Concept Development for 100 A Ampere MCCB with ultimate breaking capacity of 50 kA.

Major Project Report

Submitted in Partial Fulfillment of the Requirements for

Degree of

MASTER OF TECHNOLOGY

IN

ELECTRICAL ENGINEERING

(Electrical Power Systems)

By

Shivam
14MEEE28

NIRMA UNIVERSITY
INSTITUTE OF TECHNOLOGY
NAAC ACCREDITED 'A' GRADE

DEPARTMENT OF ELECTRICAL ENGINEERING
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Undertaking For Originality of the Work

I **Shivam** , **Roll No 14MEEE28** , give undertaking that the Major Project entitled **" Concept Development for 100A Ampere MCCB with ultimate breaking capacity of 50kA "** submitted by me , towards the partial fulfillment of the requirements for the degree of Master of Technology in **Electrical Power Systems , Electrical Engineering** , under the Institute of technology of Nirma University , Ahmedabad is the original work carried out by me and I give assurance that no attempt of plagiarism has been made . I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere , it will be in severe disciplinary action.

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This is to certify that the Major Project Report entitled "**Concept Development for 100 A MCCB with ultimate breaking capacity of 50 kA**" by **Mr. Shivam (Roll No: 14MEEE28)** towards the partial fulfillment of the requirements for degree of Master of Technology (Electrical Engineering) in the field of Electrical Power Systems of Nirma University is the record of work carried out by him under our supervision and guidance. The work submitted has in our opinion reached a level required for being accepted for examination. The results embodied in this major project work to the best of our knowledge have not been submitted to any other University or Institution for award of any degree or diploma.

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Abstract

In the present scenario of MCCB of 100 A frame the present ultimate breaking capacity of 36 kA it has to be increased to 50 kA .This will be achieved by doing changes in the present system and present components with the same structure available volume cannot be increased its the prime concern. Arc chute design is to be changed accordingly to decrease the arc splitting time and so that low let through energy will be produced .And new contact spring to be designed accordingly.

Abbreviations

1)MCCB ———— Moulded Case Circuit Breaker
2)SCPD ———— Short Circuit Protective Device
3)CP ———— Contact Pressure

Contents

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Chapter 1

Introduction to Switchgear

1.1 Introduction to Molded Case Circuit Breaker

1.1.1 History and Development

MCCB's were first introduced in EUROPE and UNITED STATES after First World War. There has been continuous development in MCCB due to number of factors, such as market demands, performance, improvement, development of new material and advance in new technologies such as solid states and microprocessor based tripping and control systems.

Using the interruption capacity of an arc in air inside the molded case, the MCCB has been designed to interrupt current with range from few amperes to several kilo amperes. These developments have greatly increased the system flexibility of MCCB and it is now possible to tailor an MCCB to satisfy a wide range of applications.

Present day scenario shows MCCB in all low voltage (less than 1000 V) applications, in residential electrical distribution panel, in the industrial power distribution center, and in main power feed panels used in large buildings such as offices, hospitals, and shopping centers

1.1.2 Operation

The circuit breaker comprises of fixed and movable contacts. The contact can be opened and closed by an operating mechanism. From the release assembly to the moving contacts, the current carrying conductors known as 'braids' that are to be brazed. To the other ends of the braids, heating elements are fixed. Current flows from moving contacts through braids to heating element. During overload current, the bimetal which is fixed to the heating element gets deflected.

When short circuit occurs, the magnet is energized due to the magnetic force formed due high rush of current through the breaker due to the short. And the release assembly is energized. Both these operations results in movement of trip plate and consequently tripping of the breaker, opening the contacts (moving and fixed contacts) and breaking of circuit. The breaker has to be reset before switching it on again.

1.1.3 Features Of MCCB

All the parts of the circuit breaker are enclosed in the molded housing, which is made of heat resistance insulating material. Only terminals are accessible for external connections. Operating knob gives a clear trip indication. It assumes a position midway between ON and the OFF on tripping. The breaker is provided with magneto-thermal release which has three bi-metal to give thermal release for overload protection and electromagnets which offers short circuit protection

Operating mechanism is quick-make, quick break and Trip free. It is independent of manual operation. All releases operate on a common trip-bar, so that all the phases are disconnected even when a fault occurs at only one of them thus eliminates the possibilities of single phasing.

Contacts are of silver alloy which have long electrical life. The mechanism is so designed that there is no arcing on the current carrying parts of the contacts. The strong wipe action of the contact system keeps the contacts surface clear of oxide films. Terminals have large dimensions to accept links or cable lugs. Terminal configuration permits straight through cabling. Barriers with adequate clearance insulate adjacent phase terminals. Arc-chutes consist of profiled de-ion plates housed in special grade vulcanized fiber casing. Individual arc-chutes envelope each contact and draw the arc away from the arcing tips and thus quenching the arc.

1.1.4 MCCB Selection Criteria

In selecting MCCBs for motor protection application, the following points are to be taken care of:

1). The thermal rating of MCCB should be greater than or equal to the motor full load current.

2). The breaking capacity of the MCCB should be greater than or equal to the prospective fault current at its installation point.

3). The magnetic threshold of the MCCB should be selected in such a way so as to avoid nuisance tripping during starting of the motor.

4). The best protection can be provided by selecting a current limiting MCCB with only magnetic protection and a suitable thermal overload relay with matching motor characteristics.

5). The thermal characteristics of MCCB (if provided) should be such that it falls above the overload relay characteristics up to the magnetic threshold of the MCCB.

6). The contactor should be able to break any currents up to the magnetic threshold of the breaker.

7). The starter should be able to withstand the let-through energy of the breaker.

1.1.5 Applications Of MCCB

1).Distribution feeder Protection

2). Transformer Protection

3). DG set Protection

4). Motor Protection

5). Capacitor Protection

6). Protection for semi-conductor fuses

7). UPS Protection

Figure 1.1: Moulded Case Circuit Breaker.

MCCB	DN0	DN1	DN2	DN3	DN4
Rating	100A	250A	400A	600A	1200A
Breaking Capacity	36kA	50kA	70kA	70kA	70kA
Release	TM	TM	TM/MTX	TM/MTX	MTX

Table 1.1: Rating Table.

8). DC load Protection

1.1.6 Current limiting Technology in MCCB's

The standard on circuit breaker IEC 947-2:1989 and IS 13947 (Part-2): 1993-define current limiting breaker as the one with the break time short enough to prevent short-circuit current reaching its prospective value. As per UL standard, a current limiting breaker when operating within its current limiting range limits the let-through energy to a value less than the energy of $\frac{1}{2}$-cycle wave of the symmetrical prospective current.

In order to meet these stipulated requirements, the current limiting MCCB should have following properties: -

1.) Breaker must respond quickly in case of a fault.

2.) Arc voltage across the contact should be controlled properly to ensure proper arc extinction.

3.) The trip mechanism must operate quickly enough to co-ordinate with the rapidly moving contacts.

Chapter 2

Construction of molded case circuit breaker

2.1 Construction Of Molded Case Circuit Breaker:

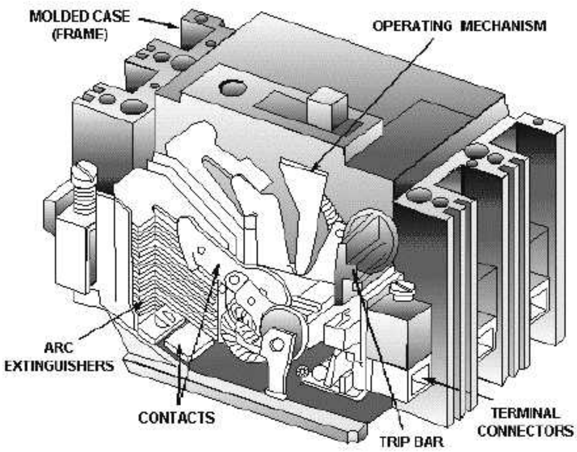

Figure 2.1: Internal Structure.

2.1.1 Basic Components Of MCCB

1.) Drive Shaft Assembly.
2.) Mechanism Assembly.
3.) Release Assembly.
4.) Upper Contact Assembly.
5.) Lower Contact Assembly.
6.) Arc Extinction Devices.
7.) Housing.
8.) Cover.

