Nadar Saraswathi College of Engineering & Technology

NSCET E-LEARNING PRESENTATION

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Electrical and Electronics Engineering

IIIYEAR/VIth Semester

EE8602-Protection and Switchgear

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UNIT 04
STATIC AND NUMERICAL PROTECTION

CIRCUIT BREAKERS

- Physics of arcing phenomenon and arc interruption
- DC and AC circuit breaking
- Rate of rise of recovery voltage
- Current chopping
- Types of circuit breakers
  - Air blast circuit breakers
  - Air break circuit breakers
  - Oil circuit breakers
  - SF6 circuit breakers
  - Vacuum circuit breakers

Arc Interruption Theory

- The insulating material (may be fluid or air) used in circuit breaker should serve two important functions. They are written as follows:

- It should provide sufficient insulation between the contacts when circuit breaker opens.

- It should extinguish the arc occurring between the contacts when circuit breaker opens.

Methods of Arc Interruption

- There are two methods by which interruption is done.

  High resistance method,

  Low resistance method or current zero interruption method.

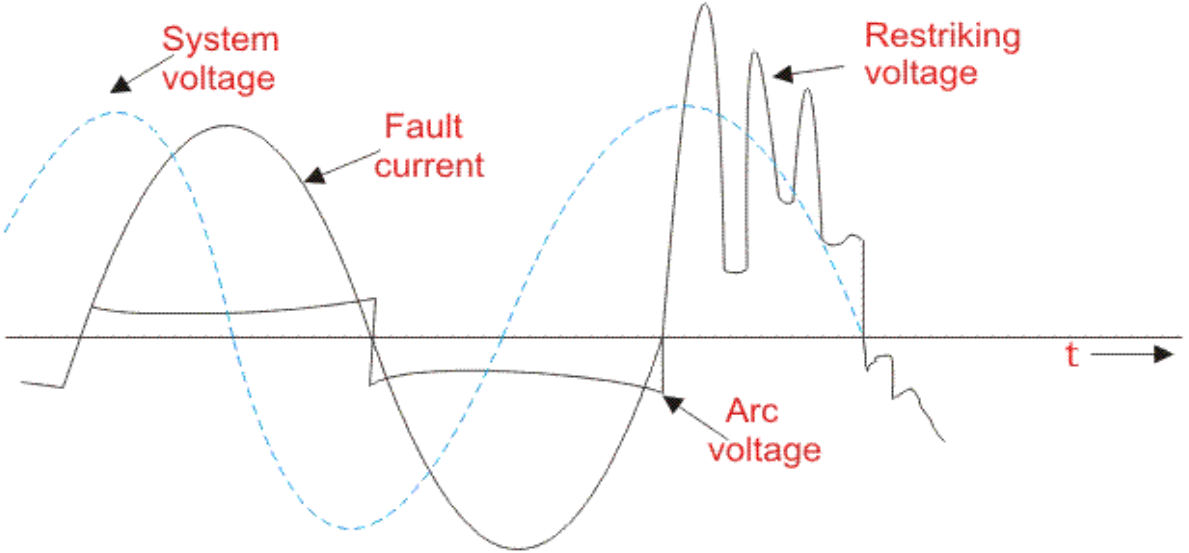
- In high interruption method we can increase the electrical resistance many times to such a high value that it forces the current to reach to zero and thus restricting the possibility of arc being restrike.

- Proper steps must be taken in order to ensure that the rate at which the resistance is increased or decreased is not abnormal because it may lead to generation of harmful induced voltages in the system.

- The arc resistance can be increased by various methods like lengthening or cooling of the arc etc.

Limitations of High Resistance Method

- Arc discharge has a resistive nature due to this most of the energy is received by circuit breaker itself hence proper care should be taken during the manufacturing of circuit breaker like mechanical strength etc.
- Therefore this method is applied in DC power circuit breaker, low and medium AC power circuit breaker.
- Low resistance method is applicable only for ac circuit and it is possible there because of presence of natural zero of current.
- The arc gets extinguished at the natural zero of the AC wave and is prevented from restricting again by rapid building of dielectric strength of the contact space.



Arc interruption theory

Restriking Voltage

- It may be defined as the voltages that appears across the breaking contact at the instant of arc extinction.

Recovery Voltage

- It may be defined as the voltage that appears across the breaker contact after the complete removal of transient oscillations and final extinction of arc has resulted in all the poles.

