Improvement of Reliability performance in 100A current rating frame of MCCB

Submitted By
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Improvement of Reliability performance in 100A current rating frame of MCCB.

Major Project Report

Submitted in partial fulfillment of the requirements for semester-IV of

Master of Technology
In
Electrical Engineering
(Electrical Power Systems)

By

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Certificate

This is to certify that the major project report entitled **"Improvement of Reliability performance in 100A current rating frame of MCCB."** submitted by **SOMPURA YASH SATISHKUMAR (17MEEE13)**, towards the partial fulfillment of the requirements for the award of degree of Master of Technology in Electrical Engineering (Electrical Power Systems) of Nirma University, Ahmedabad is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Statement of Originality

I, **SOMPURA YASH SATISHKUMAR**, Roll. No. **17MEEE13**, give undertaking that the Major Project entitled "**Improvement of Reliability performance in 100A current rating frame of MCCB.**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Electrical Engineering (Electrical Power Systems)** of Institute of Technology, Nirma University, Ahmedabad, contains no material that has been awarded for any degree or diploma in any university or school in any territory to the best of my knowledge. It is the original work carried out by me and I give assurance that no attempt of plagiarism has been made.It contains no material that is previously published or written, except where reference 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 result in severe disciplinary action.

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Date:
Place:

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Endorsed by
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Acknowledgements

With huge pleasure, I would like to present this report on the thesis work related to" Improvement of Reliability performance in 100A current rating frame of MCCB. " I am very thankful to all those who helped me for the successful completion of the thesis and for providing valuable guidance throughout the project work. It is a pleasurable aspect that I have now the chance to express my thanks towards them.

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I would also like to acknowledge Larsen &Toubro Electrical and Automation, Switch gear Design and Development Center, Vadodara for permitting me to carry out this thesis work in industry. I am thankful for providing all kind of required resources. A special thank to Dr.AlkaMahajan, Hon'ble Director, Institute of Technology, Nirma University, Ahmedabad for the kind support and providing healthy research enviornment and basic infrastructure.

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Abstract

Molded case circuit breakers (MCCB) are basically short circuit protective device (SCPD) which is used for Short circuit and Overload protection. MCCBs are generally used in industries, commercial, institutional buildings, Motors, Transformers, Distribution system and DG sets etc. for protection against short circuit faults and overload faults.
This project focuses on 100A current rating frame of L&T MCCBs. Project scope is to improve reliability of MCCB in terms of short circuit and Overload performance as per IEC 60947-2 standard. Project involves analysis of failure, identification of root cause, development of concepts to improve the performance, evaluation of concepts through simulation study by using Design modeling and Simulation Software. Prototype and physical sample testing and validation of best suitable concept for its effectiveness.

Abbreviations

MCCB	Moulded Case Circuit Breaker.
SCPD	Short Circuit Protective Device.
TAC	Trip Alarm Contact.
CP	Contact Pressure.
OT	Over Travel.
SC	Short Circuit.
UTS	Ultimate Tensile Strength.
FOS	Factor Of Safety.
MS	Mild Steel.
HV	High Voltage.
EET	Electrical Endurance Test.
MET	Mechanical Endurance Test.
TR	Temperature Rise.
FEM	Finite Elements Method.
Ag	Silver.

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Chapter 1

Introduction

1.1 History and Development

After the first world war MCCB is first introduced in united sates and Europe. There has been continuous increase growth in MCCB due to number of factors,such as market demands,quality performance,improvement,development of new material and advance technologies such as solid states and microprocessor based tripping and control systems.

1.2 Operation

MCCB is current interrupting device. Operating mechanism used for open and closed operation of circuit breaker.It contains two contact,first is fixed contact and second is moving contact.From the release assembly to the moving contacts, the current carrying conductors known as 'braids' that are to be brazed. Heaters are fixed on the other side of the braids,Current flows from moving contacts through braids to heater. During overload current, the bi-metal strip is fixed to the heaters gets deflected. During any abnormal condition such as short circuit condition,there is high inrush current flow through the breaker and this current generate electromagnetic field in fixed magnet and it attracts moving magnet. Due to the Movement of moving magnet cause rotation of trip plate and MCCB is operated to interrupt the high current.The breaker has to be reset before switching it on again.

1.3 Current limiting Technology in MCCB

As per US standard when MCCB operate at current limiting range it limits the let through energy which is less than the half cycle of symmetrical prospective current to meet specified need.

Properties of current limiting MCCB.

- In case of Any fault, Breaker must be respond quickly.
- Arc voltage generate through the contact of breaker should be control properly to confirm arc extinction.
- The trip mechanism must work rapidly enough to co-ordinate with the quickly moving contacts.

- Design of circuit breaker contact has been shown in figure. In this design direction of current is opposite in both contact of breaker so force is opposite at the time of short circuit condition.

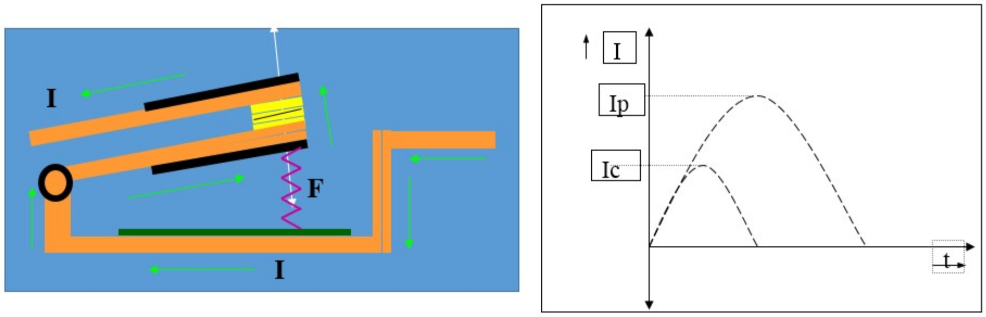

Figure 1.1: Current limiting force and peak current

1.4 Construction of MCCB

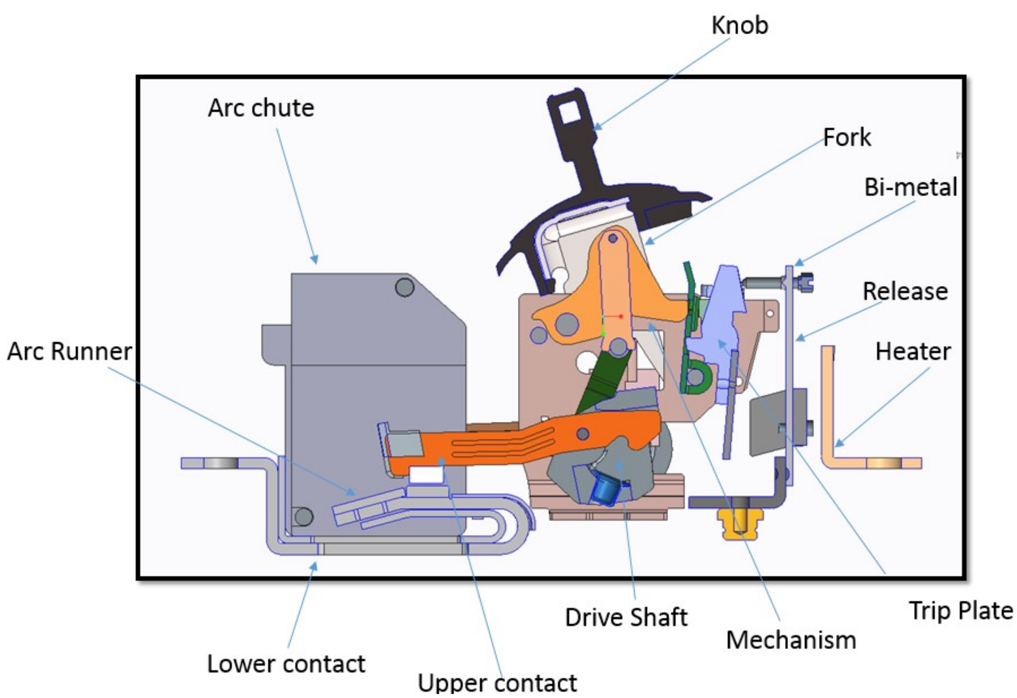

Figure 1.2: Different component and assembly of 100A MCCB

Drive Shaft Assembly

The drive shaft assembly mainly contains.