2.1.2 Drive Shaft Assembly

The drive shaft assembly mainly consists of the following-

1). Drive shaft
2). Upper contact
3). Insulator
4). Cup
5). Contact pin
6). Contact spring
7). Drive shaft link
8). Central pin

The drive shaft is made from SMC (sheet molded compound).The R and B phase of the drive shaft is composes of the assembly of the upper contact, cup, contact spring, insulator and pin. The upper contact is brazed to the copper braid, whereas the other end of the braid is brazed to the terminal. The Y phase of the drive shaft comprises of the above assembly along with the link at either ends of the contact with a pin inserted in the links. The upper contacts are made from coppers, which are silver. The links are of stainless steel.

2.1.3 Mechanism Assembly

The mechanism assembly consists of the side plates (two numbers), latch assembly (latch and the latch links), latch bracket, latch bracket spring and pins. The side plates are placed left and right of the latch. The latch assembly i.e. the latch and the lower links are riveted. The material of the side plates is of mild steel, which is then zinc plated. The material of the latch bracket and the latch is stainless steel. The latch bracket is held firmly by a pin against a torsion spring.

2.1.4 Release Assembly

The release consists of the following: -
1). Bi-metal
2). Heater
3). Magnetic assembly
4). Trip plate
5). Latch bracket mechanism assembly

The main function of the release is to trip the system at fault condition. It consists of bi-metal, magnet and heater. Bi-metal sensitivity is different for different ratings. Magnet is made of mild steel with zinc plating.

In MCCB both thermal and magnetic releases are used. A typical time current characteristic of MCCB is as shown in fig. Whenever there is overload thermal relay is energized i.e. bi-metal begins to bend.

The bending of bi-metal may be direct or indirect. As the overload current flows through the heater, adjacent to the bi-metal, the bi-metal bends as the temperature rises. A trip action is accomplished when the bi-metal deflects sufficiently to unlatch the operating mechanism. For different ratings of the breaker different bi-metals are used. In thermal release desirable delay time is built.

In case of short circuit occurs the magnetic release is energized. It is called instantaneous tripping. In this type of release both fixed and movable magnet are used. When fault current is produced the fixed magnet is energized which moves the trip plate (moving magnet) and thereby unlatches operating mechanism. It is possible to design an adjustable magnetic trip by varying the spring force and a thermal trip by varying the position of the trip plate.

Heater is the device used in breaker to generate the heat when the overload current flows through the circuit. These heaters are made up of different materials having different resistances, which depend on the range of breakers. Trip plate is the guarding component for operating the breaker. The bi-metal or the magnetic assembly senses the fault in the breaker, which further moves the trip plate to take the protective action i.e. it, makes the breaker trip.

2.1.5 Upper Contact Assembly

1). Contact finger
2). Upper contact button
3). Braid

Upper Contact finger and braids are made up of silver plated copper. Their thickness depends on the rating of the breaker. As the rating increases, thickness also increases. Contact button is made of silver alloy.

2.1.6 Lower Contact Assembly

1). Lower contact
2). Lower contact button
3). Arc runner

Lower contact assembly is also called as Incoming Terminal assembly. The thickness of the terminal changes as per the ampere range of the breaker. Generally contact button is brazed on lower contact and it is made of silver alloy.

2.1.7 Arc Chute Assembly

1). De-ion plates
2). Lining
3). Vent
4). Runner plate

2.1.8 Molded Case Housing

The external parts are the case and terminals. The molded case provides both, the insulation and the support structure for mounting all components. The entire internal assembly is first mounted into the case and then cover is put on the top.

The breaker case involves a multitude of design considerations. For example, it is important to consider not only the mechanical strength required to hold the stationary and moving parts but also the strength to withstand the magnetic force exerted though current carrying members, the thermal loading during short circuit interruption, and the gas pressure generation during high current arcing. For low voltages, the dielectric strength of case is adequate, although surface degradation may occur along the inside of case which faces the arcing chamber. The dielectric strength can be increased by appropriate selection of case material or by application of an arc resisting layer.

Chapter 3

Description Of Project

3.1 Project Description

3.1.1 Project Title

Concept development for 100 A frame MCCB with ultimate breaking capacity of Icu of 50kA

3.1.2 Description

In 100 A frame MCCB in present scenario the ultimate breaking capacity is 36kA and in this project it has to be increased to 50kA to meet the competition and challenges of this present world. The main aim of this project in the present and the same structure It has to be increased .

3.1.3 Objective

The main objective of this project is that 36kA of ultimate breaking capacity is to be increased to 50 kA in the same present structure . Main objective to be followed is to decrease the arc splitting time because as splitting time will decrease it will going to have low let through energy . As let through energy will be less it will not going to heat the breaker and melt the component of it. So to decrease this energy the main concentration is on Arc Chute designing .New arc chute is to be designed accordingly using Pro-E software and the thermal analysis of Arc chute is to be done in JMAG/ANSYS.

3.1.4 Present structure and analysis

In the present structure of the 100 A frame MCCB the upper and lower contact assembly is according to this figure in which upper contact is moving which is of 2.0mm with silver contact button . Which can bear upto 36kA. The lower contact is fitted arc runner to run the arc as early as possible.

Components to be Considered for changes

1.)Contact designing.

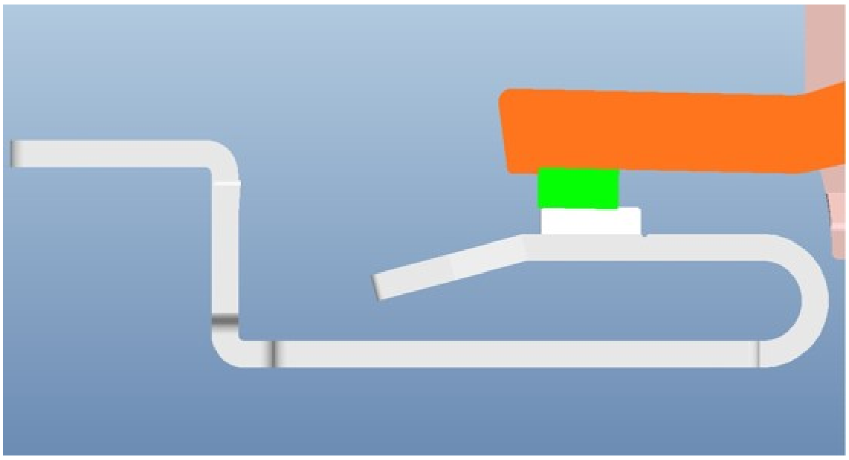

Figure 3.1: Upper and Lower Contact Assembly.

Contact of present system is around 2.0mm for the breaking capacity of 36kA to bear the force and heat produced due to 50kA will be more obviously to compensate it contact size has to be changed . It will be increased accordingly.

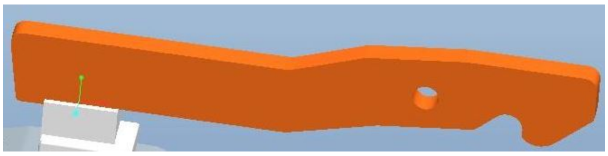

Figure 3.2: Upper Contact with Silver Button.

2.)Arc chute

To release the high heat losses which is produced due to the passage of 50kA in the 100A frame circuit breaker.New designing of arc chute and arc chamber to be designed accordingly. Each plate has to be designed .With some what sandwich structure.