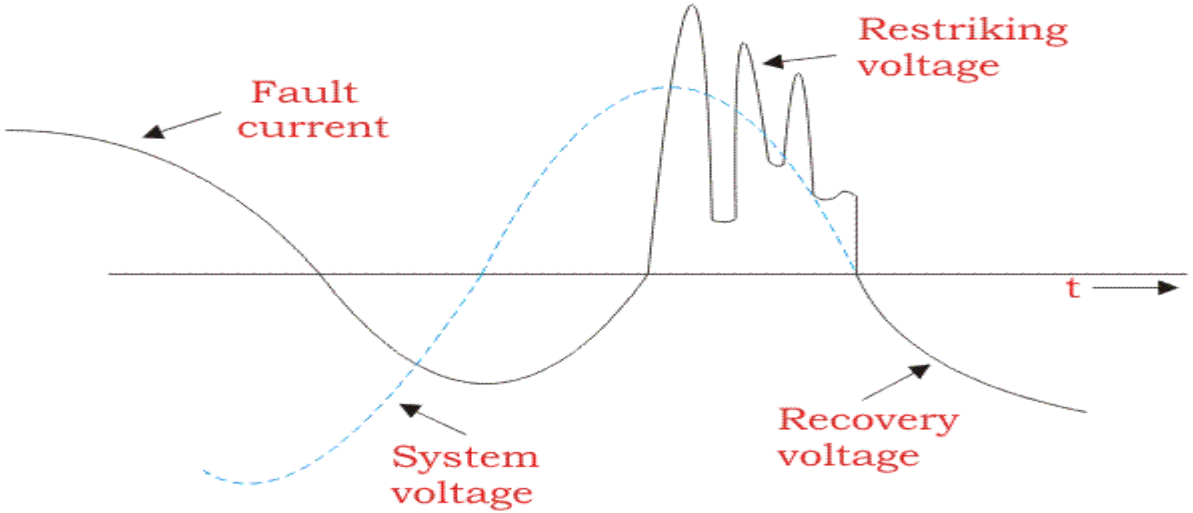
Active Recovery Voltage

- It may be defined as the instantaneous recovery voltage at the instant of arc extinction.

Arc Voltage

- It may be defined as the voltages that appears across the contact during the arcing period, when the current flow is maintained in the form of an arc. It assumes low value except for the point at which the voltage rise rapidly to a peak value and current reaches to zero.

Arc interruption



Arc interruption theory

Rate of Rise of Re-striking Voltage (RRRV)

- It is defined as the ratio of peak value of re-striking voltage to time taken to reach to peak value.

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- It is one of the most important parameter as if the rate at which the dielectric strength developed between the contacts is greater than RRRV, and then the arc will be extinguishes

AC and DC circuit breaking

- DC circuit breakers and AC breaker main difference is the ability to arc. Because the exchange of each cycle, have had zero, zero easy to extinction in the past, but has not been zero DC switching, arc extinguishing ability is poor, so to add additional interrupter device.

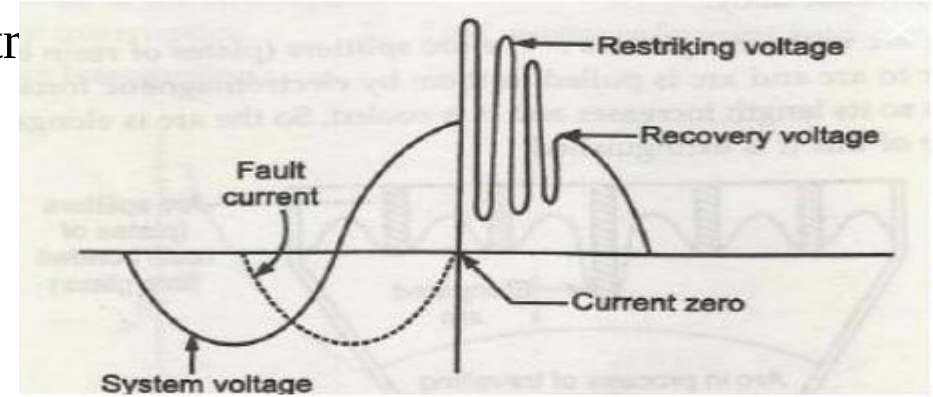
- DC arc is generally difficult, but the exchange has zero, breaking easily.

- Exchange can be derived for the DC circuit breaker protection, attention to three changes: 1, overload and short circuit protection.

Re-striking voltage and recovery voltage

- It is the transient voltage that appears across the contacts at or near current zero during arcing period.

- If dielectric strength rise is greater than the rise of re-striking voltage then the arc will not restr



Transient Recovery Voltage (TRV) is:

- Voltage that appears between the contacts of the circuit breaker after arc extinction during opening process while clearing a fault. •
- The Rate of Rise of Recovery Voltage (RRRV) is defined as peak transient recovery voltage divided by the total time from zero voltage to peak voltage.
- Level of TRV and the RRRV are key factors in determining whether the fault can be cleared successfully

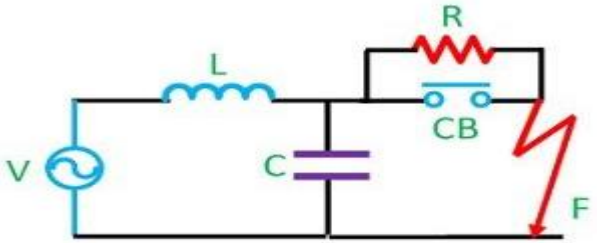
Resistance Switching

- A fixed connection of resistance in parallel with the contact space or arc is called the resistance switching.
- Resistance switching is employed in circuit breakers having a high post zero resistance of contact space.
- The resistance switching is mainly used for reducing the restriking voltage and the transient voltage surge.
- Severe voltage occurs in the system because of two reasons, firstly because of the breaking of low voltage current, and secondly because of the breaking of capacitive current.

- When the fault occurs, the contacts of the circuit breaker are open, and an arc is struck between the contacts.

- With the arc shunted by the resistance **R**, a part of arc current is diverted through the resistance.

