UNIT II-FUSE AND CIRCUIT BREAKER

SWITCHGEAR:

The apparatus used for switching, controlling and protecting the electrical circuits and equipment is known as **switchgear**.

ESSENTIAL FEATURES OF SWITCHGEAR:

The essential features of switchgear are:

(i) Complete reliability. With the continued trend of interconnection and the increasing capacity of generating stations, the need for reliable switchgear has become of paramount importance. When fault occurs on any part of the power system, the switchgear must operate to isolate the faulty section from the remainder circuit.

(ii) Absolutely certain discrimination. When fault occurs on any section of the power system, the switchgear must be able to discriminate between the faulty section and the healthy section. It should isolate the faulty section from the system without affecting the healthy section. This will ensure continuity of supply.

(iii) Quick operation. When fault occurs on any part of the power system, the switchgear must operate quickly so that no damage is done to generators, transformers and other equipment by the short-circuit currents. If fault is not cleared by switchgear quickly, it is likely to spread into healthy parts, thus endangering complete shutdown of the system.

(iv) Provision for manual control. Switchgear must have provision for manual control. In case the electrical (or electronics) control fails, the necessary operation can be carried out through manual control.

(v) Provision for instruments. There must be provision for instruments which may be required. These may be in the form of ammeter or voltmeter on the unit itself or the necessary current and voltage transformers for connecting to the main switchboard or a separate instrument panel.

SWITCHGEAR EQUIPMENTS:

The main components of switchgear are

- Circuit breakers
- Isolator or disconnecting switch
- Fuses
- Switches
- Relays
- Bus-bars
- Instruments Transformers.

SWITCHGEAR ACCOMMODATION

It is necessary to house the switchgear in power stations and sub-stations in such a way so as to safeguard personnel during operation and maintenance and to ensure that the effects of fault on any section of the gear are confined to a limited region. Depending upon the voltage to be handled, switchgear may be broadly classified into

(i) Outdoor type

(ii) Indoor type.

(i) Outdoor type. For voltages beyond 66 kV, switchgear equipment is installed outdoor. It is because for such voltages, the clearances between conductors and the space required for switches, circuit breakers, transformers and others equipment become so great that it is not economical to install all such equipment indoor.

(ii) **Indoor type.** For voltages below 66 kV, switchgear is generally installed indoor because of economic considerations. The indoor switchgear is generally of metal-clad type. In this type of construction, all live parts are completely enclosed in an earthed metal casing. The primary object of this practice is the definite localisation and restriction of any fault to its place of origin.

FUSES:

A **fuse** is a short piece of metal, inserted in the circuit, which melts when excessive current flows through it and thus breaks the circuit.

DESIRABLE CHARACTERISTICS OF FUSE ELEMENT:

The function of a fuse is to carry the normal current without overheating but when the current exceeds its normal value; it rapidly heats up to melting point and disconnects the circuit protected by it. In order that it may perform this function satisfactorily, the fuse element should have the following desirable characteristics:

(*i*) Low melting point *e.g.,* tin, lead.

(*ii*) High conductivity *e.g*., silver, copper.

(*iii*) Free from deterioration due to oxidation *e.g*., silver.

(*iv*) Low cost *e.g*., lead, tin, copper.

FUSE ELEMENT MATERIALS

The most commonly used materials for fuse element are lead, tin, copper, zinc and silver. For small currents upto 10 A, tin or an alloy of lead and tin (lead 37%, tin 63%) is used for making the fuse element. For larger currents, copper or silver is employed. It is a usual practice to tin the copper to protect it from oxidation. Zinc (in strip form only) is good if a fuse with considerable time-lag is required *i.e.*, one which does not melt very quickly with a small overload.

IMPORTANT TERMS:

The following terms are much used in the analysis of fuses:

(*i*) Current rating of fuse element. It is the current which the fuse element can normally carry without overheating or melting. It depends upon the temperature rise of the contacts of the fuse holder, fuse material and the surroundings of the fuse.

(*ii*) Fusing current: It is the minimum current at which the fuse element melts and thus disconnects the circuit protected by it. Obviously, its value will be more than the current rating of the fuse element.

(*iii*)Fusing factor: It is the ratio of minimum fusing current to the current rating of the fuse element *i.e.*

$$\text{Fusing factor} = \frac{Minimum\ fusing\ current}{\text{current rating of the fuse}}$$

(*iv*) Prospective Current:

It is the R.M.S. value of the first loop of the fault current obtained if the fuse is replaced by an ordinary conductor of negligible resistance.

(*v*) Cut-off current: It is the maximum value of fault current actually reached before the fuse melts.

(*vi*) Pre-arcing time: It is the time between the commencement of fault and the instant when cut off occurs.

(*vii*) Arcing time: This is the time between the end of pre-arcing time and the instant when the arc is extinguished.

(*viii*) Breaking capacity: It is the R.M.S. value of a.c. component of maximum prospective current that a fuse can deal with at rated service voltage.

(*ix*) Total operating time: It is the sum of pre-arcing and arcing times.

TYPES OF FUSES:

In general, fuses may be classified into:

- ***(i)*** Low voltages fuses
- ***(ii)*** High voltage fuses

Low voltage fuses can be subdivided into two classes *viz*.,

(*i*) semi-enclosed rewireable fuse (*ii*) high rupturing capacity (H.R.C.) cartridge fuse.