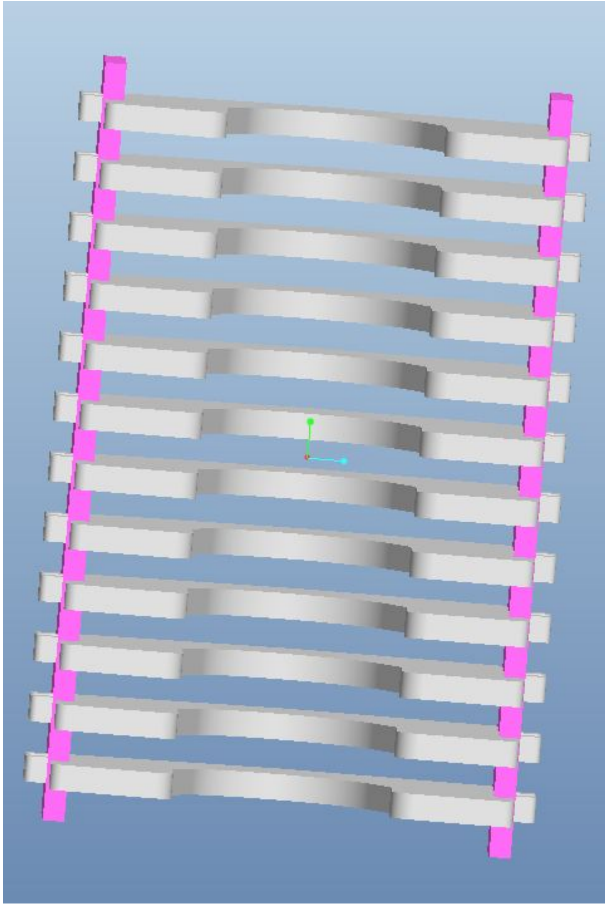

Figure 3.3: Arc chute plates profile.

3.)Ablative material.
This is the special type of material which is used in the arc chute plates . Actually it is in the form of sandwich structure. It works as when arc will be going to be attracted to mild steel plate this ablative material will going to ionise it more faster than if we kept only MS plates.

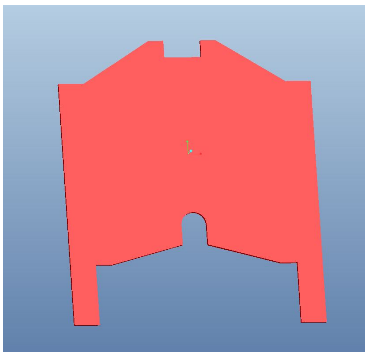

Figure 3.4: Ablative paper

4.) Spring To increase the contact pressure of the contact it is required to have some new design of spring as now according to this project breaker will now going to deal with forces which will be according to 50kA.

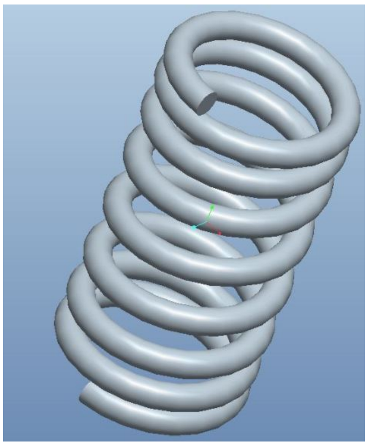

Figure 3.5: old spring

5.)Material of Contact button.

The contact button is used to make the contact between the two contacts that is upper and lower . Upper contact button is made up of normally AgNi and in the lower contact it is of AgCdO to make anode and cathode for the proper arc movement.

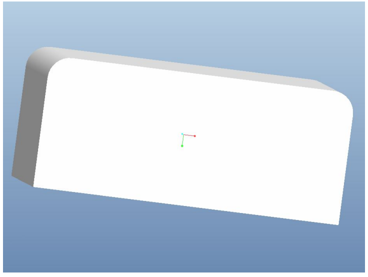

Figure 3.6: Contact Button

3.1.5 Analysis of Present System.

Short Circuit Analysis of 100 A Rating on 36 kA

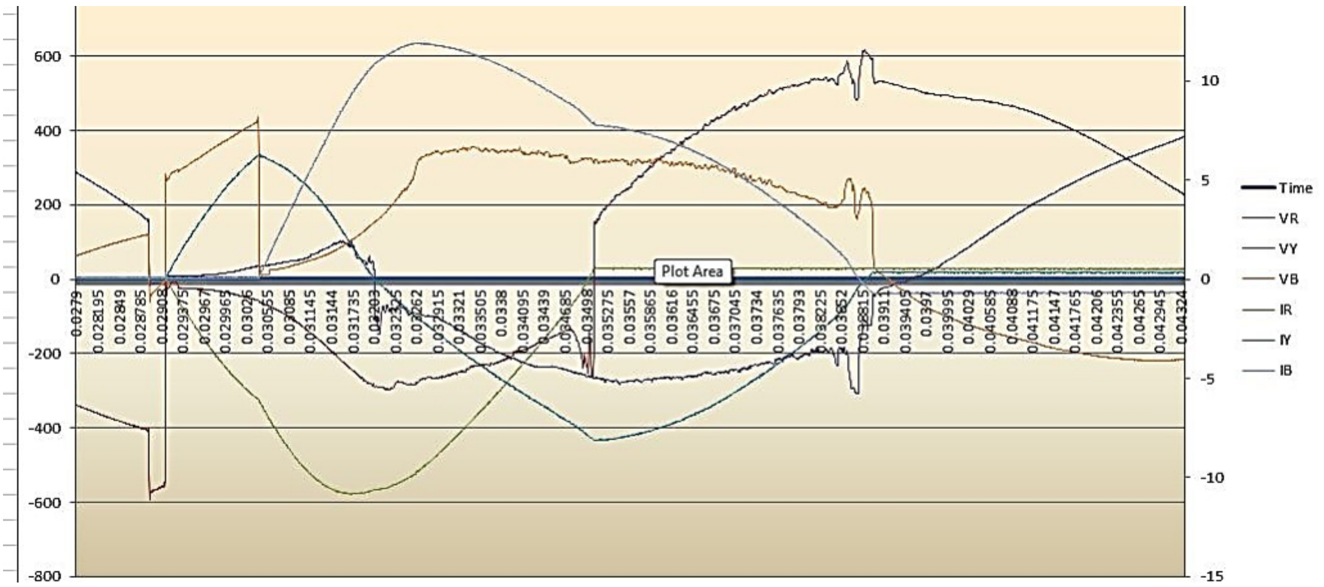

Figure 3.7: O Shot

Arcing time (s) [O Shot-18 kA]														
Total arcing time(sec)			Arc Build up Time(s)			Immobility Time (s)			Running Time (s)			Splitting Time (s)		
R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B
0.00349	0.00769	0.00767	0.00037	0.00089	0.00039	2E-05	9.5E-05	0.00015	0.00262	0.00256	0.00144	0.00048	0.00415	0.00569

Figure 3.8: O Shot

CO 1 Shot															
Arcing time (s)															
Slot Motor	Total arcing time(sec)			to (s)			ti (s)			tr (s)			ts (s)		
	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B
Without Slot Motor	0.006035	0.00992	0.00863	8.5E-05	0.00013	0.00015	0.00016	0.0014	0.00013	0.00248	0.000835	0.00178	0.00331	0.007555	0.00657

Figure 3.9: CO1 Shot

This is similar shot but according to standards I have to analyses it twice one on CO-1 shot and one on CO-2 shot. Actually , this helps us to give the more clear picture of tripping or arcing time of MCCB.

3.1.6 Expected Changes for Improvement

1) Changes in contact system designing and size.
2) Changes in Slot Motor
3) Changes in Arc chute (De-ion plates)
4) Changes in material of Arc chute casket to enable space and volume in the breaker.
5) Changes in the design of drive shaft spring.

Chapter 4

Explanation Of forces

4.1 Explanation Of Forces

4.1.1 Types Of Forces

(i) Nodal Forces
(ii)Repulsion Forces

4.1.2 Nodal Forces

These are the forces that exhibit inside the element and causes stress inside .Actually,these are the forces of finite element method.These are the force which exhibit through the environment through its nodes.It causes internal stress only.

4.1.3 Repulsion Forces

It is actually of two types and based on the principle of electromagnetic forces that is specifically repulsion and attractive forces due to magnetic field attraction due to uneven current distribution in present system contacts. In the 100A breaker the forces calculation is really important to know the present system statistics.

4.1.4 Types Of Repulsion Forces:

(i)Holms Force
(ii)Lorentz Force

4.1.5 Holms Force

The forces that operate on moving contact button and stationary contact button in 100A breaker and specifically due to the micro magnetic constriction forces on the two button because of its unsymmetrical mating of two buttons in the breaker.It depends on the material of the button as well.As un symmetric mating of the two buttons causes the current to constrict in the button due to erosion and deposition of carbon deposit it increase the resistance and hence current will constrict rapidly due to increase in resistance and force occurs.