- This results in the decreases of arc current and an increase in the rate of deionization of the arc



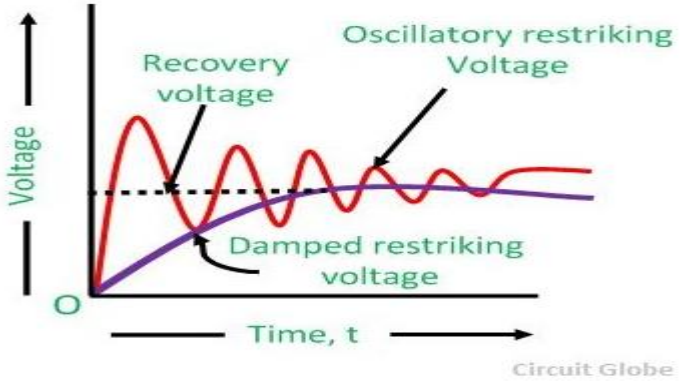
Resistance Switching Circuit

Circuit Globe

- Thus, the arc resistance is increased, leading to the further increase in current through the shunt resistance **R**.

- This builds up process continue until the current becomes so small that it fails to maintain the arc shown in the figure below.

- Now the arc is e r gets interrupted.



- Alternatively, the resistance may be automatically switched in by transference of the arc from the main contacts to the probe contact as in the case of an axial blast circuit breaker, the time required for this action is very small.

- Having the arc path substituted by a metallic path, the current flowing through the resistance is limited and then easily broken.

- The shunt resistor also helps in li[illegible]vth of re-striking voltage transients.

$$f_n = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{1}{4C^2R^2}}$$

- It can be proved mathematically that the natural frequency (f_n) of oscillations of the circuit shown is given as

- To sum up, resistor across the circuit breaker contacts may be used to perform any one or more of the following functions.

- It reduces the RRRV (Rate of Rising of Restriking Voltage) burden on the circuit breaker.

- It reduces the high-frequency restriking voltage transients during switching out inductive or capacitive loads.

- In a multi-break circuit breaker, it helps in distributing the transient recovery voltage more uniformly across the contact gaps.

- The resistance switching is not required in the plan circuit breaker because their contact space is low.

What is Current Chopping?

- Current Chopping in circuit breaker is defined as a phenomena in which current is forcibly interrupted before the natural current zero.

- Current Chopping is mainly observed in Vacuum Circuit Breaker and Air Blast Circuit Breaker.

- There is no such phenomena in Oil Circuit Breaker. Current chopping is predominant while switching Shunt Reactor or unloaded Transformer.

What is Air Circuit Breaker?

- An **Air Circuit Breaker** (also known as an **Air Blast Circuit Breaker** or **ACB**) is an automatically operated electrical switch that uses air to protect an electrical circuit from damage caused by excess current from an overload or short circuit.

- Its primary function is to interrupt current flow after a fault is detected.

- When this happens, an arc will appear between the contacts that have broken the circuit. Air circuit breakers use compressed air to blow out the arc, or alternatively, the contacts are rapidly swung into a small sealed chamber, the escaping of the displaced air, thus blowing out the arc.

- This type of circuit breaker operates in air at atmospheric pressure.

Working Principle of Air Circuit Breaker

- The working principle of this breaker is rather different from those in any other types of circuit breakers.
- The main aim of all kind of circuit breaker is to prevent the reestablishment of arcing after current zero by creating a situation where in the contact gap will withstand the system recovery voltage.
- The **air circuit breaker** does the same but in different manner. For interrupting arc it creates an arc voltage in excess of the supply voltage.
- Arc voltage is defined as the minimum voltage required maintaining the arc.

- This circuit breaker increases the arc voltage by mainly three different ways,
- It may increase the arc voltage by cooling the arc plasma. As the temperature of arc plasma is decreased, the mobility of the particle in arc plasma is reduced; hence more voltage gradient is required to maintain the arc.

- It may increase the arc voltage by lengthening the arc path. As the length of arc path is increased, the resistance of the path is increased, and hence to maintain the same arc current more voltage is required to be applied across the arc path.

- That means arc voltage is increased.

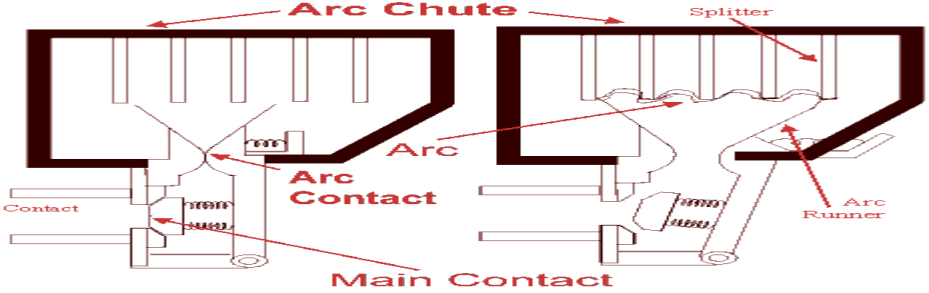
- Splitting up the arc into a number of series arcs also increases the arc voltage.