Some of the high voltage fuses are:

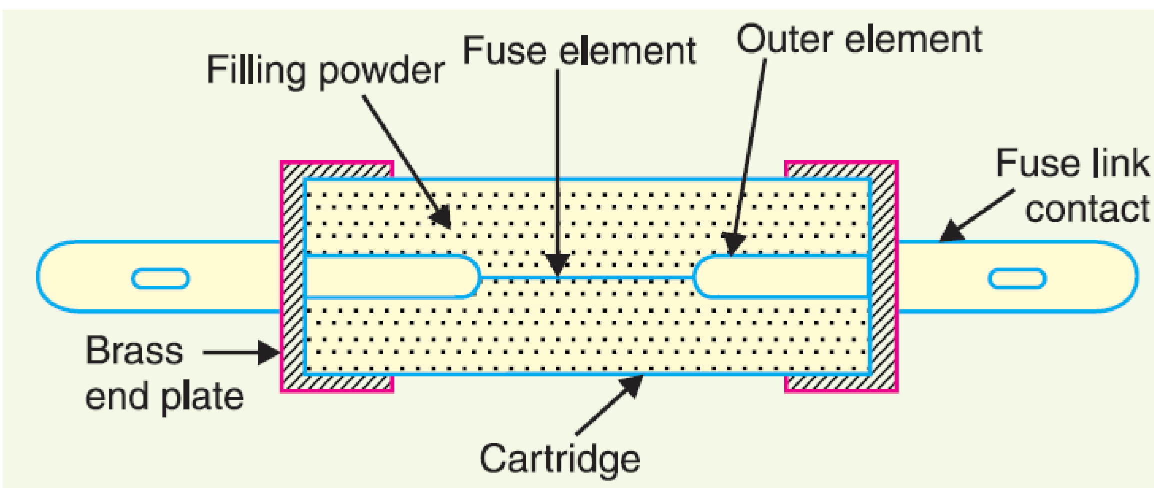
(*i*) Cartridge type. (*ii*) Liquid type (*iii*) Metal clad fuses.

High-Rupturing capacity (H.R.C.) cartridge fuse.

The primary objection of low and uncertain breaking capacity of semi-enclosed rewireable fuses is overcome in H.R.C. cartridge fuse.

Fig. shows the essential parts of a typical H.R.C. cartridge fuse. It consists of a heat resisting ceramic body having metal end-caps to which is welded silver current-carrying element. The space within the body surrounding the element is completely packed with a filling powder. The filling material may be chalk, plaster of paris, quartz or marble dust and acts as an arc quenching and cooling medium.

Under normal load conditions, the fuse element is at a temperature below its melting point. Therefore, it carries the normal current without overheating. When a fault occurs, the current increases and the fuse element melt before the fault current reaches its first peak. The heat produced in the process vaporizes the melted silver element. The chemical reaction between the silver vapour and the filling powder results in the formation of a high resistance substance which helps in quenching the arc.



Advantages:

(*i*) They are capable of clearing high as well as low fault currents.

(*ii*) They do not deteriorate with age.

(*iii*) They have high speed of operation.

(*iv*) They provide reliable discrimination.

(*v*) They require no maintenance.

(*vi*) They are cheaper than other circuit interrupting devices of equal breaking capacity.

(*vii*) They permit consistent performance.

Disadvantages:

(*i*) They have to be replaced after each operation.

(*ii*) Heat produced by the arc may affect the associated switches.

CIRCUIT BREAKERS:

A circuit breaker is a piece of equipment which can

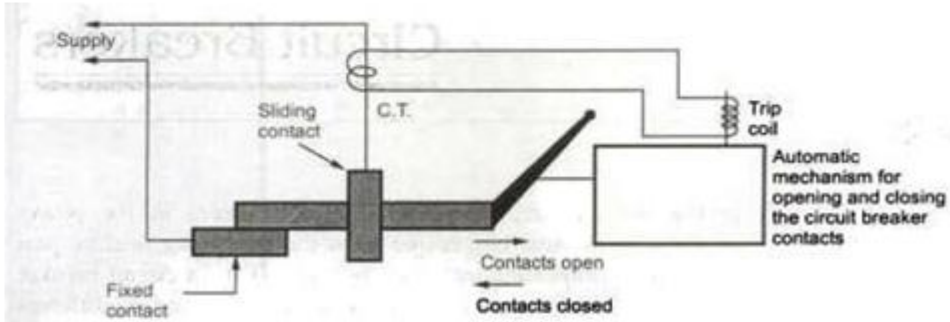
(*i*) Make or break a circuit either manually or by remote control under normal conditions

(*ii*) Break a circuit *automatically* under fault conditions

(*iii*) Make a circuit either manually or by remote control under fault conditions

Thus a circuit breaker incorporates manual (or remote control) as well as automatic control for switching functions.

WORKING OF CIRCUIT BREAKER:



Basic action of circuit breaker

Under normal working conditions the e.m.f. produced in the secondary winding of the transformer is insufficient to energize the trip coil completely for its operation. Thus the contacts remain in closed position carrying the normal working current. The contacts can be opened manually also by the handle.

Under abnormal or faulty conditions high current in the primary winding of the current transformer induces sufficiently high e.m.f. in the secondary winding so that the trip coil is energized. This will start opening motion of the contacts. This action will not be instantaneous as there is always a time lag between the energization of the trip circuit and the actual opening of the contacts. The contacts are moved towards right away from fixed contact.

As we have seen already the separation of contacts will not lead to breaking or interruption of circuit as an arc is struck between the contacts. The production of arc delays the current interruption and in addition to this it produces large amount of heat which may damage the system or the breaker. Thus it becomes necessary to extinguish the arc as early as possible in minimum time, so that heat produced will lie within the allowable limit. This will also ensure that the mechanical stresses produced on the parts of circuit breaker are less.

The time interval which is passed in between the energization of the trip coil to the instant of contact separation is called the **opening time**. It is dependent on fault current level.

The time interval from the contact separation to the extinction of arc is called arcing time. It depends not only on fault current but also on availability of voltage for maintenance of arc and mechanism used for extinction of arc.