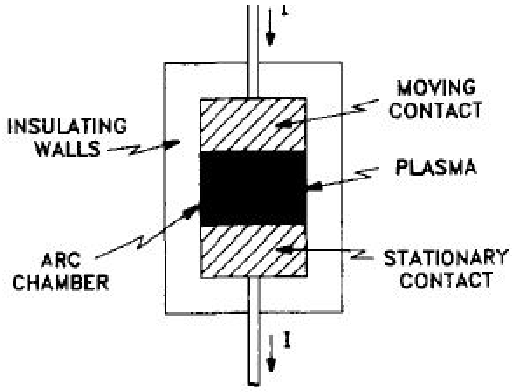

Figure 4.1: Plasma Formation.

A figure to show current constriction in the present contact. IT shows how the current pattern changes due to the different material button composition and flux distribution.

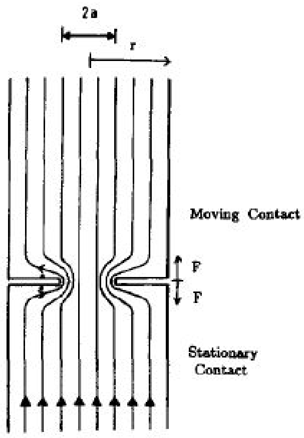

Figure 4.2: Current Pattern.

Equations required for the calculation of holms force:
A = B*L
where: A= Area of Contact
L= Length Of Overlap during Mating.
B = Hertz contact width
Now the full formula of "B"

$$\mathbf{b = 2*\sqrt{(2P/pi*l)*(2*(1-v^2)/E*(1/d1+1/d2))}}$$

Where: P = Contact Force between two contacts
E = Modulus Of Elasticity
v = Poisson Ratio
d = Diameter Of upper contact
D = Diameter Of Lower contact
Now, The Final Formula Of Holms Force
Note : Mu0 = K

$$\mathbf{F = (K*I^2)/8*pi*ln*((8*pi*H*A)/(K*I^2))}$$

4.1.6 Lorentz Force

This is the most important and the crucial force for any MCCB as whole of the process of any MCCB will depends on the contact repulsion force which is purely dependent on the Biot Savart Law of electromagnetics which can be explained as if current is flowing in the two parallel wires in the same direction it will attract each other and if the current is in opposite direction it will going to repel.As the contact of 100A frame MCCB upper contact the flow of current direction will be different from the lower contact and it will experience the lorentz force.
Actually , Lorentz force is comprised of both electrical and magnetic force.
Where:
Electrical Force due to electric field
F = q*E
Where:
F = Electrical Force
q = charge
E = Electric field
Magnetic Force due to magnetic field
F = q*(v*B)
Where:
F = Magnetic Force
q = charge
v = velocity of charge
B = Magnetic Field
Total Lorentz Force:

$$\mathbf{F = q{*}E{+}Q{*}(v{*}B)}$$

4.1.7 Spring Forces

Accordingly,In 100A frame MCCB there are three springs in the drive shaft which is straight extension spring that is when operated remains in compressed mode and applies the pressure on the contact which is properly known as contact pressure.
Actually there are three springs in the drive shaft with contact release if it is three pole otherwise it will be four for four pole breaker .And there will be constant two springs in the Latch mechanism irrespective of the number of poles.
Condition For Normal Operation
3*l <2*K
Where:
l = Spring Force of drive shaft spring
K = Spring Force of Latch Mechanism
According to the standards IEC 60947 part 1 the contact pressure should be above 220gf.

Chapter 5

Mathematical Modeling Of Present System

5.1 Mathematical Modeling Of Present System

5.1.1 Contact Pressure Calculation

New spring Introduced which is a compression double conical spring.

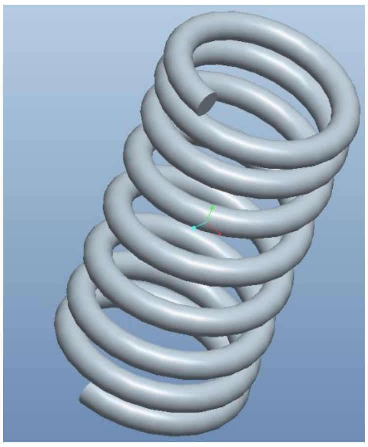

Figure 5.1: Extension spring

Existing Spring Data
Free length Of spring = 10.745+/-0.5
Spring force at 10.74mm length(Kg) = 0
Wire diameter(mm) = 0.5
Mean Diameter Of Coil(mm):= 2.35+/-0.5
Total Number Of turns = 7
Input Parameters
Compression Length L(mm) = 3.63
Force at L(Kg) = 2.438
Angle between the spring force and the useful force = 3.03
Component Of spring force along hinge point (F) Kg = 2.435
Perpendicular length Calculated From Pro-E

From hinge point to force line (L1) (mm) :7.3
From hinge point to mid plane of contact buttons (mm) = 29.87
Contact Pressure
Contact Pressure F2 *L2 = F1* L1
F2(Kg) = 0.595

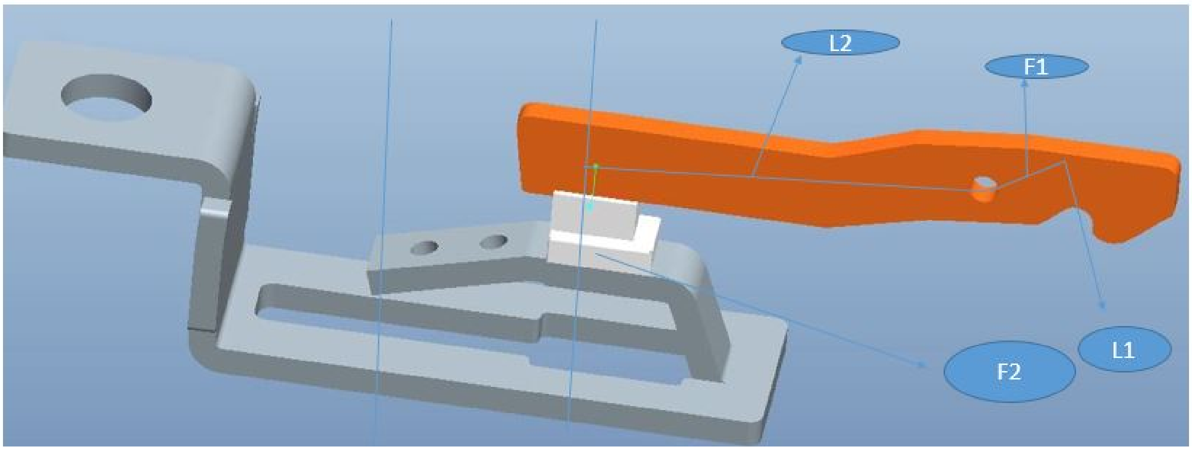

Figure 5.2: Displaying Of Force

5.1.2 Holms Force Calculation

Material Properties
Contact Material: AgNi (80% to 90%)
Modulus Of Elasticity(Kg/mm^2) : = 7379.7
Modulus Of Elasticity(N/mm^2) : = 72321.06
Poisson Ratio(v) : = 0.322
Hardness Of AgNi in various Units
(HV) : = 90
(MPa) : = 882.63
Kg/mm^2: = 90.02
N/mm^2:= 882.27 **The effective area Of contact**
A = B*L

$$\mathbf{b = 2{*}\sqrt{(2P/pi * l) * (2 * (1 - v^2)/E * (1/d1 + 1/d2))}}$$

Input Parameters
Diameter Of Upper Contact CM00020 d1(mm): = 190
Diameter Of Lower Contact d2(mm): = 310
Contact Pressure in (N): = 5.83
l(mm): = 7.3
Calculations:
E*((1/d1) + (1/d2)) (N/mm^3) = 613.93
2*(1-(v^2)) = 1.79
(2*P)/(3.14*l) (N/mm) = 0.508
2*(10^7)*H*A = 9928796988
From Equation 1 :

Hertz Contact Width (mm) = 0.077
Area Of Contact (mm^2) = 0.562
Accordingly, Holms Force Of 36kA for the present system is calculated from Eq 2 is around **131.94 N**
As short circuit capacity is to be increased from 36kA to 50kA obviously the force will also increased and it is coming around **172.39 N**

