DESIGN OF MOTOR CONTROLLED AIR BREAK DISCONNECTOR

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Abstract:

Air break disconnectors are widely used in all the substations and PowerStation in conjunction with circuit breakers primarily for isolation purpose and for enabling Safe maintenance work in this project, we have fabricated a small prototype motor operated horizontal air break disconnector.This disconnector was tested as per the standards requirement. We have incorporated a novel feature of disconnector operation through variable frequency drive in order to eliminate sturdier gearboxes leading to lot of transmission losses.Further, to this prototype development, we have brought out complete technical data design information on disconnectors for Indian substation voltage level right from low voltage to extra high voltage level.Through this project we gained adequate confidence to design air break disconnector independently for any power project.

1. INTRODUCTION

When carrying out inspection or repair in a sub-station installation, it is essential to disconnect reliably the unit or the section , on which the work is to be done, from all other live parts on the installation in order to ensure complete safety of the working staff. To guard against mistakes, it is desirable that this should be done by an apparatus which makes visible break in the circuit. Such an apparatus is the isolating switch (or isolator). It may be defined as a device used to open (or close) a circuit either when negligible current is interrupted (or established) or when no significant change in the voltage across the terminals of each pole of isolator will result from the operation.

1. Operating handles
2. Base Channel
3. Insulators
4. Arcing horns
5. Female contacts
6. Make before break after contact
7. Terminal Pad
8. Rotating arm with male contact
9. Stop for rotating arms
10. Earthing blades
11. Female contact for earthing switch

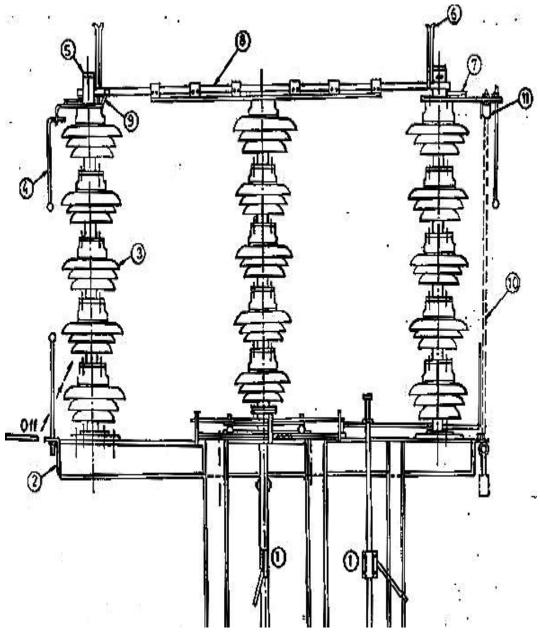


Fig. 1

The location of an isolating switch in the substation is shown above:

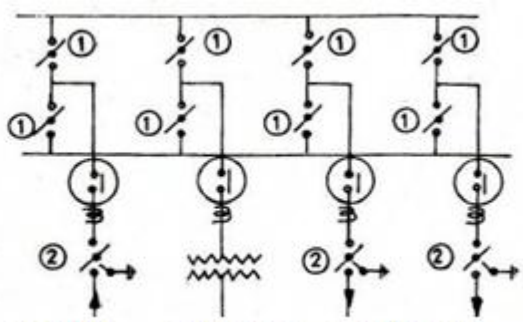


Fig. 2

The isolating switches can be broadly classified into three categories based on the functions as

1. Bus isolator
2. Line isolator cum earthing switch
3. Transformer isolating switch

Based on operation, isolators can be classified as,

1. Centre break isolators

Type of insulator	Rated voltage in kV	Rated current in A	Rated short time current in KA	Rated peak short circuit current in KA
Pantograph Disconnector series RP	245	3150	40	100
	420	3150	50	125
	525	3150	50	125
	765	3150	40	100
Vertical break Disconnector series RV	245	3150	60	150
	420	3150	60	150
	525	4000	60	150
	765	4000	60	150
Centre break Disconnector series RC	123	3150	60	150
	145	3150	60	150
	245	3150	60	150
	420	3150	60	150
	525	3150	60	150
Double break Disconnector series RD	72.5	3150	40	100
	123	3150	40	100
	145	3150	40	100
	245	3150	40	100
	420	4000	60	150
	525	4000	60	150

2. Double break isolators
3. Pantograph isolators
4. Vertical break isolators

The BS: 3078-1959 on isolators distinguishes between "offload" and "on load" isolators.