A circuit breaker essentially consists of fixed and moving contacts, called electrodes. Under normal operating conditions, these contacts remain closed and will not open automatically until and unless the system becomes faulty. Of course, the contacts can be opened manually or by remote control whenever desired. When a fault occurs on any part of the system, the trip coils of the circuit breaker get energised and the moving contacts are pulled apart by some mechanism, thus opening the circuit.

When the contacts of a circuit breaker are separated under fault conditions, an arc is struck between them. The current is thus able to continue until the discharge ceases. The production of arc not only delays the current interruption process but it also generates enormous heat which may cause damage to the system or to the circuit breaker itself. Therefore, the main problem in a circuit breaker is to extinguish the arc within the shortest possible time so that heat generated by it may not reach a dangerous value.

ARC PHENOMENON:

When a short-circuit occurs, a heavy current flows through the contacts of the circuit breaker before they are opened by the protective system. At the instant when the contacts begin to separate, the contact area decreases rapidly and large fault current causes increased current density and hence rise in temperature. The heat produced in the medium between contacts (usually the medium is oil or air) is sufficient to ionise the air or vapourise and ionise the oil. The ionised air or vapour acts as conductor and an arc is struck between the contacts. The p.d. between the contacts is quite small and is just sufficient to maintain the arc. The arc provides a low resistance path and consequently the current in the circuit remains uninterrupted so long as the arc persists.

METHODS OF ARC EXTINCTION:

There are two methods of extinguishing the arc in circuit breakers *viz.*

1. High resistance method.

2. Low resistance or current zero method.

1. High resistance method. In this method, arc resistance is made to increase with time so that current is reduced to a value insufficient to maintain the arc. Consequently, the current is interrupted or the arc is extinguished. The principal disadvantage of this method is that enormous energy is dissipated in the arc. Therefore, it is employed only in d.c. circuit breakers and low-capacity a.c. circuit breakers.

2. Low resistance or Current zero method. This method is employed for arc extinction in a.c. circuits only. In this method, arc resistance is kept low until current is zero where the arc extinguishes naturally and is prevented from restriking inspite of the rising voltage across the contacts. All modern high power a.c. circuit breakers employ this method for arc extinction.

In an a.c. system, current drops to zero after every half-cycle. At every current zero, the arc extinguishes for a brief moment. Now the medium between the contacts contains ions and electrons so that it has small dielectric strength and can be easily broken down by the rising contact voltage known as *restriking voltage.* If such a breakdown does occur, the arc will persist for another halfcycle. If immediately after current zero, the dielectric strength of the medium between contacts is built up more rapidly than the voltage across the contacts, the arc fails to restrike and the current will be interrupted.

IMPORTANT TERMS:

The following are the important terms much used in the circuit breaker analysis:

(i) **Arc Voltage.** It is the voltage that appears across the contacts of the circuit breaker during the arcing period.

(ii) **Recovery voltage.** It is the normal frequency (50 Hz) R.M.S. voltage that appears across the contacts of the circuit breaker after final arc extinction. It is approximately equal to the system voltage.

(iii) **Restriking voltage.** It is the transient voltage that appears across the contacts at or near current zero during arcing period.

(iv) **Rate of rise of re-striking voltage** (R.R.R.V)**.** It is the rate of increase of re-striking voltage

CIRCUIT BREAKER RATINGS:

A circuit breaker may be called upon to operate under all conditions. However, major duties are imposed on the circuit breaker when there is a fault on the system in which it is connected. Under fault conditions, a circuit breaker is required to perform the following three duties:

(i) It must be capable of opening the faulty circuit and breaking the fault current.

(ii) It must be capable of being closed on to a fault.

(iii) It must be capable of carrying fault current for a short time while another circuit breaker (in series) is clearing the fault.

Corresponding to the above mentioned duties, the circuit breakers have three ratings viz.

(i) Breaking capacity **(ii)** making capacity and **(iii)** short-time capacity.

(i) Breaking capacity: It is current (R.M.S.) that a circuit breaker is capable of breaking at given recovery voltage and under specified conditions (e.g., power factor, rate of rise of restriking voltage).

(ii) Making capacity: The peak value of current (including d.c. component) during the first cycle of current wave after the closure of circuit breaker is known as **making capacity.**

(iii) Short-time rating. It is the period for which the circuit breaker is able to carry fault current while remaining closed.

CLASSIFICATION OF CIRCUIT BREAKERS:

There are several ways of classifying the circuit breakers. However, the most general way of classification is on the basis of medium used for arc extinction. The medium used for arc extinction is usually oil, air, sulphur hexafluoride (SF6) or vacuum. Accordingly, circuit breakers may be classified into :

(*i*) *Oil circuit breakers* which employ some insulating oil (*e.g.,* transformer oil) for arc extinction.

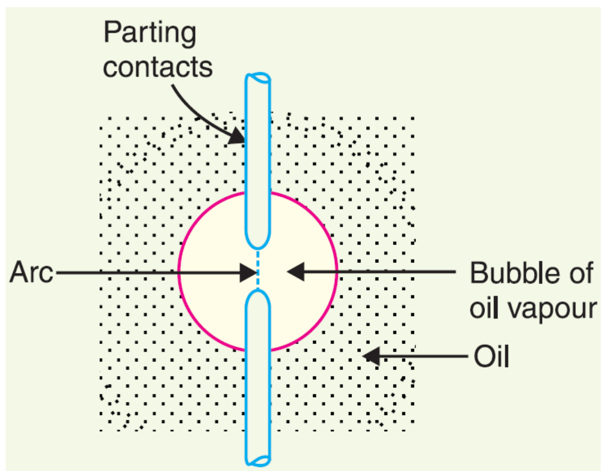
(*ii*) *Air-blast circuit breakers* in which high pressure air-blast is used for extinguishing the arc.

(*iii*) *Sulphur hexafluroide circuit breakers* in which sulphur hexafluoride (SF6) gas is used for arc extinction.