5.1.3 Lorentz Force Calculation

INPUT PARAMETERS
Overlap Length (mm) = 4.8
Distance between two contacts (mm) = 8.05
Height Of lower contact and upper contact (b) (mm) = 2
Average width Of lower contact and upper contact (a) (mm) = 5.83
Ratio (b/a) = 0.343
Ratio (d/a) = 1.38
From Dwights chart (k) = 1.03
Ratio (d/k) (D) = 7.815
Extra length c1 (mm) Current isn't flowing in this part = 0
Extra length c2 (mm) = 30.95
$C1 = ((1+(c1/l))^2 + (d/l)^2 - (c1/l)^2 + (d/l)^2)^{1/2}$
C1 = 0.2755
$C2 = ((1+(c2/l)^2 + (d/l)^2 - (c2/l)^2 + (d/l)^2)^{1/2}$
C2 = 0.971
Now ,Finally the lorentz force will be calculated :

$$\mathbf{F = 2 * 10^{-7} * I^2 *(l/D) * [C1 + C2]}$$

According to current value 0f present short circuit capacity 36kA the force will come around using above formula : = **198.58 N**
As the breaking capacity has to be increased to 50kA the force will increase and it will come out to be: = **383.07 N**

Chapter 6

New Concept Developed and Simulation Result

6.1 New Concept Developed and Simulation Result

6.1.1 Concept regarding contact system

As from the previous chapter we came to know that both the force that is Holms and Lorentz force is increasing and as the housing of the breaker is to be kept same so in that case contact release design and size to be changed to bear that force.
Accordingly , breaker available space is checked and contact size is increased to 2.5mm from 2.0mm .It has been increased such that the heat loss occured in the contact and inside the breaker should not be 15% from the loss occured due to the 36kA breaking capacity . Otherwise , it will going to heat and melt the housing also. Due to high amount of current various internal stress developed in the contact and bending of contact is also seen in previous contact of 2.0mm when tested on 50kA.

6.1.2 Mathematical Modeling for increment in size in present contact

For simplicity whole contact is considered to be a cubical .
Old Contact considered
L = 45.35mm
B = 6mm
H = 2mm
Area of the contact = 2*((L*B) + (B*H) + (H*L))
A = 749.6mm^2
Resistance Of the contact = (P*L)/A
Where: P = Resistivity Of copper = 1.7 * 10^5 ohm mm
L = Length Of Conductor
A = Area Of Conductor
Resistance Of Conductor = 0.102*10^5
Heat loss due the resistance of conductor = I^2 * R
Actually , it comes out to be =**1321W**
Now, It is to be calculated For 50kA breaking capacity :

New Contact to be Considered :
L = 45.35mm
B = 6mm
H = 2.5mm
Area of new contact = 2 * ((L*B) + (B*H) + (H*L))
A = 821.45mm^2
Resistance Of the conductor = (P*L)/A
where: P = Resistivity of copper
L = Length Of the Contact
A = Area Of the contact
Resistance = 0.0962 * 10^5
Heat loss due the resistance of conductor = I^2 * R
Actually , it comes out to be =**2341W**
As , seen that the heat loss is increasing by increasing the breaking capacity from 36kA to 50kA . To dissipate this amount of heat a new arc chute has been designed to dissipate it.

6.2 New Arc chute Design

To dissipate this amount of heat a efficient arc chute is needed in which new plate is designed with ablative paper which is used to attract the arc and ionise it faster . Some US patents and IEEE papers is being reffered by which information we get is that plates with uneven length will be more efficient to extinguish the arc plates should be smaller from lower side and huge from higher side to attract more arc.
New Concept in upper plate

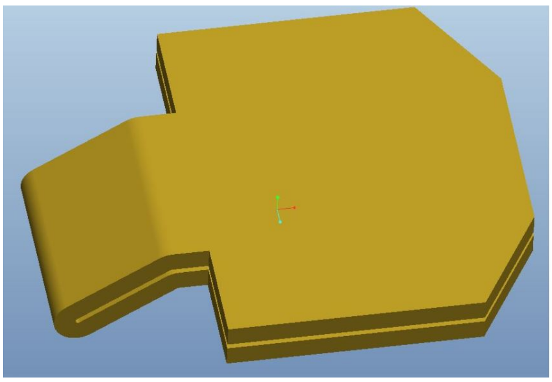

Figure 6.1: Upper Plate

This is new Concept which has been thought by refering many papers and final design comes out to be like this . As it is known that it is the upper plate at the time of contact opening the upper contact will open and finally rest on the upper plate edge which is shown extruded as the contact will rest on it and going to form the physical contact due to which arc will finally transfer into it so flashover possibility and at the time reclosing arc will not come back.
To release out heat in a more efficient manner
Two Ways have been adopted :
Change in the Arc chamber.

Change in the Slot Motor.

(I) : Change in the Arc chamber :

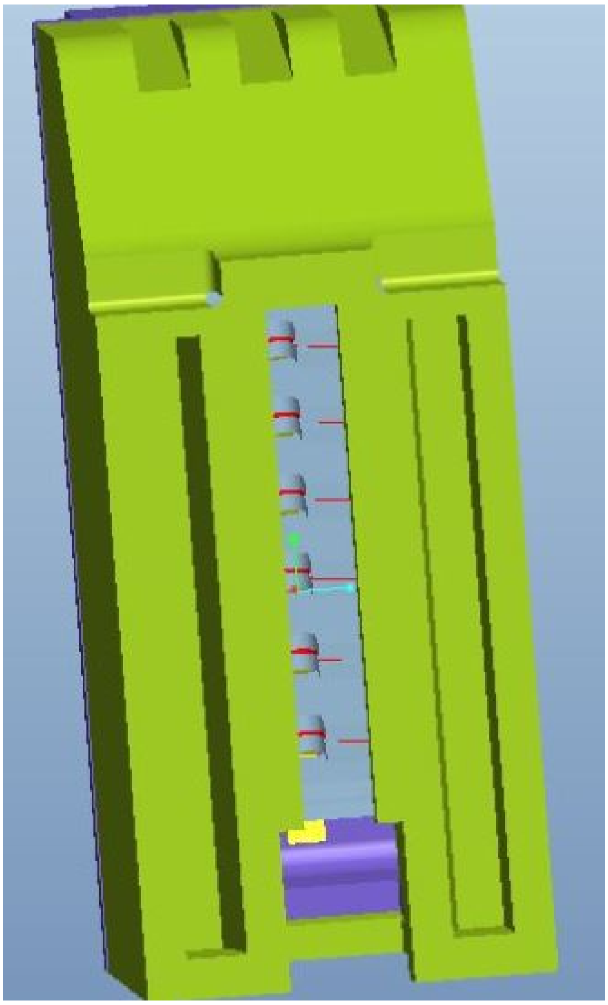

Figure 6.2: New Arc chamber

(II) : Change in Slot Motor :

Slot motor is being changed from the plates version to single rod or we can say a bar version this helps in decreasing the time of splitting and material is also reduced and hence the cost and volume required will also be required less.

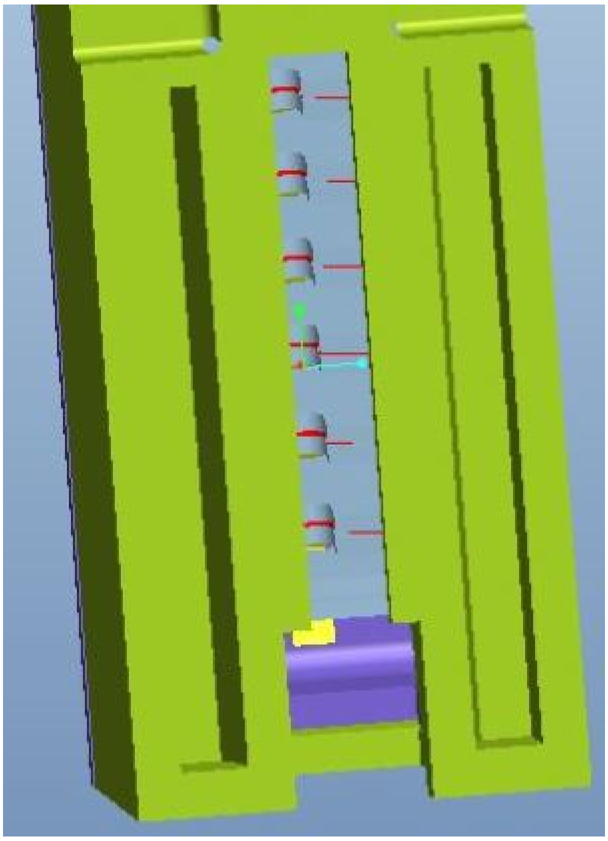

Figure 6.3: Slot Motor design

Slots which can be seen in the figure from the front two bar of the slot motor can be inserted inside which is of mild steel to attract the contact.
Changes done with respect to previous arc chamber:
In the previous Arc chamber the slot motor fixture and the plate fixture is not in a single unit but on checking it on around 50kA in short circuit testing it get damaged and burnt out completely.
To overcome this a single unit with single riveting used is recommended and with better vent system is recommended. So that easily all the hot gas pressure can vented out more easily .