Operation of ACB

- The operation of an ACB can be broken down into three steps:
- The first objective is usually achieved by forcing the arc into contact with as large an area as possible of insulating material.
- The second objective that is lengthening the arc path,
- The third technique is achieved by using metal arc slitter inside the arc chute.

- As the arc is driven upward it enters in the arc chute, consisting of splitters.

- The arc in chute will become colder, lengthen and split hence arc voltage becomes much larger than system voltage at the time of **operation of air circuit breaker**, and therefore the arc is quenched finally during the current zero.



Although these types of circuit breakers have become obsolete for medium voltage application, but they are still preferable choice for high current rating in low voltage application.

Air Blast Circuit Breaker

- These types of air circuit **breaker** were used for the system voltage of 245 KV, 420 KV and even more, especially where faster breaker operation was required. **Air blast circuit breaker** has some specific advantages over oil circuit breaker which are listed as follows,

- There is no chance of fire hazard caused by oil.

- The breaking speed of circuit breaker is much higher during **operation of air blast circuit breaker**.

- Arc quenching is much faster during **operation of air blast circuit breaker**.
- The duration of arc is same for all values of small as well as high currents interruptions.

- As the duration of arc is smaller, so lesser amount of heat realized from arc to current carrying contacts hence the service life of the contacts becomes longer

- The stability of the system can be well maintained as it depends on the speed of operation of circuit breaker.

- Requires much less maintenance compared to oil circuit breaker.

- **Disadvantages of air blast circuit breakers:**

- In order to have frequent operations, it is necessary to have sufficiently high capacity air compressor.

- Frequent maintenance of compressor, associated air pipes and automatic control equipments is also required.

- Due to high speed current interruption there is always a chance of high rate of rise of re-striking voltage and current chopping.

- There also a chance of air pressure leakage from air pipes junctions

- As we said earlier that there are mainly two types of ACB, **plain air circuit breaker** and air blast circuit breaker. But the later can be sub divided further into three different categories.

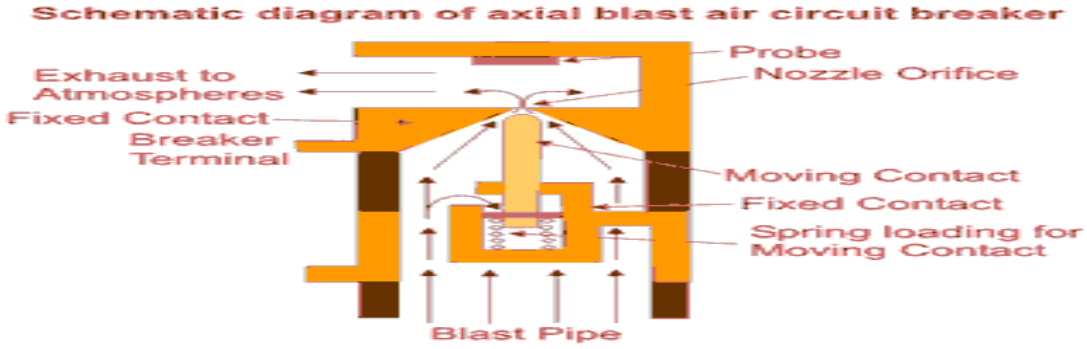
- Axial Blast ACB.
- Axial Blast ACB with side moving contact.
- Cross Blast ACB.

Axial Blast Air Circuit Breaker

- In axial blast ACB the moving contact is in contact with fixed contact with the help of a spring pressure.

- There is a nozzle orifice in the fixed contact which is blocked by tip of the moving contact at normal closed condition of the breaker.

- When fault occu chamber.



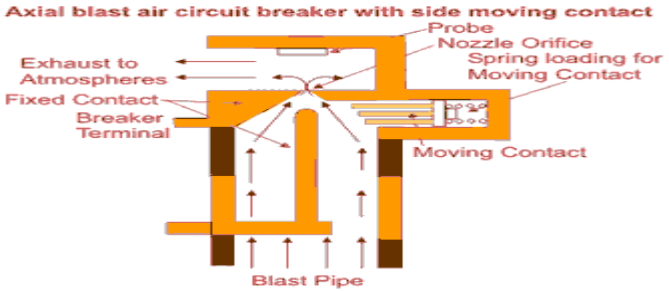
- The air pressure will counter the spring pressure and deforms the spring hence the moving contact is withdrawn from the fixed contact and nozzle hole becomes open.

- At the same time the high pressure air starts flowing along the arc through the fixed contact nozzle orifice.

- This axial flow of air along the arc through the nozzle orifice will make the arc lengthen and colder hence arc voltage become much higher than system voltage that means system voltage is insufficient to sustain the arc consequently the arc is quenched.