- Cap Drive shaft
- Contact pin
- Contact spring
- Center pin
- Upper contact
- Drive shaft link

Upper contact has been assembled in drive shaft with contact spring. contact pin pass through the upper contact and drive shaft. Drive shaft link assembled in Y-pole and center pin pass through in drive shaft link.

Mechanism Assembly

The mechanism assembly contains of the latch assembly (latch and the latch links), side plates (two numbers),latch bracket,latch bracket spring and pins.

Release Assembly

The release assembly contains,

- Bi-metal
- Heater
- Magnetic assembly
- Trip plate
- Latch bracket mechanism assembly

Above all equipment of release assembly connect through braids in brazing shop. All equipment brazed to upper contact through braid.

Upper contact assembly

- Contact finger
- Upper contact button
- Braid Contact button brazed on upper contact and release is brazed on other end of upper contact through braid.

Lower contact assembly

- Lower contact
- Lower contact button
- Arc runner

Lower contact having contact button and just after contact button arc runner has been brazed.

Arc chute assembly

- De-ion plates
- Lining
- Vent
- Runner plate

In 100A MCCB of L&T there is 9 deion plates assemble together which is all having different thickness lower 5 plates having 1.2 mm, upper 3 have 1.5 mm and at the top 1 again 1.2 mm.

1.5 Ratings of MCCB

1.5.1 Rated Current (I_n)

It is the normal operation current on which circuit breaker is in its normal condition.

1.5.2 Rated ultimate short-circuit breaking capacity (I_{cu})

At the rated voltage, Ultimate short circuit breaking capacity of circuit breaker which is consigned by manufacturer is called rated Ultimate short circuit breaking capacity. It is expressed in KA.

1.5.3 Rated service short-circuit breaking capacity (I_{cs})

At the rated voltage, Service short circuit breaking capacity of circuit breaker which is consigned by manufacturer is called rated Ultimate short circuit breaking capacity. It is expressed in KA, equivalent to one of the specified percentages of the rated ultimate short-circuit breaking capacity.

1.5.4 Rated operational voltage (U_e)

It is the voltage which, determine the application of the equipment and significant test, combine with rated operational current and utilization categories are referred. For single pole circuit breaker, the rated operational voltage is normally specified as the voltage across the pole. For multi-pole circuit breaker, it is normally stated as the voltage between phases.

1.5.5 Rated insulation voltage (U_i)

The Rated Insulation voltage of circuit breaker is the value of voltage on which dielectric test conducted in reference to creepage distance.Rated operational voltage always less than rated insulation voltage.

1.5.6 Rated impulse withstand voltage (U_{imp})

The peak value of an impulse voltage of prescribed form and polarity which the circuit breaker is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred.

Chapter 2

Project Description

2.1 Project Title

Improvement of Reliability performance in 100A current rating frame of MCCB.

2.2 Description

Molded Case Circuit Breakers are widely used for protection against short circuit fault sand overload currents in LT lines. Improvement in Reliability performance of MCCB will give benefit to customer as well as company.

2.3 Objective

Objective of this project is to improve reliability performance of 100 A MCCB of L&T E&A. 100 A MCCB is widely use in short circuit and overload protection of several applications and LT lines. So main focus of the project is to 100 A MCCB operates securely without any malfunctioning. This objective will be achieved through analysis of failure, identification of root cause, development of concepts to improve the performance, theoretical verification, use of JMAG software for electromagnetic simulation, PTC Cero software for design new component, prototyping of concepts & validation testing of MCCBs made with proposed concepts.

2.4 Challenges of project and Proposed solutions(Under validation)

Cause-Effect diagram

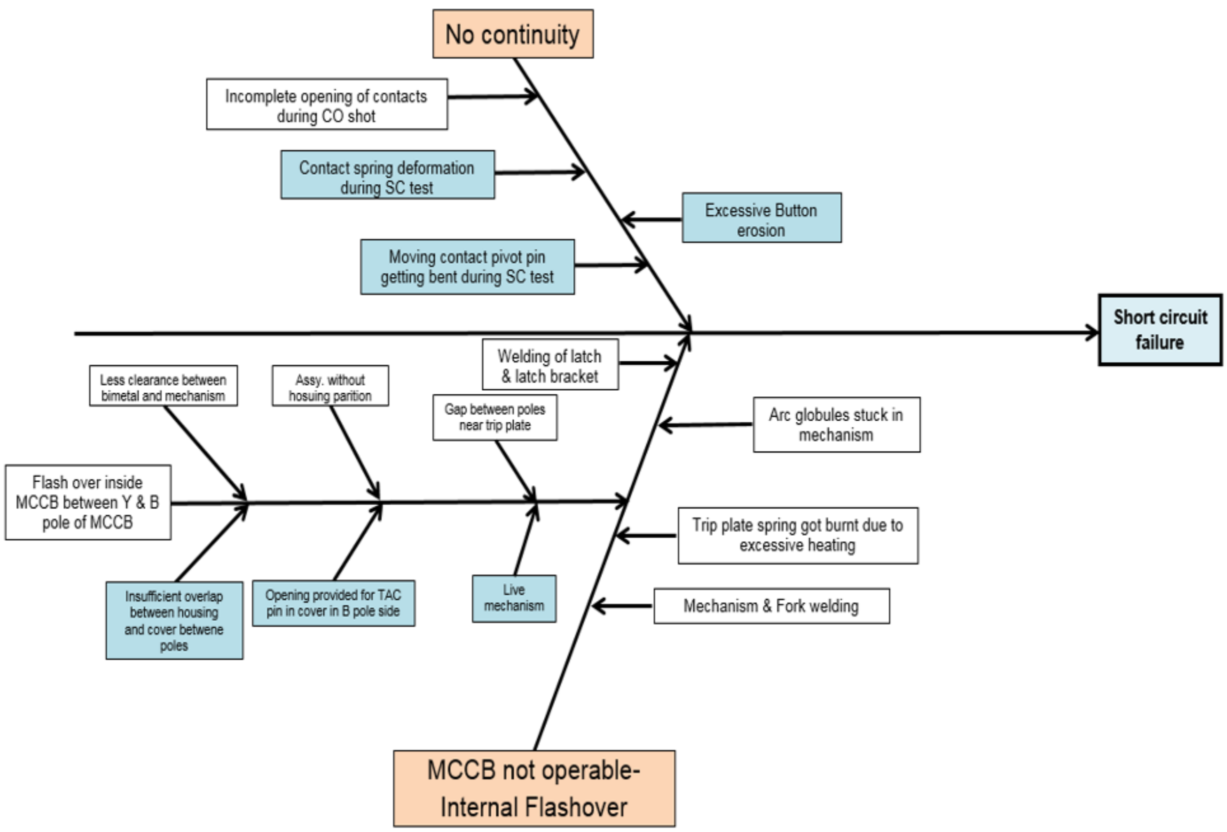

Figure 2.1: Cause-Effect Diagram

This diagram involves the short circuit analysis of the existing 100A MCCB.
There are two effects observed in existing MCCB.
Effect-1:No Continuity

Rout Causes:

- Incomplete opening of contact during CO-Shot.
- Contact spring deformation during short circuit test.
- Moving contact pivot pin bent during short circuit test. item Excessive button erosion.

Effect-2:MCCB not operatable / Internal flash over

Rout Causes:

- Flash over between Y and B pole of MCCB.

- Less clearance between bi-metal and mechanism.
- Assembly without housing partition.
- Opening provided for TAC pin in cover in B-pole side.
- Live mechanism because of drive shaft pivot pin passing through moving contact.
- Gap between poles near trip plate.
- Trip plate spring got burnt due to excessive heating.
- Mechanism and fork welding during short circuit test.

Challanges	**Proposed solution**
Low Vidt (Energy Dissipated by breaker while short circuit) as much as Possible while short circuit fault.	Change in Dion Plate profile, Number of plates, Spacing between plates, Thickness of plates.
Contact Button Erosion while short circuit.	Try different Composition of contact button material as per its Properties.
Contact spring deformation while short circuit-Over Travel and Contact Pressure loss.	Change spring Design, Try torsion Spring as per new drive shaft design, Change length of lower link and change length of Y piece.
Internal Flash over while short circuit.	Change in design of cover. Position and Shape of slot motor and Arc Runner, proper Venting of Gases at back side of arc chute. Overlapping and drive shaft pin design.