6.2.1 Changes in material:

In the old and existing structure of Arc chute thermoplastic material is used which is of glass fibre in which the composition of nylon 6/6 and polysterene.

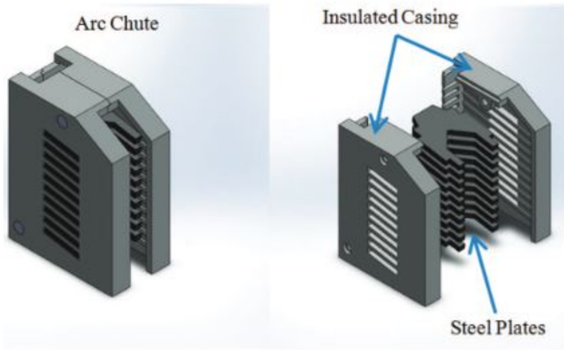

Figure 6.4: Arc chute with thermoplastic material

Waveform Captured during short circuit testing of old Arc chute:

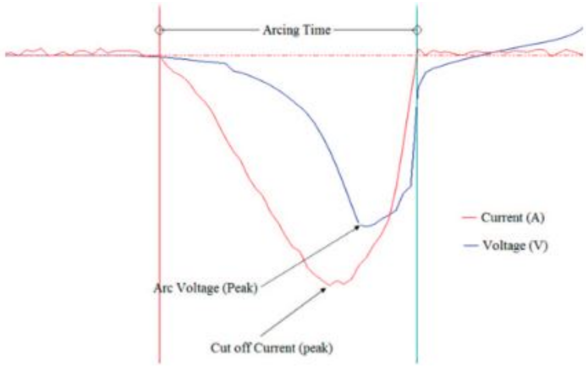

Figure 6.5: Pattern of breaking current and recovery voltage

A comparison table has been taken from IEEE paper which shows the complete comparison of all the material.

Table 1. Results of 10-kA Short-Circuit Tests of Molded-Case Circuit Breakers.

Arc-chute material	Peak cut-off current (kA)	Arcing time (ms)	Peak arc voltage (V)	Arc voltage rate of rise (V/ms)	$I^2t \times 10^3$ (A^2s)	Estimated soot formed (mg)
Thermoset	9.09	9.81	274	46.3	378	73
PA-66 Akulon® S227C	9.07	6.96	359	58.3	288	11
PA-46 Stanyl® TW341	8.55	7.15	422	66	225	19
Fiberglass-filled PA-46 Stanyl® CR310	7.96	7.94	374	55	176	31

Figure 6.6: Comparison Of Different material don short circuit test.

Fault current comparison of both thermosetting plastic and thermoplastic

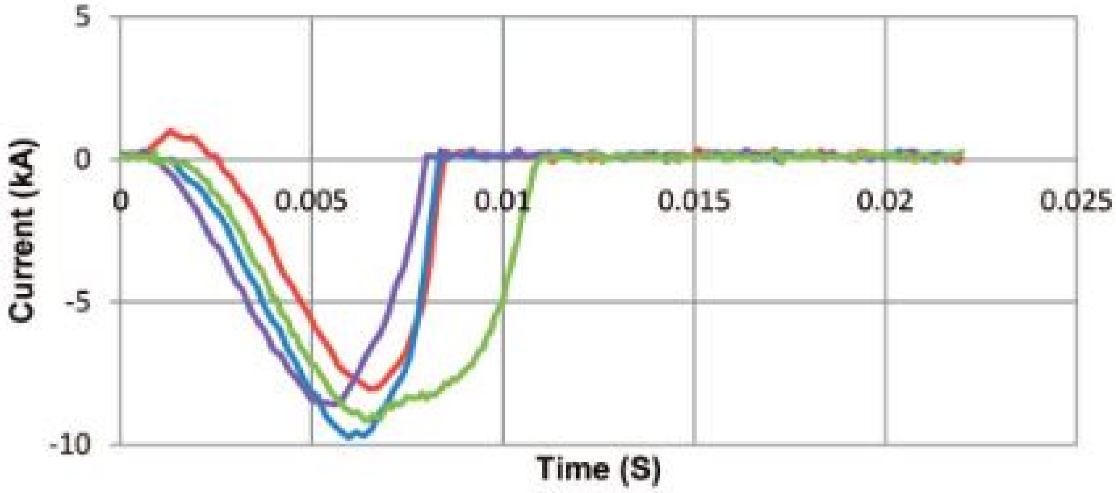

Figure 6.7: Arc current comparison.

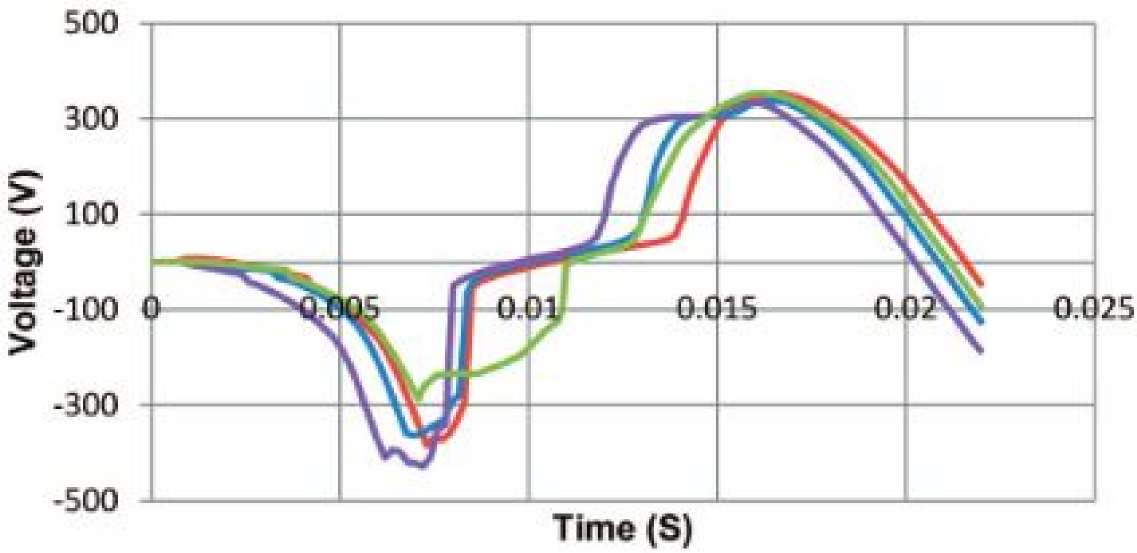

Figure 6.8: Arc Voltage comparison.