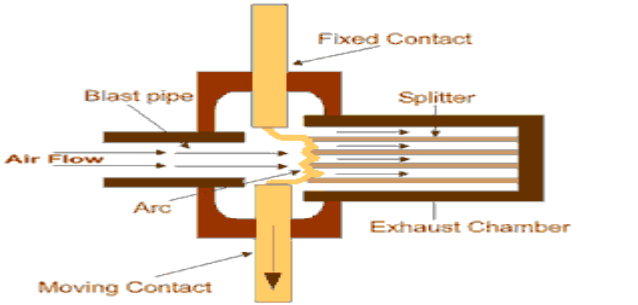
Axial Blast ACB with Side Moving Contact

- In this type of axial blast air circuit breaker the moving contact is fitted over a piston supported over a spring.
- In order to open the circuit breaker the air is admitted into the arcing chamber when pressure reaches to a predetermined value, it presses down the moving contact; an arc is drawn between the fixed and moving contacts.
- The air blast immediately transfers the arc to the arcing electrode and is consequently quenched by the axial flow of air



Cross Blast Air Circuit Breaker

- The working principle of cross blast **air circuit breaker** is quite simple. In this system of **air blast circuit breaker** the blast pipe is fixed in perpendicular to the movement of moving contact in the arcing chamber and on the opposite side of the arcing chamber one exhaust chamber is also fitted at the same alignment of blast pipe, so that the air comes from blast pipe can straightly enter into exhaust chamber through the contact gap of the breaker.



Principle of Cross Blast Air Circuit Breaker

- The exhaust chamber is spit with arc splitters. When moving contact is withdrawn from fixed contact, an arc is established in between the contact, and at the same time high pressure air coming from blast pipe will pass through the contact gap and will forcefully take the arc into exhaust chamber where the arc is split with the help of arc splitters and ultimately arc is quenched.

Oil Circuit Breaker

- Oil circuit breaker is such type of circuit breaker which used oil as a dielectric or insulating medium for arc extinction.

- In oil circuit breaker the contacts of the breaker are made to separate within an insulating oil.

- When the fault occurs in the system the contacts of the circuit breaker are open under the insulating oil, and an arc is developed between them and the heat of the arc is evaporated in the surrounding oil.

- The oil circuit breaker is divided into two categories

  Bulk oil

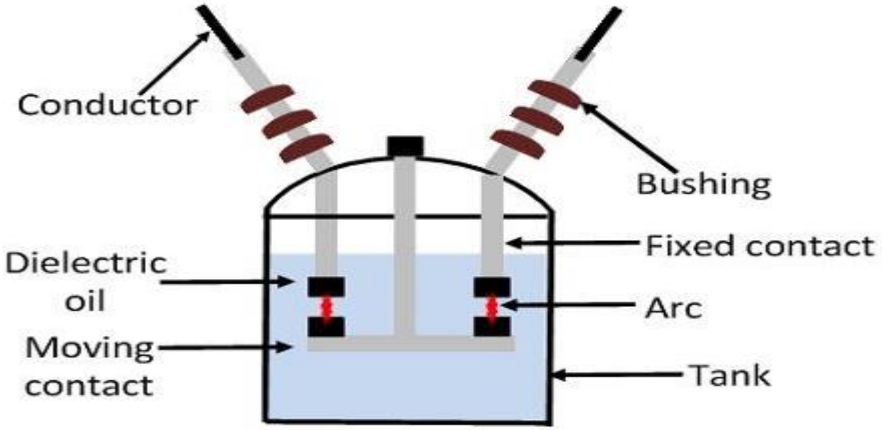
  Minimum oil

- Oil circuit breaker is very easy in construction. It consists of current carrying contacts enclosed in a strong, weather-tight earth metal tank and the tank is filled with transformer oil.

- The oil is both acts as an arc extinguishing medium and as an insulator between the live part and earth.

- At the top of the oil, air is filled in the tank which acts as a cushion to control the displaced oil on the formation of gas around the arc and also to absorb the mechanical shock of the upward movement of oil.

- The breaker tank is securely bolted for carrying out the vibration caused on interrupting very high current. Oil circuit breaker consists gas outlet which is fitted in the tank cover for the removal of the gases.

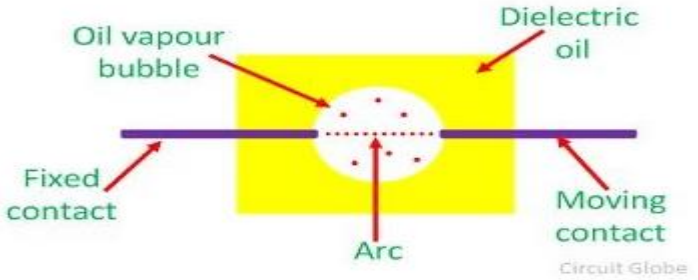

Conductor
Bushing
Fixed contact
Dielectric oil
Arc
Moving contact
Tank
Oil Circuit Breaker
Circuit Globe

- During the normal operating conditions, the contact of the oil circuit breaker is closed and carry the current.
- When the fault occurs in the system, the contacts of the breaker are moving apart, and an arc is struck between the contacts.
- Due to this arc, a large amount of heat is liberated, and a very high temperature is reached which vaporises the surrounding oil into gas.
- The gas, thus liberated surrounds the arc and its explosive growth around it displace the oil violently.
- The arc is extinguished when the distance between the fixed and moving contact reaches a certain critical value, depends on the arc current and recovery voltage.

- The oil circuit breaker is very reliable in operation, and it is very cheap.

- The most important feature of oil circuit breaker is that no special devices are used for controlling the arc caused by moving contact.

- The oil as an arc quenching medium has certain advantages and disadvantages



Advantages of Oil as an Arc Quenching

- The oil has a high dielectric strength and provides insulation between the contact after the arc has been extinguished.
- The oil used in circuit breaker provides a small clearance between the conductors and the earth components.
- The hydrogen gas is formed in the tank which has a high diffusion rate and good cooling properties.