(*iv*) *Vacuum circuit breakers* in which vacuum is used for arc extinction.

OIL CIRCUIT BREAKERS:

In such circuit breakers, some insulating oil (*e.g.,* transformer oil) is used as an arc quenching medium. The contacts are opened under oil and an arc is struck between them. The heat of the arc evaporates the surrounding oil and dissociates it into a substantial volume of gaseous *hydrogen at high pressure. The hydrogen gas occupies a volume about one thousand times that of the oil decomposed. The oil is, therefore, pushed away from the arc and an expanding hydrogen gas bubble surrounds the arc region and adjacent portions of the contacts. The arc extinction is facilitated mainly by two processes. Firstly, the hydrogen gas has high heat conductivity and cools the arc, thus aiding the de-ionisation of the medium between the contacts. Secondly, the gas sets up turbulence in the oil and forces it into the space between contacts, thus eliminating the arcing products from the arc path. The result is that arc is extinguished and circuit current interrupted.



Advantages:

The advantages of oil as an arc quenching medium are:

(*i*) It absorbs the arc energy to decompose the oil into gases which have excellent cooling properties

. **(*ii*)** It acts as an insulator and permits smaller clearance between live conductors and earthed components.

(*iii*) The surrounding oil presents cooling surface in close proximity to the arc.

Disadvantages:

The disadvantages of oil as an arc quenching medium are:

(*i*) It is inflammable and there is a risk of a fire.

(*ii*) It may form an explosive mixture with air

(*iii*) The arcing products (*e.g.,* carbon) remain in the oil and its quality deteriorates with successive operations. This necessitates periodic checking and replacement of oil.

PLAIN BREAK OIL CIRCUIT BREAKERS:

The plain-break oil circuit breaker is the earliest type from which all other circuit breakers have developed. It has a very simple construction. It consists of fixed and moving contacts enclosed in a strong weather-tight earthed tank containing oil upto a certain level and an air cushion above the oil level. The air cushion provides sufficient room to allow for the reception of the arc gases without the generation of unsafe pressure in the dome of the circuit breaker. It also absorbs the mechanical shock of the upward oil movement. Fig shows a double break plain oil circuit breaker. It is called a double break because it provides two breaks in series.

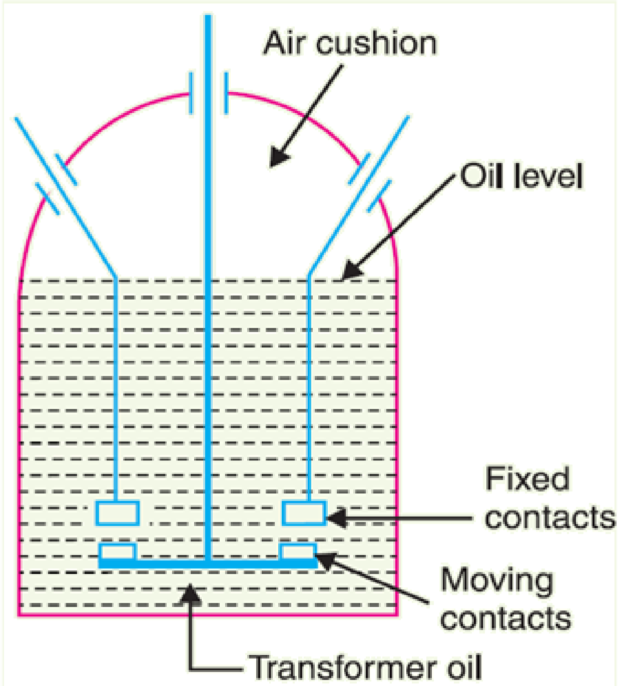
Under normal operating conditions, the fixed and moving contacts remain closed and the breaker carries the normal circuit current. When a fault occurs, the moving contacts are pulled down by the protective system and an arc is struck which vapourises the oil mainly into hydrogen gas. The arc extinction is facilitated by the following processes:

(*i*) The hydrogen gas bubble generated around the arc cools the arc column and aids the deionization of the medium between the contacts.

(*ii*) The gas sets up turbulence in the oil and helps in eliminating the arcing products from the arc path.

(*iii*) As the arc lengthens due to the separating contacts, the dielectric strength of the medium is increased.

The result of these actions is that at some critical gap length, the arc is extinguished and the circuit current is interrupted.



Advantages:

The advantages of oil as an arc quenching medium are:

(*i*) It absorbs the arc energy to decompose the oil into gases which have excellent cooling properties

. **(*ii*)** It acts as an insulator and permits smaller clearance between live conductors and earthed components.

(*iii*) The surrounding oil presents cooling surface in close proximity to the arc.

Disadvantages:

(*i*) There is no special control over the arc other than the increase in length by separating the moving contacts. Therefore, for successful interruption, long arc length is necessary.

(*ii*) These breakers have long and inconsistent arcing times.

(*iii*) These breakers do not permit high speed interruption.

Applications: plain-break oil circuit breakers are used only for low-voltage applications where high breaking-capacities are not important. It is a usual practice to use such breakers for low capacity installations for voltages not exceeding †11 kV.

AIR-BLAST CIRCUIT BREAKERS:

TYPES OF AIR-BLAST CIRCUIT BREAKERS:

Depending upon the direction of air-blast in relation to the arc, air-blast circuit breakers are classified into:

(i) Axial-blast type in which the air-blast is directed along the arc path.

