increases when there is any fault in the circuit because of temperature coefficient of fuse element.

This increase value of fault of current will limit the fault current in the circuit. After clearance of fault, temperature of element is drop and circuit work under normal condition. Resettable or resetting fused are widely used in aerospace applications or military application where fuse replacement is difficult.

4. Thermal Fuses

Thermal fuses are also known as thermal links or thermal cutouts (TCO). Thermal fuses uses a one time fusible link i.e. after each operations replacement of fuse element is become necessary. Thermal fuses are basically temperature sensitive fuses. Fuse element is made up of a temperature sensitive alloy.

When any fault occurs in the system, the temperature around the fuse element increases due to over-current. The fuse element alloy melt and spring mechanism operates.

Table 1: Difference Between Fuse And Circuit Breaker

FUSE	CIRCUIT BREAKER
FUNCTION: It performs detection and interruption.	FUNCTION: It performs interruption only.
OPERATION: Automatic	OPERATION: It requires a relay for action.
BREAKING CAPACITY: Breaking capacity is small.	BREAKING CAPACITY: Breaking capacity is very large.
OPERATING TIME: Its operating time is very small around 0.002 sec. or so.	OPERATING TIME: Its operating time is comparatively large around 0.02 sec.
REPLACEMENT: Replacement after each operation.	REPLACEMENT: No replacement after each operation.

Advantages

1. It is the cheapest form of protection as compared to circuit breaker.
2. No maintenance is required.
3. Its operation is completely automatic unlike a circuit breaker.
4. It is most suitable protective device for over-current protection.
5. Size of fuse is small and compact.
6. Operating time is less as compared to circuit breaker.
7. Noise and smoke problem does not occurs in the fuse.

Disadvantages

1. The fuse element is replaced after each operation. Due to this considerable time is lost.
2. It can be applicable on low voltage and medium voltage circuit.
3. The current time characteristics of a fuse is not always be correlated with that of the protective device.

Applications

The fuse are the important part of electrical and electronics system. Some applications in which fuses are used are given below:

- They are used in home distribution boards to protects the home appliances like television, computers etc.
- They are used in all automobiles such as car, bus, trucks, and other electrical vehicle.
- They are also used in laptops, printers, cell phones, hard disk drive.
- They are used in capacitive transformers, motor starter, power transformer.
- They are used in gaming consoles, power adaptors and air conditioners.

Conclusion

A fuse is basically a over-current protective device which is designed to open when excessive over-current are present in the circuit. Fuses are cheapest form of protective device among all the protective device. Fuses are most popular and best available device to give protection against short circuit current. We have studied about different type of fuse. Every fuse has a certain application. Kit Kat fuse are widely used in home. Blade type fuses are used in automobile. Resettable fuses are used in application where replacement of fuse element is difficult like in military and aerospace applications. Thermal fuse are used in hair dryer, water heater etc. Surface mount fuses are used in cell phones, hard disk driver, camera etc.

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