Disadvantages of Oil as an Arc Quenching

- The oil used in oil circuit breaker is inflammable and hence, cause a fire hazard.
- There is a risk of formation of explosive mixture with air.
- Due to decomposition of oil in the arc, the carbon particles is generated which polluted the oil and hence the dielectric strength of the oil decreases.

Bulk Oil Circuit Breaker

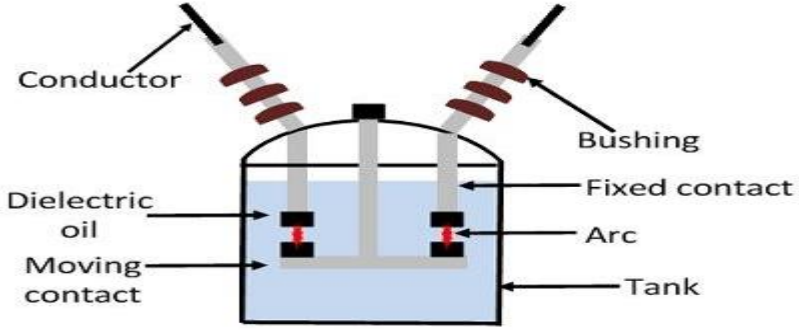
- A breaker which uses a large quantity of oil for arc extinction is called a bulk oil circuit breaker.

- Such type of circuit breaker is also known as dead tank-type circuit breaker because their tank is held at ground potential. The quantity of oil requires in bulk oil circuit breaker depends on the system voltage.

- If the output rating of the voltage is 110 KV, then it requires 8 to 10 thousand kg of oil, and if their output rating is 220 KV, then breakers need 50 thousand Kg of oil.

In bulk oil circuit breaker, oil performs mainly two functions. Firstly, it acts as an arc extinguishing medium and secondly, it insulates the live parts of the breaker from earth.

The quantity of oil requires for arc extinction is only about one-tenth of the total and the rest being used for the insulation



Bulk Oil Circuit Breaker

- These large quantities of oil are subject to the carbonisation, sludging, etc., which occurs due to arc interruption and other causes reducing the insulating properties and requires regular maintenance.

- Bulk oil circuit breaker needs a large tank which increases expenses and also increases the weight of the circuit breaker.

- Because of the following disadvantage the low oil circuit breaker is developed which use minimum oil for arc extinction.

Minimum Oil Circuit Breaker

- In this type of circuit breaker minimum oil is used as an arc quenching medium and it is mounted on a porcelain insulator to insulate it from the earth.

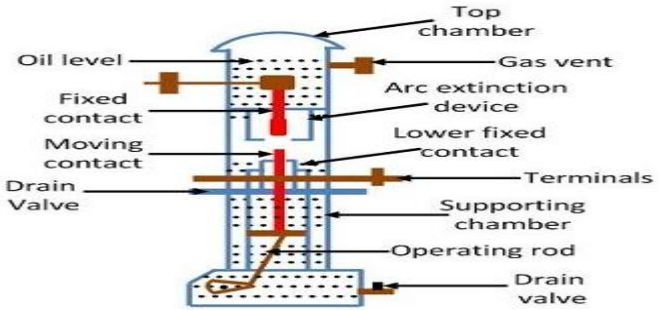
- The arc chamber of such type of circuit breaker is enclosed in a bakelised paper. The lower portion of this breaker is supported by the porcelain and the upper porcelain enclosed the contacts.

- This circuit breaker is of the single breaker type in which a moving contact tube moves in a vertical line to make or break contact with the upper fixed contacts mounted within the arc control devices.

- A lower ring of fixed contacts is in permanent contact with the moving arm to provide the other terminal of the phase unit.

- Within the moving contact, the tube is a fixed piston. When the moving contact moves downwards, it forces the insulating oil to enter into the arc control devices .

- Thus, the arc gets extinguished.



Minimum oil circuit breaker requires less space as compared to bulk oil circuit breaker which is an important feature in large installations.

But it is less suitable in places where the frequent operation is required because the degree of carbonization produced in the small volume of oil is far more dangerous than in the conventional bulk oil circuit breakers and this also decreases the dielectric strength of the material.

The low oil circuit breakers have the advantages of a requirement of the lesser quantity of oil, smaller space requirement, smaller tank size, smaller weight, low cost, reduced risk of fire and reduced maintenance problems.

Minimum oil circuit breaker suffers from the following drawbacks when compared with the bulk oil circuit breakers Increased degree of carbonization due to a smaller quantity of oil.

The dielectric strength of oil decreases due to a high degree of carbonization.