Table 2.1: Challenges and Proposed solution(Under validation)

Chapter 3

Literature survey

1. "Arc Root Mobility during Contact Opening at High Current" IEEE TRANSACTIONS ON COMPONENTS, PACKAGING, AND MANUFACTURING TECHNOLOGY—PART A, VOL. 21, NO. 1, MARCH 1998 Authors: -John W. McBride, P. M. Weaver, and P. A. Jeffery

   Summary:- This paper presents a test system, designed for the analysis of short circuit arcs related to MCCBs. to identify arc root motion an optical fiber imaging system is used.

   Two methods are used to measure contact motion of Molded case circuit breakers,

   (a) A non-contact linear position sensor
   (b) The optical fiber array.

   The optical fiber array uses software image processing to recognize the position of the arc roots in the arc chamber. The identification of the arc roots allows for a study of the arc immobility at the initial stages of the event.

2. "Analysis of the Interruption Processof Molded Case Circuit Breakers" IEEE TRANSACTIONS ON COMPONENTS AND PACKAGING TECHNOLOGIES, VOL. 30, NO. 3, SEPTEMBER 2007 Authors: -Xingwen Li, Degui Chen, Senior Member, IEEE, Yunfeng Wang, Qian Wang, and YingsanGeng

   Summary:- In this paper author presents optimization design of MCCBs. For this it is essential and required to simulate the interruption method and analyze the characteristics.The interactive coupled phenomena of electromagnetic field, Mechanism motion system in MCCB and electric circuit.
   The simulation model for the operation mechanism of MCCB can be built by virtual prototyping technology and experiments have been carried out to confirm its validity. Then, with the existence of electrodynamics repulsion force, the interruption process of the MCCB has been investigated with closing phase angle, arc voltage, mechanism starting motion time, blow open force and prospective current. It proves the proposed method is effective and is capable of evaluating the new design of MCCB products.

3. "Test Results of Different Silver / Graphite Contact Materials inRegard to Applications in Circuit Breakers" Authors: - V.Behrens, Th.Honig, A.Kraus, E.Mahle, R.Michal, K.E.Saeger

   Summary:- In this paper it is analysis of silver/graphite contact material properties by testing and get basic information about welding resistance and contact erosion.
   This paper includes comparison of behavior of standard silver/graphite materials and new type of silver/graphite based on graphite fiber.
   It was found that the new silver graphite material in a symmetric combination is markedly superior to conventional silver/graphite combinations in terms of Welding resistance,contact erosion, and over temperature behavior.

4. "Development of Contact Material Solutions for LowVoltage Circuit Breaker Applications" Authors: - TimoMützel, Peter Braumann, Ralf Niederreuther

   Summary:- This paper analyzes the contact material, production parameter and influence of contact materials.

   By model-switch it is examined properties of AgC and AgWc i.e. erosion rate post short circuit and contact resistance during short circuit test and analysis of mass loss during break operation is heavily influenced by magnetic flux density.

   Compared the all materials properties, analyze different manufacturing parameters and fiber operations.
   The paper represents a guideline for material selection and problem solving during protection device design by comparing the varying contact material behavior under different types of loads.

5. "The Process of Arc-Splitting Between Metal Platesin Low Voltage Arc Chutes" Manfred Lindmayer, Erik Marzahn, Alexandra Mutzke,ThomasRüther,D-38106 Braunschweig, Germany.

   Summary:- The behavior of arcs in low voltage switching devices is affected by several interactions. For studying simple arrangements of arc runners without metallic splitter plates ("Deion plates") a 3D simulation system has already been developed. It takes into account the plasma fluid dynamics, the current flow within the electrodes and the plasma, and the magnetic field generated by both currents.

   For the simulation of the splitting process between metallic Deion plates the simulation model has to be extended. In experiments including high-speed movies it is shown that this process is a continuous transition of current flow from the still undivided arc to the new arc roots formed on the metal plates. A new simulation model representing the roots by a thin layer of current-dependent resistivity is discussed and simulation results are compared with switching experiments.

6. "Electrical Contacts Principle and Application" Authors: - Paul G. Slade, Cutler Hammer, Hoeseheads, New York.

7. IEC 60947-1 General rules "Low-voltage switchgear and control gear" Discuss about standard definitions followed and the general guidance for designof any switchgear.

8. IEC 60947-2 Circuit Breaker "Low-voltage switchgear and control-gear" Discuss about testing requirements and specifications.

9. Spring Handbook published by Accurate Spring pvt ltd, Mumbai.
In this manual discuss about all spring and its calculations.

Chapter 4

Improvement in instantaneous tripping of 100A MCCB

4.1 Problem definition in Magnetic operation of MCCB

4.1.1 Shunting Problem

There is shunting problem in Y-Pole of 100A MCCB due to latch bracket pin which is placed parallel to Moving Magnet of trip plate and produce opposite magnetic field and moving magnet require more force to trip breaker.figure shows the shunting.

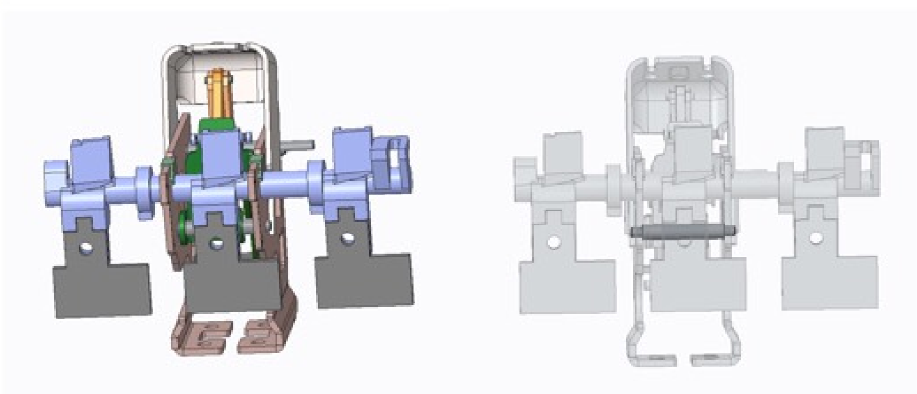

Figure 4.1: Shunting in Y-pole

4.2 Mathematical modeling

4.2.1 Forces on MCCB

1. Mechanical Force
2. Electromagnetic Force

4.2.2 Mechanical Force

At ON condition of MCCB there are two Trip plate springs in mechanism which is hold trip plate in F1 direction as per shown in figure.
In overload condition because of heat bi-metal will deflect towards trip plate with thermal screw which increases force on trip plate. When this force higher than spring force,then MCCB will trip. Now in short circuit condition there is high inrush current flow from breaker and this current create electromagnetic field in fixed magnet and it attracts moving magnet. Movement of moving magnet cause rotation of trip plate and breaking operation of MCCB is achieved.

Calculation of mechanical force

To calculate mechanism force,There are two conditions to be taken into consideration for breaker.

1. Non-Trip Condition
2. Trip condition

For trip condition force= 300 gm.
For Non-trip condition force =200 gm.