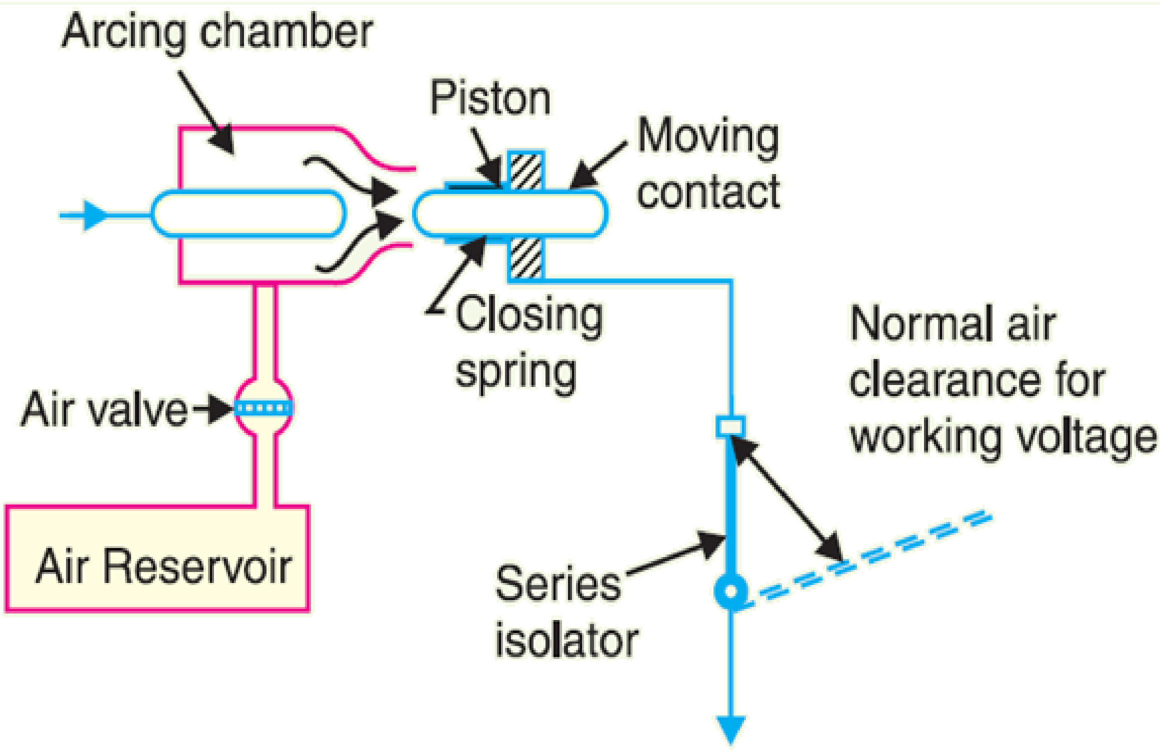
(ii) Cross-blast type in which the air-blast is directed at right angles to the arc path.

(iii) Radial-blast type in which the air-blast is directed radially.

(i) Axial-blast air circuit breaker:

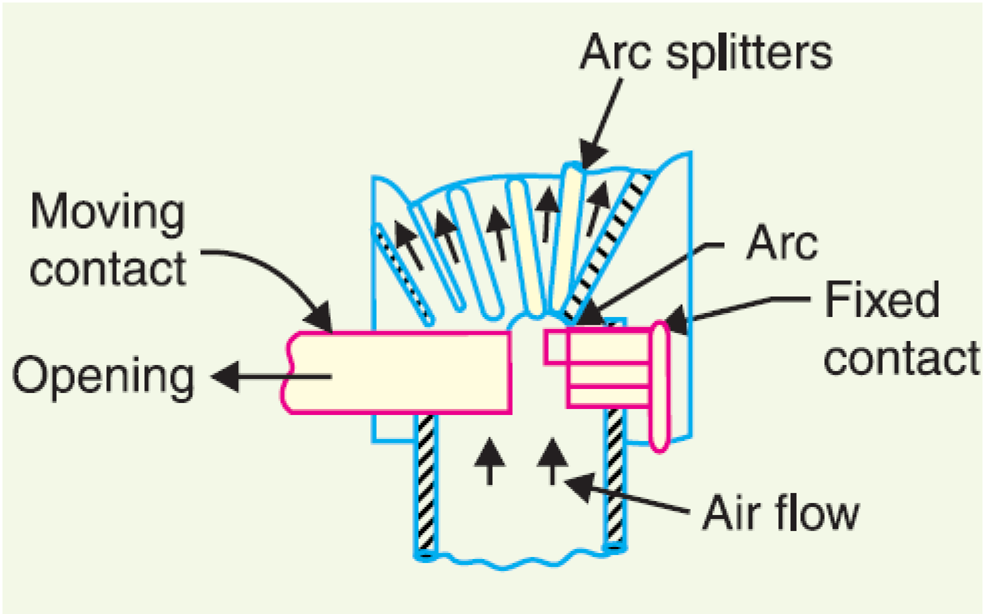
Fig shows the essential components of a typical axial blast air circuit breaker. The fixed and moving contacts are held in the closed position by spring pressure under normal conditions. The air reservoir is connected to the arcing chamber through an air valve. This valve remains closed under normal conditions but opens automatically by the tripping impulse when a fault occurs on the system.

When a fault occurs, the tripping impulse causes opening of the air valve which connects the circuit breaker reservoir to the arcing chamber. The high pressure air entering the arcing chamber pushes away the moving contact against spring pressure. The moving contact is separated and an arc is struck. At the same time, high pressure air blast flows along the arc and takes away the ionized gases along with it. Consequently, the arc is extinguished and current flow is interrupted. It may be noted that in such circuit breakers, the contact separation required for interruption is generally small (1·75 cm or so). Such a small gap may constitute inadequate clearance for the normal service voltage. Therefore, an isolating switch is incorporated as a part of this type of circuit breaker. This switch opens immediately after fault interruption to provide the necessary clearance for insulation.



(*ii*) Cross-blast air breaker.