Difficulty in removal of gases from the contact space-time

Vacuum Circuit Breaker

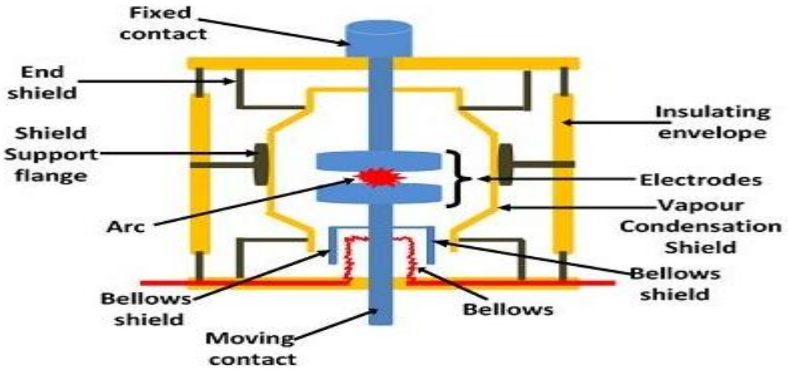
- A breaker which used vacuum as an arc extinction medium is called a vacuum circuit breaker. In this circuit breaker, the fixed and moving contact is enclosed in a permanently sealed vacuum interrupter. The arc is extinct as the contacts are separated in high vacuum. It is mainly used for medium voltage ranging from 11 KV to 33 KV.

- Vacuum circuit breaker has a high insulating medium for arc extinction as compared to the other circuit breaker.

- The pressure inside the vacuum interrupter is approximately 10^{-4} torrent and at this pressure, very few molecules are present in the interrupter. The vacuum circuit breaker has mainly two phenomenal properties.

- High insulating strength: In comparison to various other insulating media used in circuit breaker vacuum is a superior dielectric medium. It is better than all other media except air and SF_6, which are employed at high pressure.

- When an arc is opened by moving apart the contacts in a vacuum, an interruption occurs at the first current zero. With the arc interruption, their dielectric strength increases up to a rate of thousands time as compared to other breakers.



- The outer envelope of vacuum circuit breaker is made up of glass because the glass envelope help in the examination of the breaker from outside after the operation.

- If the glass becomes milky from its original finish of silvery mirror, then it indicates that the breaker is losing vacuum.

- The fixed and moving contacts of the breaker are placed inside the arc shield.

- The pressure in a vacuum interrupter at the time of sealing off is kept at about 10^{-6} torr.

- The moving contacts of the circuit breaker are move through a distance of 5 to 10 mm depending upon the operating voltage.

- When the fault occurs in the system, the contacts of the breaker are moved apart and hence the arc is developed between them.
- When the current carrying contacts are pulled apart, the temperature of their connecting parts is very high due to which ionization occurs.
- Due to the ionization, the contact space is filled with vapour of positive ions which is discharged from the contact material.
- The density of vapour depends on the current in the arcing.
- Due to the decreasing mode of current wave their rate of release of vapour fall and after the current zero, the medium regains its dielectric strength provided vapour density around the contacts reduced.
- Hence, the arc does not restrike again because the metal vapour is quickly removed from the contact zone.

Current Chopping in Vacuum Circuit Breaker

- Current chopping in vacuum circuit breaker depends on the vapour pressure and the electron emission properties of the contact material.
- The chopping level is also influenced by the thermal conductivity–lower the thermal conductivity, lower is the chopping level.
- It is possible to reduce the current level at which chopping occurs by selecting a contact material which gives out sufficient metal vapour to allow the current to come to a very low value or zero value, but this is rarely done as it affects the dielectric strength adversely.

- Vacuum Arc recovery of Vacuum Circuit Breaker

- High vacuum possesses extremely high dielectric strength. At zero current the arc is extinguished very quickly, and the dielectric strength is established very quickly.

- This return of dielectric strength is because of the vaporized metal which is localized between the contacts diffuses rapidly due to the absence of gas molecules.

- After arc interruption, the recovery strength during the first few microseconds is 1 kV/μs second for an arc current of 100A.

- Because of the above-mentioned attribute of vacuum circuit breaker, it is capable of handling the severe recovery transients associated with short-line faults without any difficulty.

Advantages of Vacuum Circuit Breaker

- Vacuum circuit breaker does not require any additional filling of oil or gas. They do not need periodic refilling.
- Rapid recovery of high dielectric strength on current interruptions that only a half cycle or less arcing occurs after proper contact separation.
- Breaker unit is compact and self-contained. It can be installed in any required orientation.
- Because of the above reasons together with the economic advantage offered, vacuum circuit breaker has high acceptance.

Disadvantage of Vaccum Circuit Breaker

- Requirements of high technology for production of vacuum interrupters.
- It needs additional surge suppressors for the interruption of low magnetizing currents in a certain range.
- Loss of vacuum due to transit damage or failure makes the entire interrupter useless, and it cannot be repaired on site.

Applications of Vacuum Circuit Breaker

- Because of the short gap and excellent recovery of vacuum circuit breaker, they are very useful as very high speed making switches in many industrial applications.
- When the voltage is high and current to be interrupted is low these breakers have definite superiority over the other breakers.
- For low fault interrupting capacities the cost is low in comparison to other interrupting devices.
- Because of the least requirements of maintenance, these breakers are very suitable for the system which requires voltage from 11 to 33 kV

Sulphur Hexafluoride (SF6) Circuit Breaker

- circuit breaker in which SF_6 under pressure gas is used to extinguish the arc is called SF_6 circuit breaker.

- SF_6 (sulphur hexafluoride) gas has excellent dielectric, arc quenching, chemical and other physical properties which have proved its superiority over other arc quenching mediums such as oil or air.