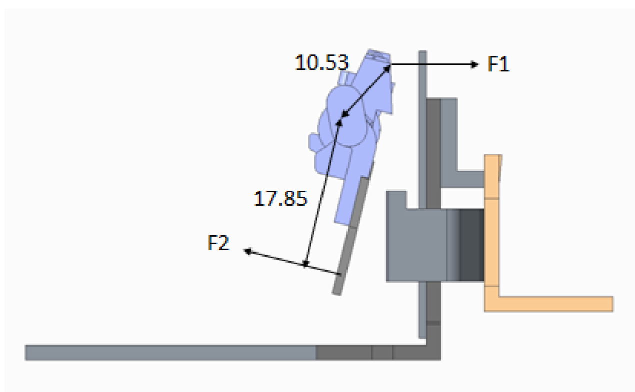

Figure 4.2: Mechanism Force

L1=17.85mm
L2=10.53mm

Non Trip Condition Force F1=200gm,
Trip Condition Force F2=300gm

F1*L1=F2*L2
Non trip Force up to F2=128gm,
Trip Force F2=190gm

4.2.3 Electromagnetic Force

It is the force produced between one or two objects having attractive magnetic force with same directions of motion and objects with charge have a repulsive magnetic force moving in opposite directions.
As per Maxwell's equation, Magnetic flux always forms a closed loop .but the path of the loop depends on the reluctance of the ambient parameter. It is determined around the path of least reluctance. Air and vacuum have high reluctance, while soft iron have low reluctance which is easily magnetized materials. Mechanical forces , produced by strong magnetic fields due to concentration of low reluctance material always an attractive force tend to move the metal towards region of higher flux.
To find electromagnetic force reluctance has to be find in fix magnet moving magnet and air gap.

$$S = \frac{l * 10^{-3}}{\mu_0 * \mu_r * A * 10^{-6}} + \frac{lg * 10^{-3}}{\mu_0 * A * \mu_r(air) * 10^{-6}}$$

Where,
N = Number of turns
I = Short circuit current
l1 = Length of fix magnet
l2 = Length of moving magnet
l = l_1+ l_2 = Total length
l_g = Length of air gap
A= Cross sectional area
μ_0 =Permeability of free space
$\mu_r(air)$ =Permeability of air
μ_r = Relative permeability of material
a= Acceleration

$$\phi = \frac{f}{S}$$

$$Bg = \frac{\phi}{A}$$

Where,
ϕ = magnetic flux
N= Number of turns
I = current flowing in conductor
Bg= Magnetic flux density
A= Area of fixed magnet limb and air gap
A Thermal-Magnetic force is produce between the magnets, which is responsible for the attraction and it would be given by following equation.

$$F = \frac{A * Bg^2}{2 * \mu_0 * \mu_r(air)}$$

Where,
F= force exerted on flapper surface
Force in grams Mass m = F/a gm

Input Parameter

Short circuit current for 100A MCCB is 9In = (900A) Non trip Current up to =720A Trip Current =1080A and above

Parameters	Values	
	100A Not Trip	100A Trip
No Of Turns (N)	1	1
Short circuit Current (I)(two pole in series)	720A	1080
Length of Fix Magnet (l_1)	33mm	33mm
Length of Moving Magnet (l_2)	17.5	17.5
Total Length (L)	50.5	50.5
Length of Air gap (lg)	5.2	5.2
Cross Sectional Area (A)	40	40
Permeability of free space (μ_0)	$4\pi * 10^{-7}$	$4\pi * 10^{-7}$
Permeability of Air (μ_r air)	1	1
Relative Permeability of material (μ_r)	2000	2000
Acceleration (a)	10	10

Table 4.1: Input Parameters

Output parameter-Two Pole in series

For Two pole in Series Mechanism Force
Non Trip condition Fm= upto 64gm
Trip condition Fm=95gm

Parameters	Values	
	100A Non trip	100A Trip
Reluctance(S)	$1.04 * 10^8$	$1.04 * 10^8$
mmf(f)(NI)	720A	1080A
Flux(Ø)	$6.923 * 10^{-6}$	$1.038 * 10^{-5}$
Flux Density (Bg)	0.173	0.259
Force in Newton (F)	0.476	1.068
Force in Grams (F)	47.6	106.8

Table 4.2: Output Parameters

Fe=47.6gm<64gm (Non-Trip Condition)
Fe=106.8gm>95gm (Trip Condition)

For Single Pole – Tripping Force

For Single pole short circuit current 15In = 1500A

Parameters	Values
	100A Trip Single Pole
Reluctance(S)	$1.04 * 10^8$
mmf(f)(NI)	1500A
Flux(Ø)	$1.44 * 10^{-5}$
Flux Density (Bg)	0.36
Force in Newton (F)	2.063
Force in Grams (F)	206.3

Table 4.3: Output Parameter

Fe=206.3gm>190gm

4.3 Analysis in JMAG Software

4.3.1 Two pole in series

Figure shows model of two pole in series of 100A MCCB. This analysis is done at assemble angle of trip plate 257 in on condition.
There is threshold limit for 100A MCCB in Two pole in series is 9In (In=rated current).
Not trip current=720A
Trip current=1080A
Condition for Not-trip Fm>Fe
Condition for trip Fm<Fe

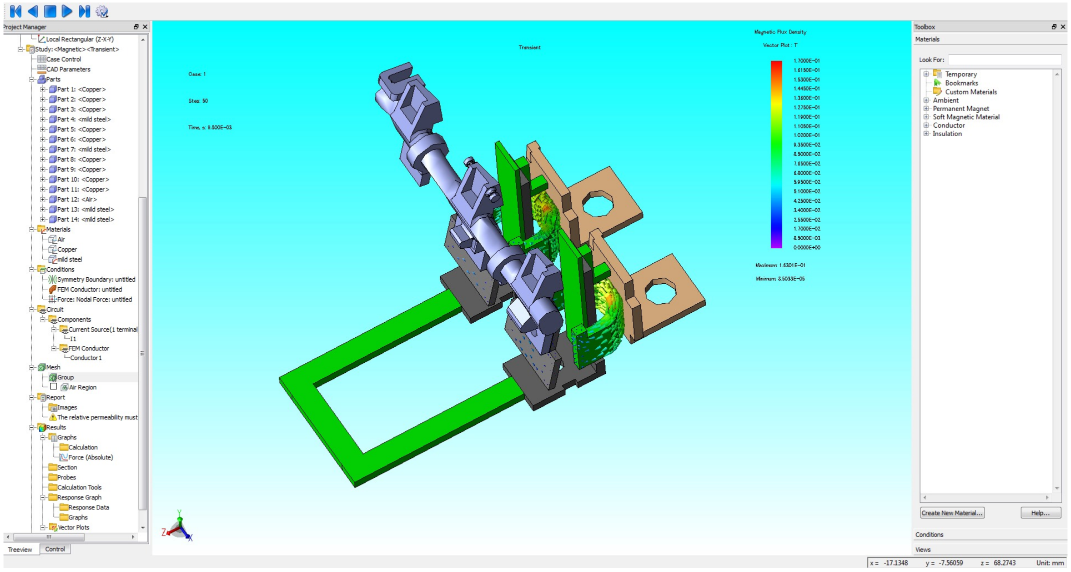

Figure 4.3: Two pole in series JMAG analysis

4.3.2 Result

Analysis result(non-trip condition) at 720A current

Angle of Trip Condition in ON condition 257		
Thickness of moving magnet(mm)	Electromagnetic Force on moving magnet (N)	Electro magnetic force on moving magnet (gm)
1.2	0.52	52
1.3	0.54	54
1.4	0.58	58
1.5	0.61	61
1.6	0.63	63

Table 4.4: Electromagnetic force for different thickness of moving magnet for 720A (two pole in series)

For 1.5 mm thickness of moving magnet 61 gm which is less than 64gm.
And for 1.6 mm thicknes of moving magnet 63 gm which is also less than 64 gm.

Analysis result (trip condition) at 1080A current.

257 Degree(On Condition of Breaker		
Thickness of moving magnet (mm)	Electromagnetic force(N)	Electromagnetic force(gm)
1.2	1.04	105
1.3	1.09	110
1.4	1.17	118
1.5	1.21	122
1.6	1.25	126

Table 4.5: Electromagnetic force for different thickness of moving magnet for 1080A (two pole in series)

This analysis is done at 1080A
So at 1.5mm Fe=122 gm > Fm = 95gm.
And at 1.6mm Fe=126 gm > Fm = 95gm.
As per Results1.5mm thickness magnet for R and B Pole and 1.6mm Magnet in Y-Pole to overcome shunting problem.

4.3.3 Single pole

Figure shows model of single pole in series of 100A MCCB. This analysis is done at assemble angle of trip plate 257 in on condition. There is threshold limit for 100A MCCB in Two pole in series is 15In (In=rated current).