In this type of circuit breaker, an air-blast is directed at right angles to the arc. The cross-blast lengthens and forces the arc into a suitable chute for arc extinction. Fig. shows the essential parts of a typical cross-blast air circuit breaker. When the moving contact is withdrawn, an arc is struck between the fixed and moving contacts. The high pressure cross-blast forces the arc into a chute consisting of arc splitters and baffles. The splitters serve to increase the length of the arc and baffles give improved cooling. The result is that arc is extinguished and flow of current is interrupted. Since blast pressure is same for all currents, the inefficiency at low currents is eliminated. The final gap for interruption is great enough to give normal insulation clearance so that a series isolating switch is not necessary.



Advantages:

An air-blast circuit breaker has the following advantages over an oil circuit breaker:

(*i*) The risk of fire is eliminated.

(*ii*) The arcing products are completely removed by the blast whereas the oil deteriorates with successive operations; the expense of regular oil replacement is avoided.

(*iii*) The growth of dielectric strength is so rapid that final contact gap needed for arc extinction is very small. This reduces the size of the device.

(*iv*) The arcing time is very small due to the rapid buildup of dielectric strength between contacts. Therefore, the arc energy is only a fraction of that in oil circuit breakers, thus resulting in less burning of contacts.

(*v*) Due to lesser arc energy, air-blast circuit breakers are very suitable for conditions where frequent operation is required.

(*vi*) The energy supplied for arc extinction is obtained from high pressure air and is independent of the current to be interrupted.

Disadvantages:

The use of air as the arc quenching medium offers the following disadvantages:

(*i*) The air has relatively inferior arc extinguishing properties.

(*ii*) The air-blast circuit breakers are very sensitive to the variations in the rate of rise of restriking voltage.

(*iii*) Considerable maintenance is required for the compressor plant which supplies the air-blast.

Applications: The air blast circuit breakers are finding wide applications in high voltage installations. Majority of the circuit breakers for voltages beyond 110 kV are of this type.

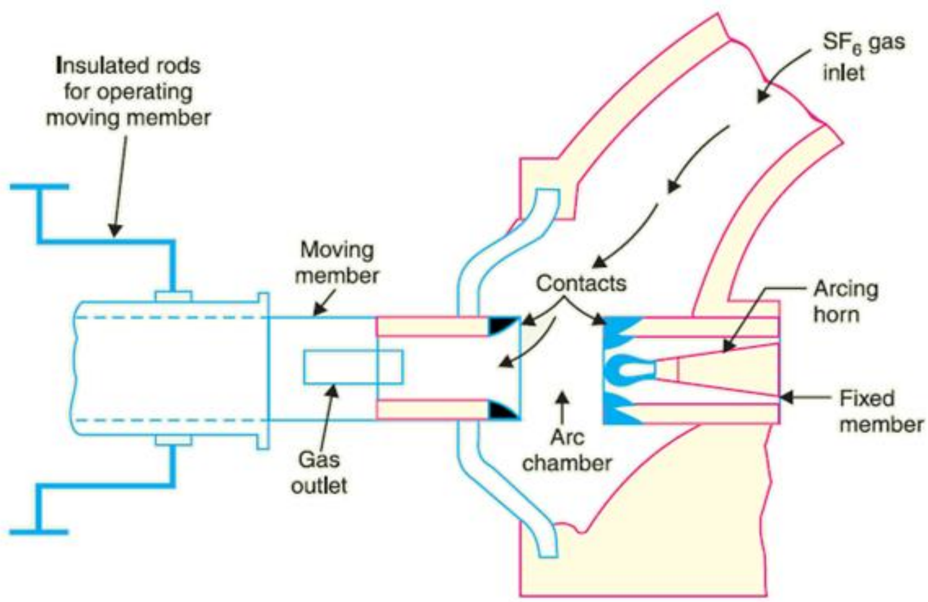
Non-PUFFER TYPE SULPHUR HEXAFLOURIDE (SF6) CIRCUIT BREAKERS:

Construction:

Fig. shows the parts of a typical SF6 circuit breaker. It consists of fixedand moving contacts enclosed in a chamber (called arc interruption chamber) containing SF6 gas. This chamber is connected to SF6 gas reservoir. When the contacts of breaker are opened, the valve mechanism permits a high pressure SF6 gas from the reservoir to flow towards the arc interruption chamber. The fixed contact is a hollow cylindrical current carrying contact fitted with an arc horn. The moving contact is also a hollow cylinder with rectangular holes in the sides to permit the SF6 gas to let out through these holes after flowing along and across the arc. The tips of fixed contact, moving contact and arcing horn are coated with copper-tungsten arc resistant material. Since SF6 gas is costly, it is reconditioned and reclaimed by suitable auxiliary sytem after each operation of the breaker.

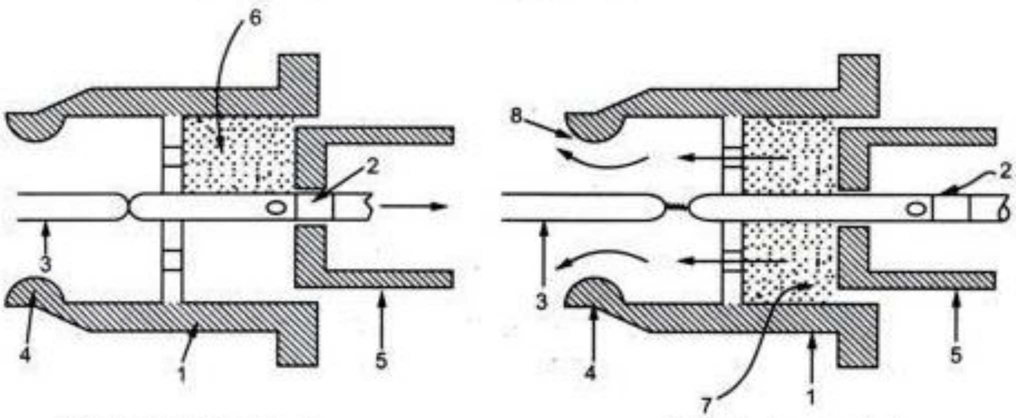
Working:

In the closed position of the breaker, the contacts remain surrounded by SF6 gas at a pressure of about 2·8 kg/cm2. When the breaker operates, the moving contact is pulled apart and an arc is struck between the contacts. The movement of the moving contact is synchronised with the opening of a valve which permits SF6 gas at 14 kg/cm2 pressure from the reservoir to the arc interruption chamber. The high pressure flow of SF6 rapidly absorbs the free electrons in the arc path to form immobile negative ions which are ineffective as charge carriers. The result is that the medium between the contacts quickly builds up high dielectric strength and causes the extinction of the arc. After the breaker operation (*i.e.,* after arc extinction), the valve is closed by the action of a set of springs.