6.2.2 Thermal analysis of present contact system in JMAG

A JMAG analysis of present contact system is being done and various heat loss has been detected and accordingly design is being done. The analysis is done on Steady state and accordingly heat loss of various part is as follows:
Total Heat Generation: (W)
Part 1 = 9.31E-02
Part 2 = 3.73E-03
Part3 = 2.74E-04
Part4 = 5.25E-02
Part5 = 3.15E-03
Average Temperature in deg C:
All Part is = 4.88E+02

And heat flow is: 6.22E-02 W Part1 = upper contact
Part2 = lower contact
Part 3= upper contact button
Part4 = lower contact button
Part5 = Heater

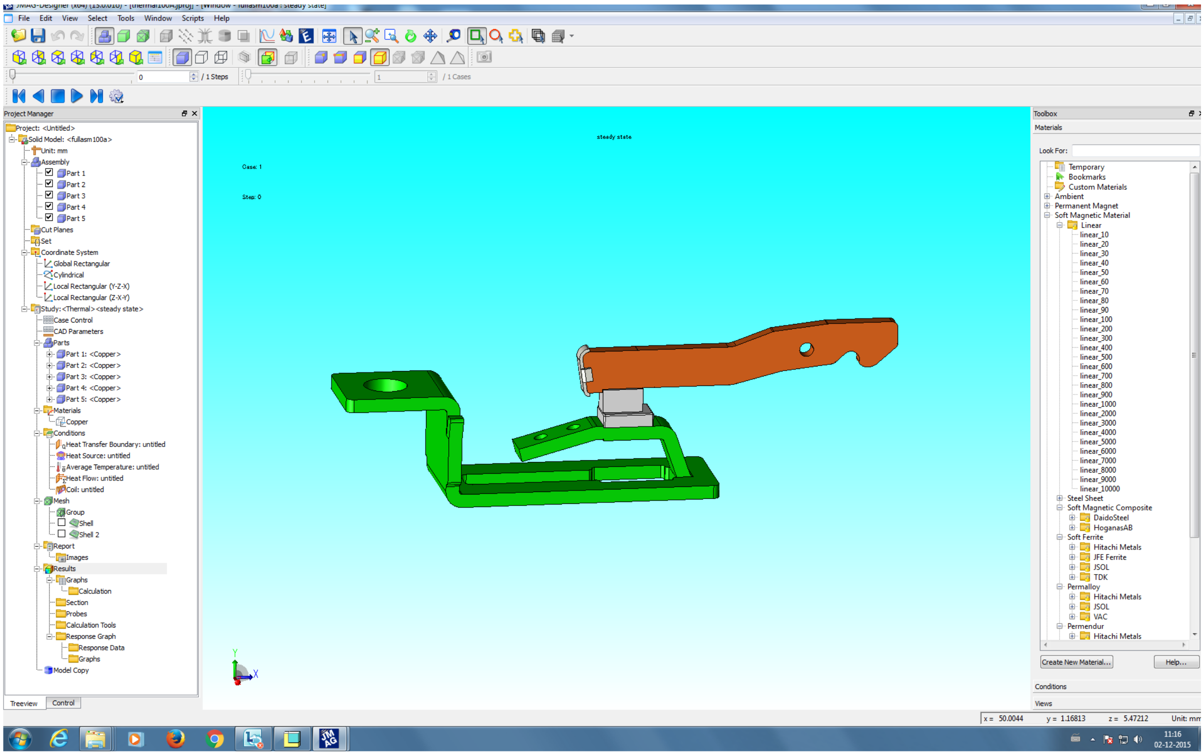

Figure 6.9: JMAG simulation

Chapter 7

Analysis,Testing and Short Circuit Results

7.1 Thermal analysis on single plate of Arc chute

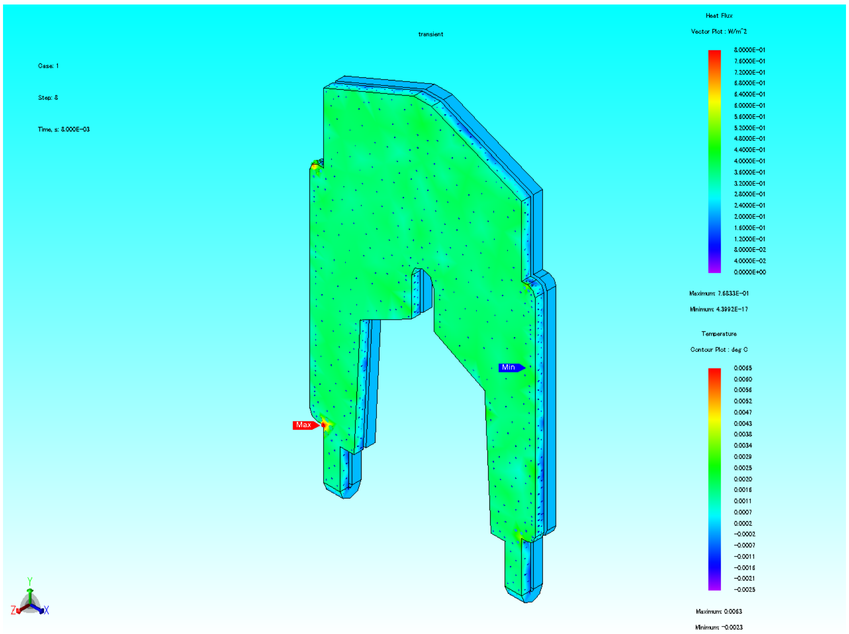

Figure 7.1: JMAG Thermal Analysis

This is the simulation done on one of the plate of arc chute to know the average temperature and total heat generation across it its volume is around 301.6 mm^3. As it is seen that heat is distributed equally over the surface of arc chute plate due to the symmetrical structure and as this plate is having the sandwiched structure but not having the ablative material so the space between the two plates of around 0.1 mm is helping in reducing the average temperature and total heat generation in Watts.

7.2 Average temperature variation across the plate.

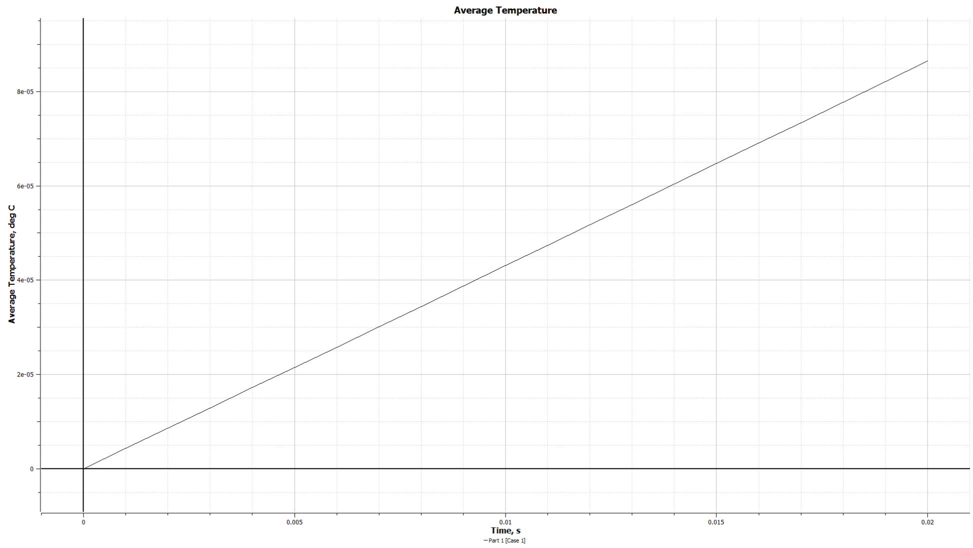

Figure 7.2: Average temperature in deg C

From this graph it can be interpreted that average temperature is increasing linearly across the single plate over a cycle of 20ms.It is due to the symmetrical structure of plate.