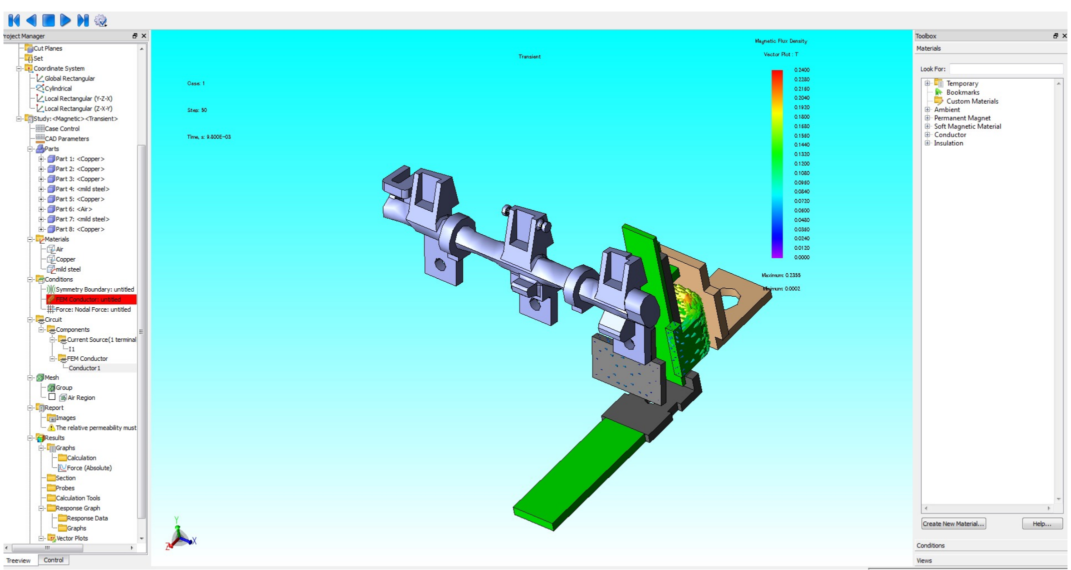

Figure 4.4: Single pole JMAG analysis

Result

Angle of tip plate in on condition 257 Degree		
Thickness of moving magnet(mm)	Electromagnetic Force(N)	Electromagnetic force(gm)
1.2	2.05	205
1.3	2.09	209
1.4	2.13	213
1.5	2.17	217
1.6	2.21	221

Table 4.6: Electromagnetic force for different thickness of moving magnet(single pole)

As per result for 1.5 mm and 1.6 mm electromagnetic force is 217 gm and 221 gm respectively, which is greater than 195 gm (Mechanical force)

4.4 Validation testing of 10 MCCB with new moving magnet

Existing Trip plate R, Y, B-Pole = 1.2 mm

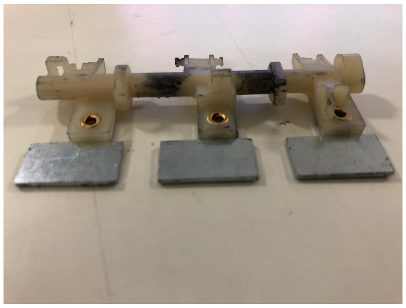

Figure 4.5: Existing Trip plate

Proposed Trip plate: R & B pole:-1.5 mm,Y pole:-1.6 mm

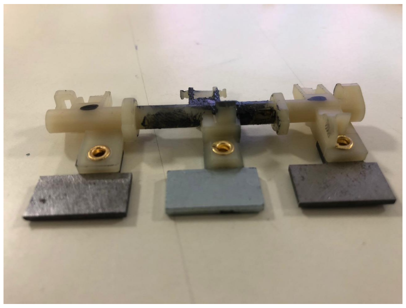

Figure 4.6: Proposed Trip plate

Below data indicates the reading of two pole in series of ten 100A MCCB with new proposed trip plate.

Condition	RY	BR	YB
Non Trip	809	817	764
Trip	825(180)	853(64)	786(156)
Non Trip	802	803	772
Trip	819(45)	845(96)	797(86)
Non Trip	853	788	858
Trip	899(185)	888(74)	936(82)
Non Trip	1025	903	995
Trip	1035(108)	940(126)	1022(180)
Non Trip	860	828	957
Trip	906(116)	865(142)	983(129)
Non Trip	999	859	834
Trip	1052(146)	944(168)	876(84)
Non Trip	897	898	881
Trip	937(187)	935(116)	908(58)
Non Trip	986	1041	944
Trip	1033(188)	1070(147)	1015(114)
Non Trip	971	917	841
Trip	1002(56)	952(161)	881(45)
Non Trip	1034	768	981
Trip	1049(127)	861(66)	1002(118)

Table 4.7: Reading of two pole in series of 100A MCCB with proportional Trip plate

All data indicates that breaker has been trip and not trip between threshold limit.

Chapter 5

Product Development

5.1 Short circuit analysis

While conducting short circuit on MCCB , above graph is observed. According to study , the whole operating time of CB is divided into following time zone as described below:

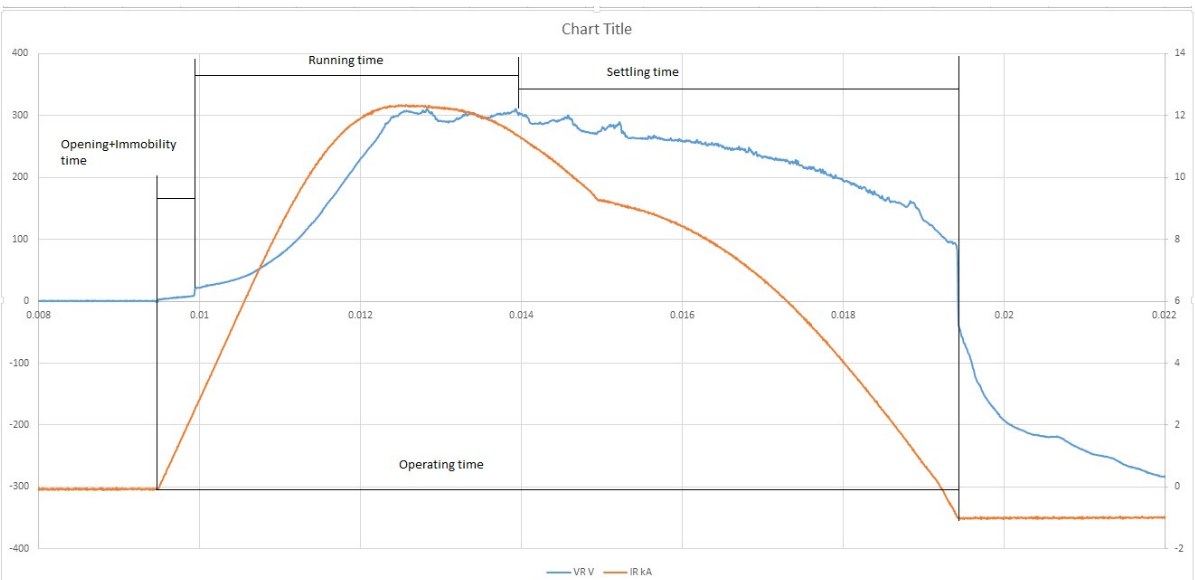

Figure 5.1: Short circuit Waveform

On Time (Ton): It is the total time interval when the current through breaker is non-zero. It covers the time interval from detection of short circuit fault to clear it. For desired operation of power system , the total on time is to be minimum. As the millivolt drop across the breaker decreases , total on time decreases.

Opening Time(To): Opening time of breaker includes the time interval of release senses the abnormal current , trip plate rotates , moving contact of breaker moves apart from fixed contact and settle to its upper most limit.

Immobility Time (Ti): Immobility time of breaker includes the time interval from root of an arc is produced to the time for which arc is immobile in nature. In this period of time , an arc is only between the two contacts of MCCB , it will not run towards the arc chute.

Running Time(Tr): Starting point of running time is when the arc starts moving towards the arc chute assembly from between the contacts. And end point running time is when the arc reaches to deion plates of arc chute assembly. As its contribution in total operating is highest ,its value kept as low as possible.

Settling Time (Ts): Settling time is that fraction time of short circuit in which arc is lengthen across the deion plates and completely quenched. After end of settling time , current is zero. Amount of settling time depends upon the number of deion plates ,plating material, venting area of arc chute which is exposed to the outside of breaker etc. From the above short circuit graph , it is observed that contribution of running time and settling time in the total on time is highest. So to reduce the total on time , reduction in running and settling time is necessary. So the project objective is to be fulfil by this one.

5.1.1 Observation of Short circuit breaker (Existing breaker)

1. Deformation of drive shaft spring: - It leads to over travel loss in Circuit breaker so continuity would not maintain in poles after short circuit test.