OFF load isolator is an isolator which is operated in a circuit either when the isolator is already disconnected from all sources of supply or when the isolator is already disconnected from the supply.

ON load isolator is an isolator which is operated in a circuit where there is a parallel path of low impedance so thatno significant change in the terminals of each pole occurs when it is operated.

2. TECHNICAL PRE QUALIFICATION

The technical pre qualifications for an isolator are,

i) Disconnector Ratings
ii) Technical Specifications
iii) Disconnector Drives
iv) Terminal Connectors
v) Test Reports

2.1 Technical Specifications:

Particulars	Centre break 245kV/ 420kV	Double break 245kV/ 420kV	Pantograph
Contact pressure(Kg)	9/9	9/9	40
Contact area	Line contact	Line contact	Point contact
Motor rating(H.P)	0.5/0.5	0.5/1	1
Max. starting current(A)	4/4	4/8	8
Max. full load current(A)	1/1	1/2	2
Max. weight of motor(Kg)	9/9	9/14	14
R.P.M of motor	1370/1370	1370/1400	1400
Operation	3pole/ 1pole	3pole/ 1pole	1 pole
Max. torque required(Kg m)	30/20	40/45	65
Weight of Disconnector metallic without insulators(Kg)	140/400	150/420	250
Max. weight of electrical operating mechanism	130/130	130/130	175
Motor type	Squirrel cage		
No.of operations without deterioration	1000		
Safety factor	1.5 to 2		
Max.charging current that can be interrupted	0.7A		
Bearing type	Ball bearing		

2.2 Disconnector Drives:

The operating mechanism of disconnectors can be broadly classified into three types as

1) Manual operated
2) Manual winch operated
3) Pneumatic operated
4) Motor operated

Manual operated and manual winch operated method needs our human effort to operate an isolator switch. Hence they can't be used for systems above 245kV. The operating cabinet is suitably designed and gasketed for protection against water and dust. If the system voltage is 11kv or above, high torque is required to operate the disconnectors hence it is very difficult to operate manually. In such cases manual winch type operating mechanism is used. This mechanism uses gear assembly to reduce human efforts.

The pneumatic operating mechanisms are of single cylinder double acting piston construction actuating a rack and pinion arrangement for developing required torques. The linear piston movement is transmitted to the pinion which is engaged to the rack causing the output shaft to rotate. The main disadvantage of pneumatic operating mechanism is it needs more attention. Small leakages in pipe lead to mal operation of disconnectors.

Motor operated disconnectoruses squirrel cage induction motors for rotating the shaft to which the moving contacts are connected. Upto 245kV single motor can be used to operate all the three poles of an isolator after that we have to use separate motor for each pole of isolator.

2.3Terminal Connectors:

In order to connect the transmission lines to the terminals of isolators terminal connectors are used. It should have sufficient mechanical strength to withstand the weight of transmission lines. The connector is cast with aluminium alloy to grade LM6 of specification BS1490. It should have good corrosion resistance. For 220kV and 400kV systems corona free connectors are designed so that under fair weather operating conditions the voltage gradients at the connector surface will be at a level that will not cause corona.

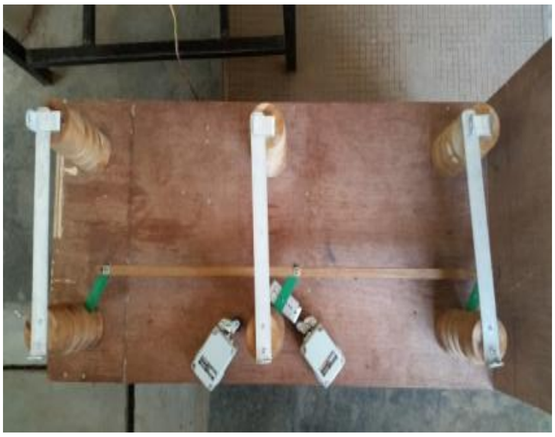


3. FABRICATION OF ISOLATOR

For making the prototype of air break disconnector we have replaced the insulator in original assembly with wood. We have used 25*3mm aluminium flat for moving contact. The isolator contacts in the closed and positions are shown below.