- The SF_6 circuit breaker is mainly divided into three types
- Non-puffer piston circuit breaker
- Single- puffer piston circuit breaker.
- Double-puffer piston circuit breaker.

- The circuit breaker which used air and oil as an insulating medium, their arc extinguishing force builds up was relatively slow after the movement of contact separation.

- In the case of high voltage circuit breakers quick arc extinction properties are used which require less time for quick recovery, voltage builds up.

- SF_6 circuit breakers have good properties in this regards compared to oil or air circuit breakers. So in high voltage up to 760 kV, SF_6 circuit breakers is used

- Sulphur hexafluoride possesses very good insulating and arc quenching properties.
- These properties are

- It is colourless, odourless, non-toxic, and non-inflammable gas.

- SF_6 gas is extremely stable and inert, and its density is five times that of air.

- It has high thermal conductivity better than that of air and assists in better cooling current carrying parts.

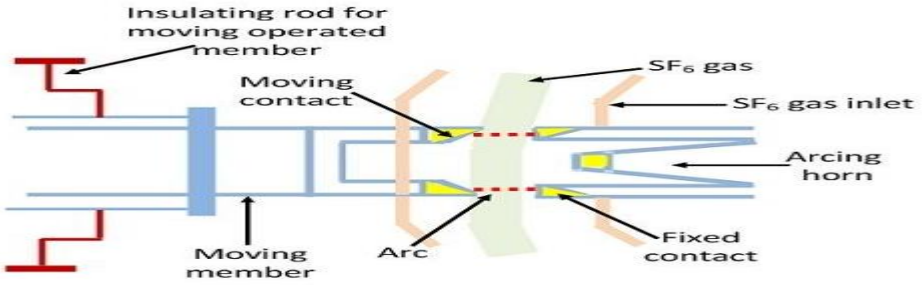
- SF_6 gas is strongly electronegative, which means the free electrons are easily removed from discharge by the formation of negative ions.

- It has a unique property of fast recombination after the source energizing spark is removed. It is 100 times more effective as compared to arc quenching medium.

- Its dielectric strength is 2.5 times than that of air and 30% less than that of the dielectric oil. At high pressure the dielectric strength of the gas increases.

- Moisture is very harmful to SF_6 circuit breaker. Due to a combination of humidity and SF_6 gas, hydrogen fluoride is formed (when the arc is interrupted) which can attack the parts of the circuit breakers.

- SF_6 circuit breakers mainly consist of two parts, namely (a) the interrupter unit and (b) the gas system.
- **Interrupter Unit** – This unit consists of moving and fixed contacts comprising a set of current-carrying parts and an arcing probe. It is connected to the SF_6 gas reservoir.
- This unit consists slide vents in the moving contacts which permit the high-pressure gas into the main tank.



Interrupter Unit of SF6 Circuit Breaker

Circuit Globe

- The closed circuit gas system is employed in SF_6 circuit breakers.
- The SF_6 gas is costly, so it is reclaimed after each operation.
- This unit consists low and high-pressure chambers with a low-pressure alarm along with warning switches.
- When the pressure of the gas is very low due to which the dielectric strength of gases decrease and an arc quenching ability of the breakers is endangered, then this system gives the warning alarm.

- In the normal operating conditions, the contacts of the breaker are closed.
- When the fault occurs in the system, the contacts are pulled apart, and an arc is struck between them.
- The displacement of the moving contacts is synchronized with the valve which enters the high-pressure SF_6 gas in the arc interrupting chamber at a pressure of about 16kg/cm^2.
- The SF_6 gas absorbs the free electrons in the arc path and forms ions which do not act as a charge carrier.
- These ions increase the dielectric strength of the gas and hence the arc is extinguished.

- This process reduces the pressure of the SF_6 gas up to 3kg/cm^2 thus; it is stored in the low-pressure reservoir.

- This low-pressure gas is pulled back to the high-pressure reservoir for re-use.

- Now a day puffer piston pressure is used for generating arc quenching pressure during an opening operation by mean of a piston attached to the moving contacts.

- SF_6 circuit breakers have the following advantages over conventional breaker
- SF_6 gas has excellent insulating, arc extinguishing and many other properties which are the greatest advantages of SF_6 circuit breakers.
- The gas is non-inflammable and chemically stable. Their decomposition products are non-explosive and hence there is no risk of fire or explosion.
- Electric clearance is very much reduced because of the high dielectric strength of SF_6.
- Its performance is not affected due to variations in atmospheric condition.
- It gives noiseless operation, and there is no over voltage problem because the arc is extinguished at natural current zero.

- There is no reduction in dielectric strength because no carbon particles are formed during arcing.

- It requires less maintenance and no costly compressed air system is required.

- SF_6 performs various duties like clearing short-line faults, switching, opening unloaded transmission lines, and transformer reactor, etc. without any problem.

- SF_6 gas is suffocating to some extent. In the case of leakage in the breaker tank, the SF_6 gas being heavier than air and hence SF_6 are settled in the surroundings and lead to the suffocation of the operating personnel.
- The entrance of moisture in the SF_6 breaker tank is very harmful to the breaker, and it causes several failures.
- The internal parts need cleaning during periodic maintenance under clean and dry environment.
- The special facility requires for transportation and maintenance of quality of gas.