Figure 5.2: Double conical spring pre- short circuit and post short circuit test

Left side spring is before Short circuit test and right side spring indicates post short circuit test.

2. Contact button erosion: No continuity

5.2 Way to overcome this problem

1. To overcome above problem of over travel loss must be eliminate.
2. To eliminate over travel loss, new drive shaft spring design.
3. Existing spring: Double conical spring Proposed spring: Double torsion spring
4. New design of drive shaft link to isolate mechanism of MCCB.
5. by using different Ag alloys we can eliminate contact button erosion.

5.3 Over travel in MCCB

With and without lower contact difference in hight of upper contact when breaker is in ON condition. If over travel of breaker is high so overlapping of upper contact and lower contact is also high.
As per present scenario over travel is maintain 3 mm to 4 mm in existing breaker.
If over travel is low at that time there is gaping between the both upper and lower contacts in on condition so in normal condition there will be hot spot and sparking created on contact buttons and temperature increases and contact button erosion also increase.
So higher over travelling leads to improve contact pressure(CP) of MCCB which is good for short circuit test also in terms of continuity.

5.4 Contact Pressure of MCCB

It is the pressure between the upper and lower contact button under the ON condition of breaker.

5.5 Mathematical modeling of springs

5.5.1 Existing spring: Double conical spring

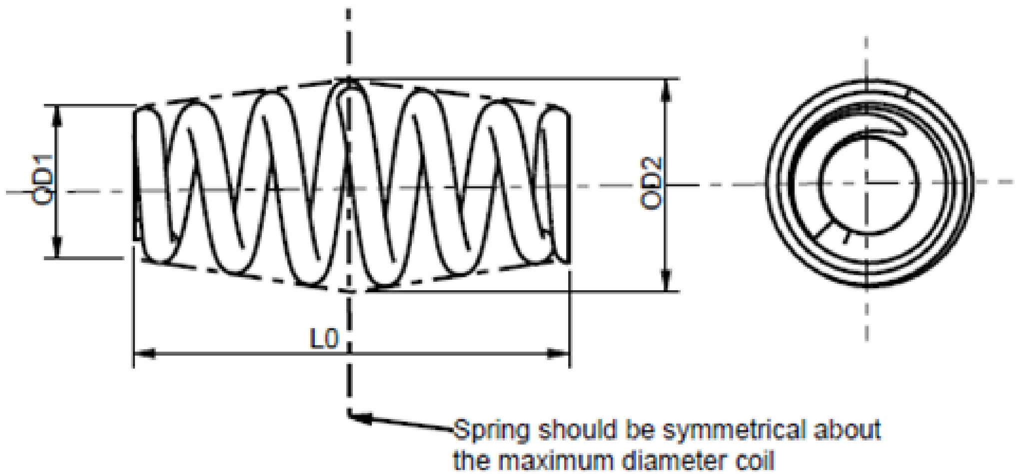

Figure 5.3: Double conical Spring

d= Wire diameter
Di= Inner diameter
Do=Outer diameter
L0= Free length
G = Modulus of rigidity kg/mm2
fn = Deflection
If= Active number of coils
Ig= Total number of coils

$$Dm = \frac{(D_o + D_i)}{2} = Meandiameterinmm$$

$$LoadF = \frac{G * d^4 * f}{8 * D_0^3 * i_f}$$

$$Springrate(Sc) = \frac{\Delta F}{\Delta f} = \frac{G * d^4}{8 * D_m^3 * i_f}$$

$$SpringIndex(W) = \frac{Dm}{d} = (Meandiameter)/(Wirediameter)$$

$$Stressuncorrected = \frac{8 * (2F) * Do}{\pi * d^3}$$

$$Stresscorrected = 1.2397 * (stressuncorrected)$$

Where,

$$1.2397 = correctionfactor = [((4Si(max) - 1)/(4Si(max) - 4)) + (0.615/Si(max))]$$

Where,

Si(max)=Spring index (maximum) = $\frac{Do}{d}$

Si(min)=Spring index (minimum) = $\frac{Di}{d}$

$$Permissiblestress = \frac{T * 0.5}{9.81}$$

Where, T = Tensile strength

Parameter of Double conical spring

Wire grade	Cold Drawn Unalloyed Steel Wire, Grade 3 IS: 4454 Part 1
Wire Dia.(d)	0.7mm
Inner Dia(Di)	3mm
Outer Dia.(Do)	4.4mm
Free Length(L0)	11.1mm
Modulus of Rigidity (G) kg/mm2	8300
Deflection(mm)	5
Mean Diameter(Dm)	3.7
Active number of coil	7
Load F (kg)	4.1775
Stresses uncorrected	136.53
Stress Corrected	169.26
Stress at assemble length	23.7
Permissible stress	118.24

Table 5.1: Parameter of Double conical spring

5.5.2 Proposed spring: Double Torsion spring

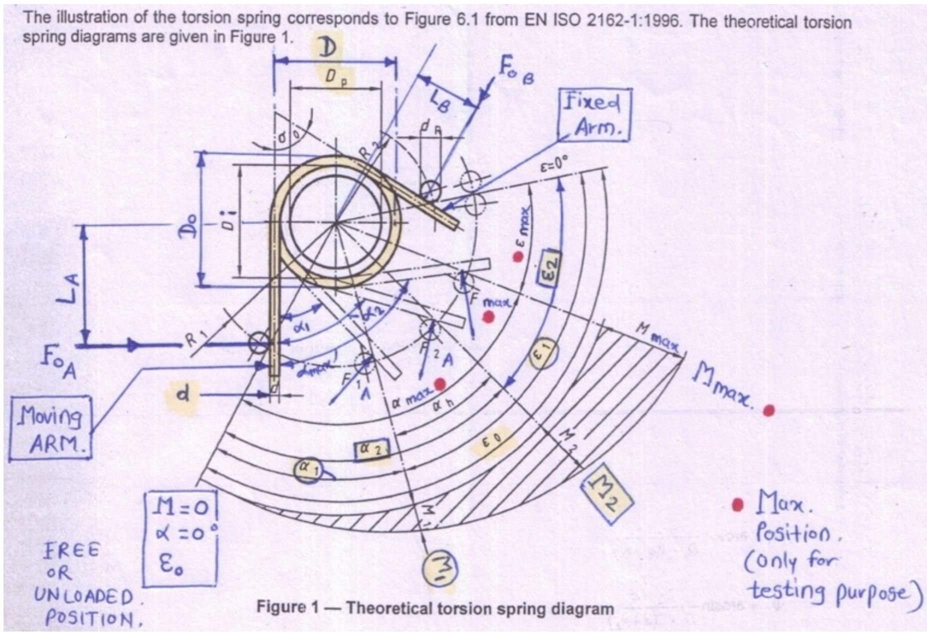

Figure 5.4: Torsion spring

The mode of operation of torsion spring is different from double conical spring. Torsion spring is in effect, a wound up cantilever. Torsion spring supply or withstand torque. To supply this torque, torsion spring require some form of spring lag. The type of spring lag is dictated by the application.

These springs consist of a left hand wound series of coils and a series of right hand wound coils connected at the center. For Stress and Torque calculation, each series is calculated separately as individual springs; then the Torque are added together, but deflection are not added.

$$Torque, M = F * R$$

$$M = W * \alpha$$

Where, for wound wire,

$$W = (\pi * d^3)/32$$

$$M = (\pi * d^3 * \alpha)/32$$

$$M = (d^4 * E * \alpha)/(3667 * D * n)$$

Where,
M = Torque in Nmm
d= Wire diameter in mm
E= Modulus of elasticity in N/mm2
D=Mean coil diameter in mm
n= number of active coils
F= spring load in Newton

R= length of arm at which load is applied in mm
α= angular deflection degree

parameter for torsion spring

Parameter	Value	Values for double torsion spring
Material	IS:4454 (Part 1):2001: Patented & Cold Drawn Unalloyed Steel wire: Grade IV	
Wire Dia.	0.8mm	
Mean Dia.	4.3 mm	
No. of Active Turns	2.375	
Free Angle	53 deg.	
Assembled angle	32.4 deg.	
Angle at Contact repulsion	17.3 deg.	
Torque at Assembled angle	3.79 Kgmm	7.58 Kgmm
Torque at repulsion angle	6.57 Kgmm	13.14 Kgmm
Permissible stress as per material standard	176.96 Kg/mm2	
Max. stress at assembled angle	88.38 Kg/mm2	50% of permissible stress
Max.Stress at repulsion angle	153.16 Kg/mm2	87% of permissible stress

Table 5.2: Parameter of torsion spring

So as per above mathematical modelling of both spring, it is clear that Permissible stress of double torsion spring higher than double conical spring.
And there is no chance of deformation of torsion spring so over travel loss is eliminated and continuity will be OK after Short Circuit test.