7.3 Total Heat generation in the plate.

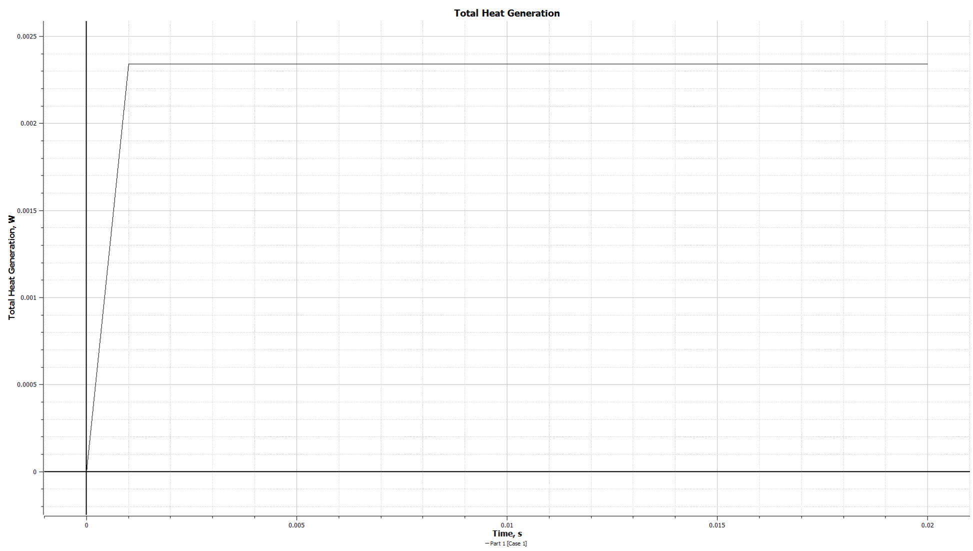

Figure 7.3: Total heat generation in Watts

From this graph it can be seen that heat generation in single plate is around 0.025W after the completion of 20ms.

7.4 Analysis of short circuit results

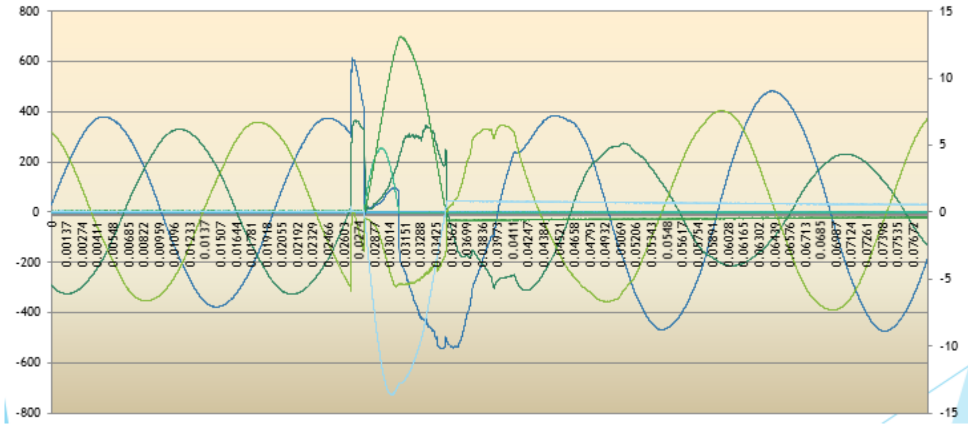

Figure 7.4: Short circuit waveform

This is the waveform generated after the short circuit results and in which it can be seen that in B-pole there is a huge peak due to which it can be said that splitting time is being increased by some milliseconds.

O Shot															
Arcing time (s)															
Slot Motor	Total arcing time(sec)			to (s)			ti (s)			tr (s)			ts (s)		
	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B
Without Slot Motor	0.006035	0.00992	0.00863	8.5E-05	0.00013	0.00015	0.00016	0.0014	0.00013	0.00248	0.000835	0.00178	0.00225	0.006555	0.00757

Figure 7.5: Analysis Result

From this result arcing time is recorded and it can be easily judged that a spectacular change is seen in splitting time results which is being reduced by one to two millisecond but some unexpected result is being achieved with B-pole. In which amount of splitting time is being increased by one millisecond.
For which changes has to be done in the designing of arc chute to compensate for the same unexpected result.

7.5 After Effect of short circuit results

On performing the short circuit test performance on on breaker having a new arc chute on prototype carbon deposition is being seen and severe effect is visible on B-Pole of the breaker.

Figure 7.6: Burnt Contact

This is a burnt contact after the short circuit test performed on the breaker with new prototype of arc chute . Due to the increment in splitting time heat produced is so high that it has burnt the whole contact and the button is is completely eroded.

Figure 7.7: Burnt Arc chute

7.6 New Arc chute design

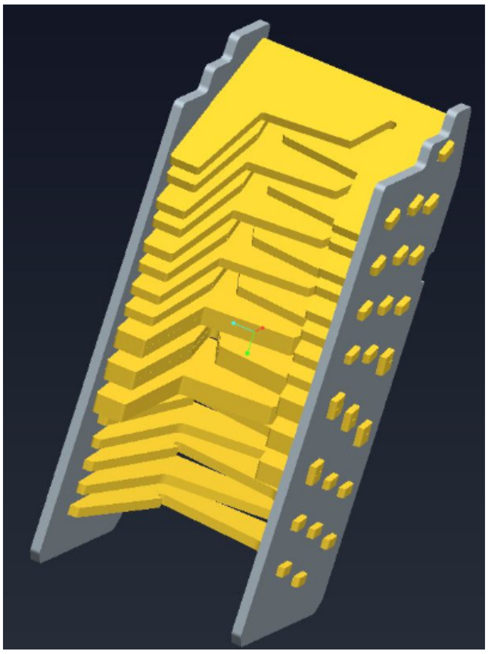

Figure 7.8: Arc chute

This is arc chute which is being designed accordingly in which new zig -zag structured design is being adopted to increase the resistance and hence decrease the current and hence increase the RRRV (Rate of rise of restriking voltage) which is further given by (dV/dT) . For faster splitting of arc it should be high and by giving more zig-zag structure we can achieve this as amount of resistance is increased.
In this new arc chute design sandwiched structure is not been taken only profile of the each plate is being changed in the design.

Chapter 8

Flow Chart,Future Scope and Conclusion

8.1 Flow Chart

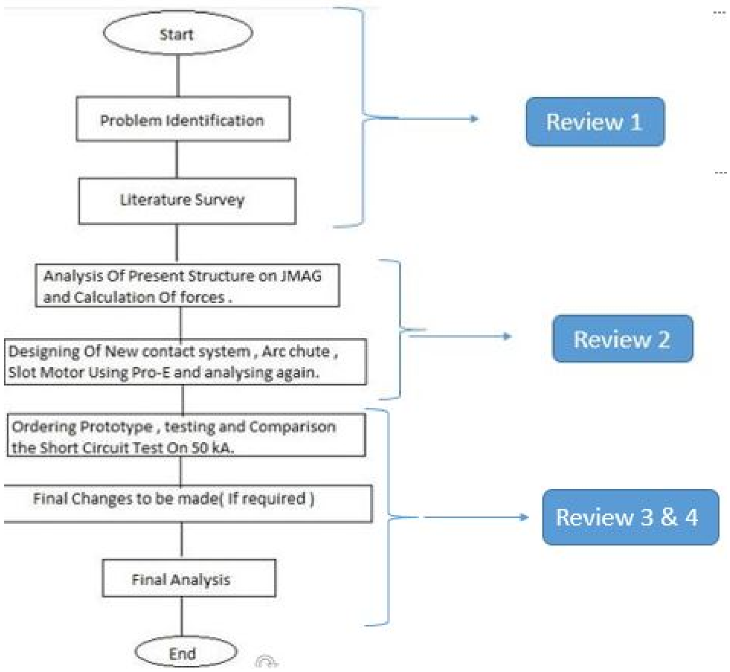

Figure 8.1: Flow Chart

8.2 Future Scope

After successfully designing , software analysis and practical test bench testing of new Arc chute it can be seen that by using or implementing this in the present frame of MCCB will going to increase the ultimate breaking capacity. Further in this project the improvement of short circuit performance for 50 kA and saving of silver button can be done accordingly.

8.2.1 Conclusion

In prior to the whole project and its proceedings accordingly the tests and various simulations is being performed on JMAG/ANSYS software and following conclusions is being made that for increasing the breaking capacity from 36kA to 50kA of 100 A ampere breaker specifically the splitting time is to be reduced but the point of concern is that why to reduce the splitting time so the reason is that if splitting is reduced the gas pressure which is produced will be more and hence to increase that the arc chute design to be changed and most appropriately the designing new arc chute plates . The design of arc chute plate is to increase restraining voltage by increasing the resistance and hence the voltage that is the attraction force .
Various mathematical modeling of forces is being done and also validated from software analysis and also mathematical modeling of contact spring is being done and also mechanical endurance test is being performed and result is quite good mechanical life is being improved by 10,000 operations . Various short circuit tests results on 36 kA and 50 kA is being performed .[2]

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