Single Pressure Puffer Type SF_6 Circuit Breaker

It employs puffer principle explained earlier. The Fig. shows principle of operation of single pressure puffer type SF_6 circuit beraker. The operating mechanism (1) is installed at base of the insulator and is linked with movable contact in the interrupter by means of insulating operating rod (4) and a link mechanism (5).The circuit breaker is filled with SF_6 gas at a pressure of about 5 kgf/cm^2. The breaking time obtained with puffer type breaker is nearly 3 cycles.



(a) Breaker fully closed **(b) Contacts separated**

1. Moveable Cylinder (Puffer Cylinder)
2. Moving Contact
3. Fixed Contact
4. Insulating Nozzle
5. Fixed Piston
6. Gas trapped in before compression
7. Compressed gas between 1 and 5
8. The arc being extinguished by puffer action

Fig. Single pressure puffer type SF_6 breaker

In this case, gas is compressed by the moving cylinder system and is released through a nozzle while extinction of an arc.

The Fig.(a) illustrates fully closed position of interrupter. Moving cylinder 1 is coupled with moving contact 2 against the fixed piston 5. As a result there is a relative motion between 1 and 5 and the gas is compressed in the cavity 6. This trapped gas is released through a nozzle hole, during arc extinction process. During the travel of moving contact 2 and movable cylinder 1 gas puffs over the arc and reduces arc diameter by axial convertion and radial dissipation. At current zero arc diameter becomes too small and arc gets extinguished.

The puffing action continues for sometime even after the arc extinction until the contact space is filled with cool and fresh gas.

Advantages:

(*i*) Due to the superior arc quenching property of SF6, such circuit breakers have very short arcing time.

(*ii*) Since the dielectric strength of SF6 gas is 2 to 3 times that of air, such breakers can interrupt much larger currents.

(*iii*) The SF6 circuit breaker gives noiseless operation due to its closed gas circuit and no exhaust to atmosphere unlike the air blast circuit breaker.

(*iv*) The closed gas enclosure keeps the interior dry so that there is no moisture problem.

(*v*) There is no risk of fire in such breakers because SF6 gas is non-inflammable.

(*vi*) There are no carbon deposits so that tracking and insulation problems are eliminated.

(*vii*) The SF6 breakers have low maintenance cost, light foundation requirements and minimum auxiliary equipment.

(*viii*) Since SF6 breakers are totally enclosed and sealed from atmosphere, they are particularly suitable where explosion hazard exists *e.g.*, coal mines.

Disadvantages:

(*i*) SF6 breakers are costly due to the high cost of SF6.

(*ii*) Since SF6 gas has to be reconditioned after every operation of the breaker, additional equipment is required for this purpose.

Applications: A typical SF6 circuit breaker consists of interrupter units each capable of dealing with currents upto 60 kA and voltages in the range of 50—80 kV. A number of units are connected in series according to the system voltage. SF6 circuit breakers have been developed for voltages 115 kV to 230 kV, power ratings 10 MVA to 20 MVA and interrupting time less than 3 cycles.

VACUUM CIRCUIT BREAKERS (VCB):

Principle: The production of arc in a vacuum circuit breaker and its extinction can be explained as follows : When the contacts of the breaker are opened in vacuum (10−7 to 10−5 torr), an arc is produced between the contacts by the ionisation of metal vapours of contacts. However, the arc is quickly extinguished because the metallic vapours, electrons and ions produced during arc rapidly condense on the surfaces of the circuit breaker contacts, resulting in quick recovery of dielectric strength. The reader may note the salient feature of vacuum as an arc quenching medium. As soon as the arc is produced in vacuum, it is quickly extinguished due to the fast rate of recovery of dielectric strength in vacuum.

Construction: Fig. shows the parts of a typical vacuum circuit breaker. It consists of fixed contact, moving contact and arc shield mounted inside a vacuum chamber. The movable member is connected to the control mechanism by stainless steel bellows. This enables the permanent sealing of the vacuum chamber so as to eliminate the possibility of leak. A glass vessel or ceramic vessel is used as the outer insulating body. The arc shield prevents the deterioration of the internal dielectric strength by preventing metallic vapours falling on the inside surface of the outer insulating cover.

Working: When the breaker operates, the moving contact separates from the fixed contact and an arc is struck between the contacts. The production of arc is due to the ionization of metal ions and depends very much upon the material of contacts. The arc is quickly extinguished because the metallic vapours, electrons and ions produced during arc are diffused in a short time and seized by the surfaces of moving and fixed members and shields. Since vacuum has very fast rate of recovery of dielectric strength, the arc extinction in a vacuum breaker occurs with a short contact separation (say 0·625 cm).

Advantages: Vacuum circuit breakers have the following advantages:

(*i*) They are compact, reliable and have longer life.

(*ii*) There are no fire hazards.

(*iii*) There is no generation of gas during and after operation.