5.6 New Drive shaft Concept to isolate mechanism in MCCB

Problem Definition: Flash over through mechanism in short circuit test (reverse).
Proposed solution: New drive shaft design for non-live mechanism in MCCB.
Existing Design: In this design moving contact pivot pin passing through moving contact and drive shaft link so, mechanism is live while breaker is in ON condition.

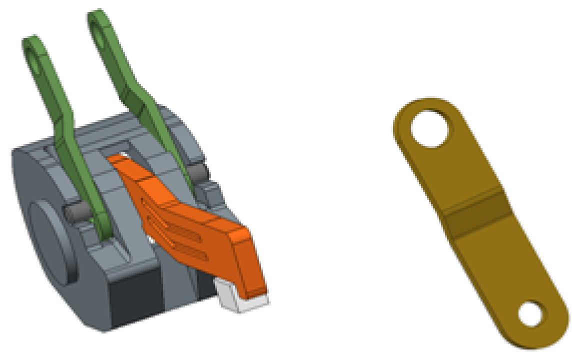

Figure 5.5: Existing design of drive shaft and drive shaft link

Proposed Design: In this new design moving contact pivot pin is not passing through moving contact and drive shaft link so, mechanism is not live while breaker is in on condition and it will help to prevent flash over through mechanism.

Figure 5.6: Proposed design of drive shaft and drive shaft link

5.7 Contact Pressure in new proposed design

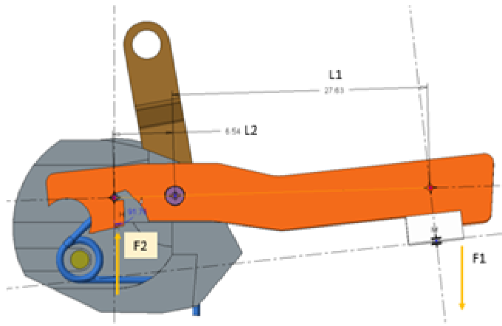

Figure 5.7: Contact pressure in new drive shaft

Parameter	Value
Force Provided by torsion spring at assemble angle (F_2)	**1.518 Kg**
L_1	**27.6 mm**
L_2	**6.5 mm**
Force at Moving contact button (F_1)	**0.358 Kg = 358 gms**

5.8 Drive shaft assembly with new torsion spring

Figure shows the existing design of drive shaft and drive shaft assembly with new double torsion spring.

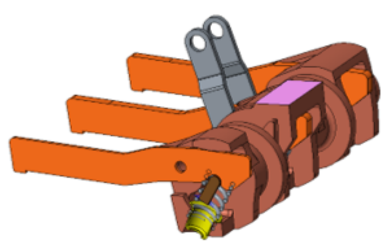

Figure 5.8: Existing Drive shaft assembly

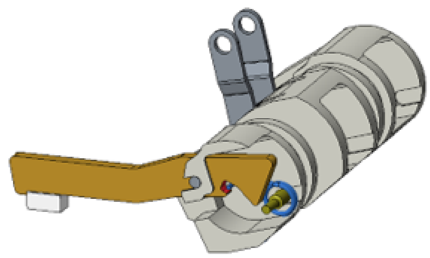

Figure 5.9: New Drive shaft assembly

5.9 Stress comparison of Existing Double conical spring and Proposed Double Torsion spring

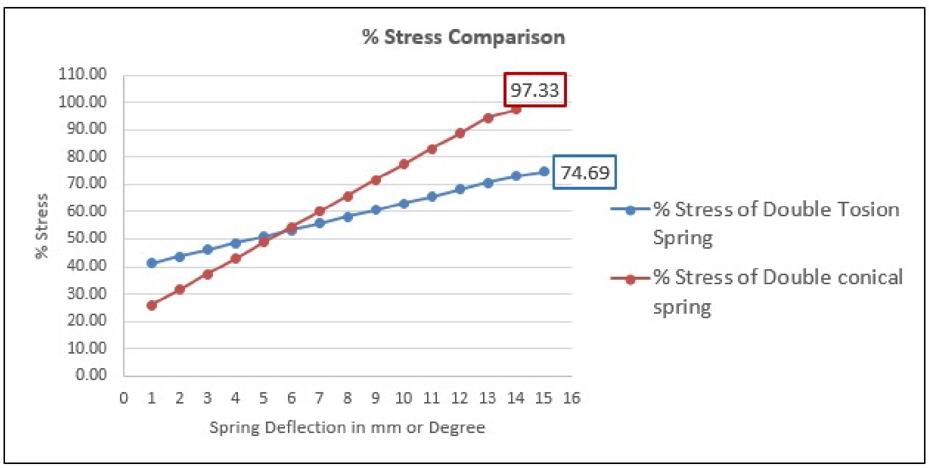

Figure 5.10: Stress comparison of both spring

97.33 is Stress at maximum repulsion of 8.3 mm in Double conical spring. 74.69 is Stress at maximum repulsion of 13 mm in double torsion spring.

5.10 Stress analysis in new Drive shaft

5.11 Stress

The stress applied to a material is the force per unit area applied to the material.
Breaking stress or Ultimate tensile stress (UTS): The maximum stress of material can stand before it breaks is called the breaking stress or Ultimate tensile stress. Tensile means the material is under tension. The force acting on it are trying to stretch the material. Compression is when the force acting on an object are trying to squash it.

$$\begin{aligned} Stress &= \frac{Force}{Area} \\ &= \frac{F}{A} \end{aligned} \tag{5.1}$$

Stress= stress measured in Nm^{-2} or pascals (Pa).
F= force in newton(N).
A= cross-section area.

There is three place in drive shaft where stress must be measure and check withstand ability against stress.

1. On drive shaft link slot through mechanism spring.
2. On pivot pin slot of drive shaft in Dynamic condition considering Lorentz force. (15KA current)
3. On moving magnet through torsion spring force

5.11.1 On drive shaft link slot through mechanism spring:

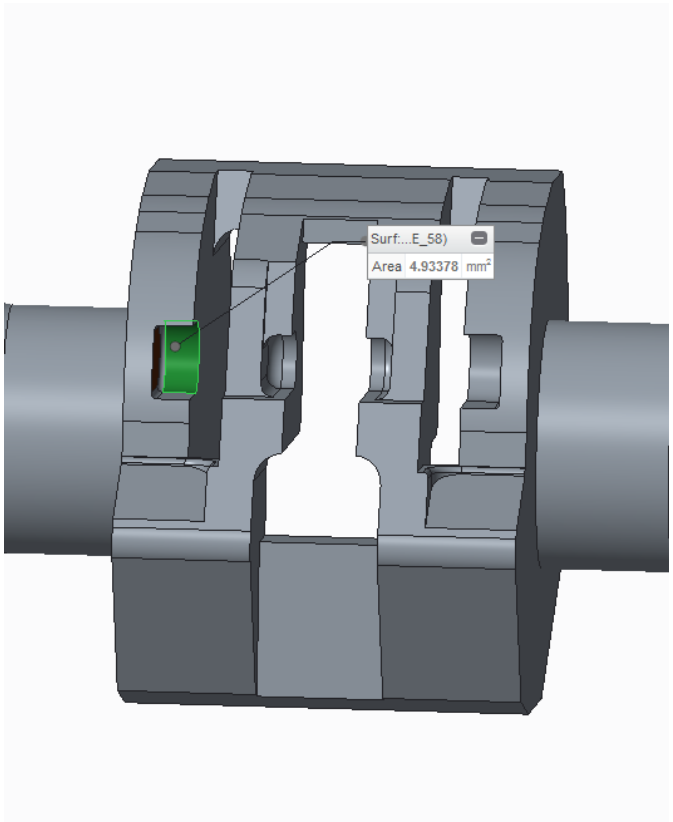

Figure 5.11: Area of Drive shaft link in mm2

Mechanism Force on drive shaft slot provided for drive shaft link is 6.5 Kg. (mechanism spring force) Further 15 % extra load considered for improving safety margin.

$$\begin{aligned} 6.5 * 0.15 &= 0.975Kg \\ Total force &= 6.5 + 0.975 \\ &= 7.475kg \\ &= 76.197N \end{aligned} \tag{5.2}$$

$$\begin{aligned} As per figure Area of Drive shaft slot &= 4.93378mm^2 \\ &= 4.93378 * 10^{-6}m^2 \end{aligned} \tag{5.3}$$

$$\begin{aligned} Stress &= \frac{Force}{Area} \\ &= \frac{76.19}{4.93378 * 10^{-6}Nm^{-2}} \\ &= 15.45 * 10^6 Nm^{-2} \\ &= 15.45MPa \end{aligned} \tag{5.4}$$

Mechanism Force calculation: Vertical and horizontal component of mechanism force on drive shaft link and drive shaft link slot is calculated below. And then simulate in PTC creo software pro mechanical and get maximum stress.