The three moving isolators are connected by means of wooden stick so that they can open and close at the same time.Motor shaft is connected to the middle isolator so that the load can be equally divided. The entire arrangement with the motor is shown below.


Once the contacts have completely closed or opened, motor should be automatically turned off. For this purpose two limit switches are used. The limit switch arrangements are shown below.



At present, gear boxes are used to reduce the speed of motor in motor controlled air break disconnector. We have replaced the gear box with a Variable Frequency Drive which is also a energy efficient practice.

The control circuit for operating the motor in both forward and reverse direction, indication lamps and motor protection are shown below.

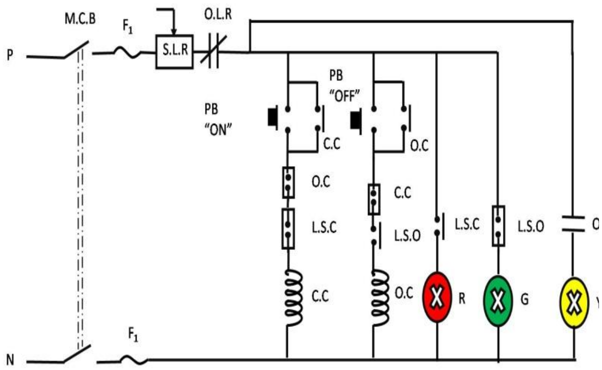
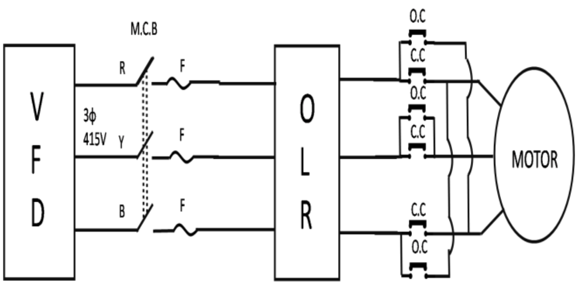


Fig. 3

The power circuit for isolator operation is shown below.



To close the isolator ON push button is pressed and Close Contact coil (C.C) gets energised. This will close the C.C contact in power circuit and hence motor rotates in normal direction. Once the isolator switch is closed in will press the limit switch close and RED lamp glows to indicate that the isolator is in operation. If OFF push button is pressed then Open Contact coil (O.C) gets energised. This will actuate the O.C in power circuit and phase sequence to the motor is changed. As a result the motor rotates in reverse direction. If the contact is opened completely it will press the limit switch open and GREEN lamp glows to indicate that the isolator is open. If the motor is overloaded overload relay will get actuated and motor is turned OFF. YELLOW lamp glows to indicate the abnormal condition.

Testing:

The commonly used tests for analysing the performance of isolators are,

- (i) Power frequency tests
  - (a) Dry and Wet Flashover Tests
  - (b) Wet and Dry Withstand Tests (One Minute)
- (ii) Impulse test
  - (a) Impulse Withstand Voltage Tests.
  - (b) Impulse Flashover Test
- (iii) Dielectric tests
- (iv) Temperature rise tests
- (v) Mechanical endurance tests
- (vi) Short circuit tests
- (vii) Milli volt drop tests
- (viii) Operation tests

Special Tests:

There are certain special tests that are performed mainly on the demand of the customers and the location where it has to be operated. Some of the special tests are

1. Pollution tests
2. Seismic tests

We have done some tests which can be performed with the resources available in our college.