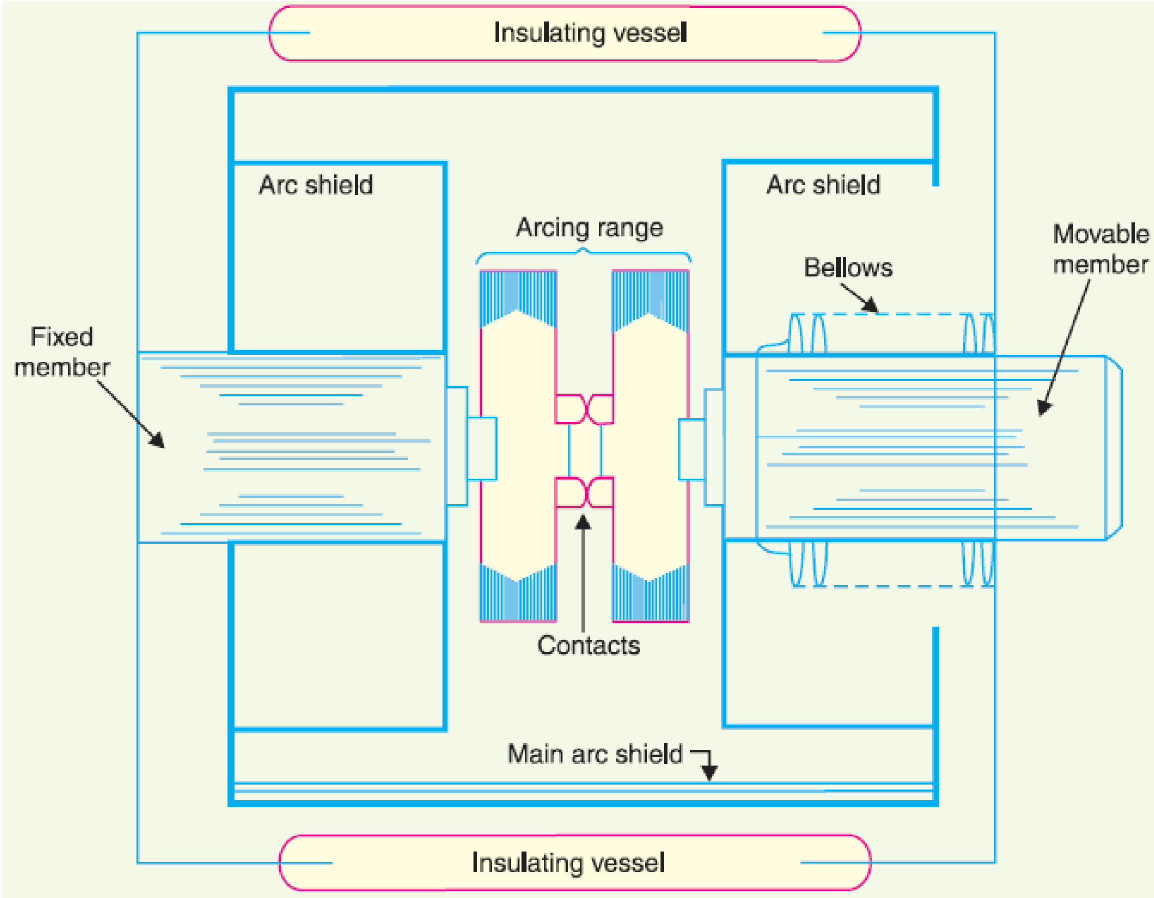
(*iv*) They can interrupt any fault current. The outstanding feature of a VCB is that it can break any heavy fault current perfectly just before the contacts reach the definite open position.

(*v*) They require little maintenance and are quiet in operation.

(*vi*) They can successfully withstand lightning surges.

(*vii*) They have low arc energy.

(*viii*) They have low inertia and hence require smaller power for control mechanism.



Application: Vacuum circuit breakers are being employed for outdoor applications ranging from 22 kV to 66 kV. Even with limited rating of say 60 to 100 MVA, they are suitable for a majority of applications in rural areas.

CIRCUIT BREAKER MAINTENANCE:

Minimum Oil Circuit Breaker Maintenance:

In case of MOCB, the breaker should be checked monthly for oil leakage and oil level. If oil leakage is found it must be attended and for low oil level top up oil up to desire level. Visual inspection of circuit breaker and its operating mechanism along with quality of painting, mechanism kiosk door gasket should be carried out quarterly if any damaged found take proper action. The oil dash pot in operating mechanism must be checked for oil leakage quarterly if leakage is found, replace the defective and damaged O – rings. It is also highly recommended to ensure the prescribed duty cycle of operation of the breaker including reclosing annually.

Maintenance of Air Blast Circuit Breaker:

For air blast circuit breaker there are some special cares to be taken in addition to general instruction for maintenance of operating mechanism. Actually for operating mechanisms and for other some features the maintenance processes and schedules are same for all oil circuit breaker, air circuit breaker, SF_6 circuit breaker and vacuum circuit breaker. In air circuit breaker, the air leakage should be checked as and when it is required. If leakage is found, plug the leakage. The grading capacitors must be checked for oil leakage monthly. If leakage found plug it. Yearly, dew point of the operating air at the outlet of the air dryer should be measured with the help of Dew Point Meter or Hygro Meters.

SF_6 Circuit Breaker Maintenance:

SF_6 circuit breaker must be checked for SF_6 gas leakage, if unwanted SF_6 low gas pressure alarm comes. This is efficiently done by gas leakage detector. If the circuit breaker is provided with gradient capacitors, these must be checked for oil leakage monthly. If leakage found plug it. Dew point of SF_6 should be checked with the help of dew point meter or hygro meters in every 3 to 4 years interval.

Maintenance of Vacuum Circuit Breaker

In case of vacuum circuit breaker there is nothing special all the processes and schedules are same as in case of other circuit breaker.