4. TEST TABULATIONS

4.1 Milli volt drop test

Before heat run test:

Bill of materials:

Equipment's	quantity	Cost per equipment (rupees)	Total cost (rupees)
0.5hp 3phase motor	1	6050	6050
Variable Frequency drive	1	14450	14450
Power Contactor	2	914	1828
Auxillary contacts	2	150	300
Push button	3	36	108
Indicating Lamp	3	30	90
Over Load Relay	1	500	500
Limit switch	2	232	464
Circuit breaker	1	900	900
Design cost			4000
Total amount			28690

After heat run test:

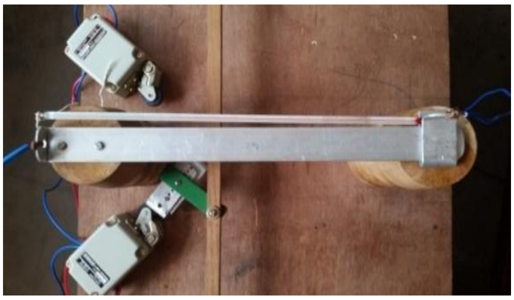


Fig. 4

4.2 POLLUTION TEST:

Phase connection		Insulation value(MΩ)			
		25%	50%	75%	100%
R	Y+B+E	125	80	50	40
Y	R+B+E	110	60	40	30
B	R+Y+E	250	200	160	100
R	R	600	500	400	300
Y	Y	130	100	80	70
B	B	1100	800	700	200

4.3 INSULATION TEST:

R	Y+B+E	150MΩ
Y	R+B+E	125MΩ
B	R+Y+E	350MΩ
R	r	800MΩ
Y	Y	150MΩ
B	B	1500MΩ

S. no	Current (A)	Voltage drop (mV)			Resistance (MΩ)		
		R	Y	B	R	Y	B
1	0.2	0.9	1.1	1.0	4.5	5.5	5
2	0.4	2.1	1.8	1.8	5.25	4.5	4.5
3	0.6	3.2	2.5	3.1	5.33	4.17	5.17
4	0.8	3.8	3.7	4.2	4.75	4.63	5.25
5	1	4.2	5.2	4.6	4.2	5.2	4.6
Average resistance					4.806	4.8	4.90

5. RESULTS

S. no	Current (A)	Voltage drop (mV)			Resistance (MΩ)		
		R	Y	B	R	Y	B
1	0.2	0.7	0.8	0.5	3.5	4	2.5
2	0.4	1.7	1.8	1.6	4.25	4.5	4
3	0.6	2.5	2.6	2.2	4.16	4.33	3.67
4	0.8	4.7	4.6	4.3	5.87	5.75	5.37
5	1	5.5	6.3	5.9	5.5	6.3	5.9
Average resistance					4.65	4.97	4.3

1) The millivolt drop test was performed and the contact resistance was measured in all three poles through DC current injection.

2) The heat run test was conducted by injecting an AC current of 20Amperes in all three poles simultaneously. The maximum temperature stabilise at 63^{o}C.Ambient temperature was from around 31^{o}C.Temperature rise was from 32^{o}C.As per standards, for aluminium maximum allowable temperature is 75^{o}C.

3) The physical condition of moving and fixed contacts were after temperature rise test ,the resistance measurement has revealed the same 4.6 milliohm.

4)The insulation measurements was carried out for the poles using 5KV insulation test.The maximum and minimum values were observed to be 125 MΩ and 1500MΩ which is quite adequate for 415V.

5) An artificial pollution test has been taken,minimum value of insulation was 40MΩ which is adequate for 415V.

6) Few mechanical open/close operation were made using Variable Frequency Drive. About 300

operations were made we couldn't observe any wear and tear at the main current contacts.

6. CONCLUSIONS

Air Break Disconnectors are the heart of any substation they are basically OFF load device they can be interrupt line charging current to the level of 0.7A.The design of this device is very critical from radio interference and corona discharge point of view. Also the clearance between isolator busbar junction and earth is very significant for avoiding flash over the contact profile, interlocks, creepage distance across isolator distance are all important in the design of air break disconnector to ensure reliable operation. Then is plenty of scope to introduce vertical break and pantograph isolators in power/substation. Such isolation will occupy lesser area of substation. Since, land cost is huge constraints for a power station we must explore the feasibility of using more and more vertical break/Pantograph isolators exact control design is critical and trouble free operation. Operation specification of isolator is equally important we could also explain the economic feasibility of VFD instead of mechanical gearbox in the future from every energy conservation point of view.

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