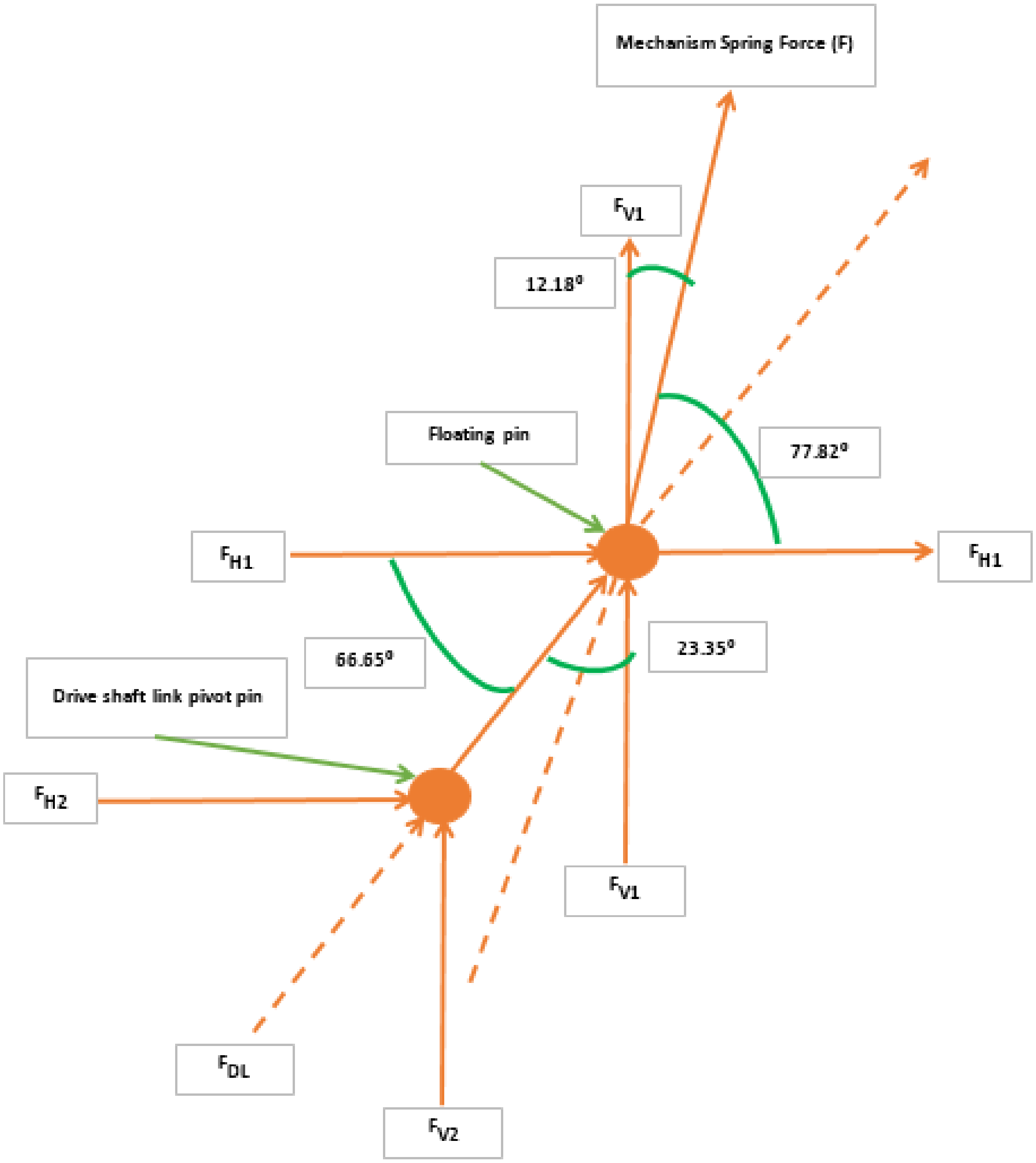

Figure 5.12: Free body diagram

Parameter	Value	Unit
Mechanism Spring Length at Positive isolation Position	26	mm
Mechanism spring maximum length at toggle point	26.4	mm
Mechanism spring force at 26.4 mm length (F)	6.5 +15/-5 % 7.475 kg Max 6.175 kg Min	kg
Mechanism force horizontal component angle at floating pin	77.82	1.358215
Mechanism force horizontal component at floating pin (F_{H1})	COS(77.82)*7.475=1.57710242	kg
Mechanism force vertical component angle at floating pin	12.18	0.212581
Mechanism force horizontal component at floating pin (F_{V1})	COS(12.18)*7.475=7.30673477	kg
Angle between F_{H1} and Drive shaft link force direction	66.65	1.163262
F_{H1} component acting on drive shaft link	COS(66.65)*1.577=0.62507957	Kg
Angle between F_{V1} and Drive shaft link force direction	23.35	0.407534
F_{V1} component acting on drive shaft link	COS(23.35)*7.3067=6.70831942	kg
Total force on drive shaft link hinge point (FDL)	0.62507957+6.708319=7.333399	kg

Table 5.3: Parameters which is responsible for stress on drive shaft link slot

$$\begin{aligned} Horizontal component of F_{H2} &= (Angle) * (Total force (FDL)) \\ &= COS(66.65) * 7.33 \\ &= 0.3963 * 7.33 \\ &= 2.9062 \end{aligned} \tag{5.5}$$

$$\begin{aligned} Vertical component of F_{V2} &= (Angle) * (Total force (FDL)) \\ &= COS(23.35) * 7.33 \\ &= 0.9181 * 7.33 \\ &= 6.73 \end{aligned} \tag{5.6}$$

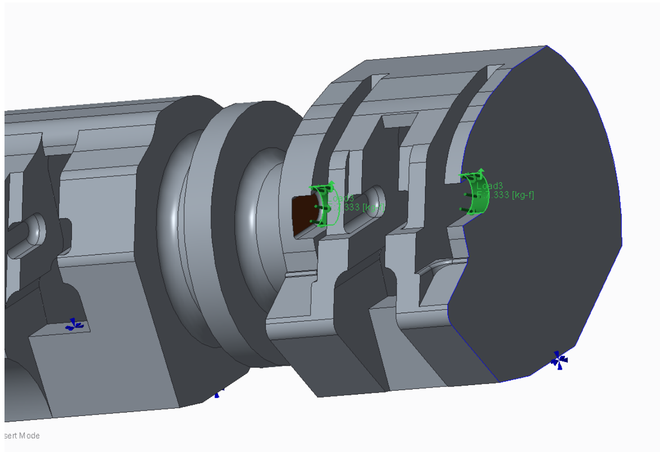

Figure 5.13: Stress direction in drive shaft link position

- Drive Shaft Material: GLASS REINFORCED POLYSTER MOLDING COMPOUND (DMC) (Existing DN0 Material)
- APPROVED GRADE: 606/25 OF M/s SIROPLAST
- UTS (Ultimate Tensile Stree) value: 40 Mpa
- 50 % Safety margin in UTS value: 20 Mpa
- Observed Stress Value: 16 Mpa
- Factor of Safety (FoS):20/16= 1.25.

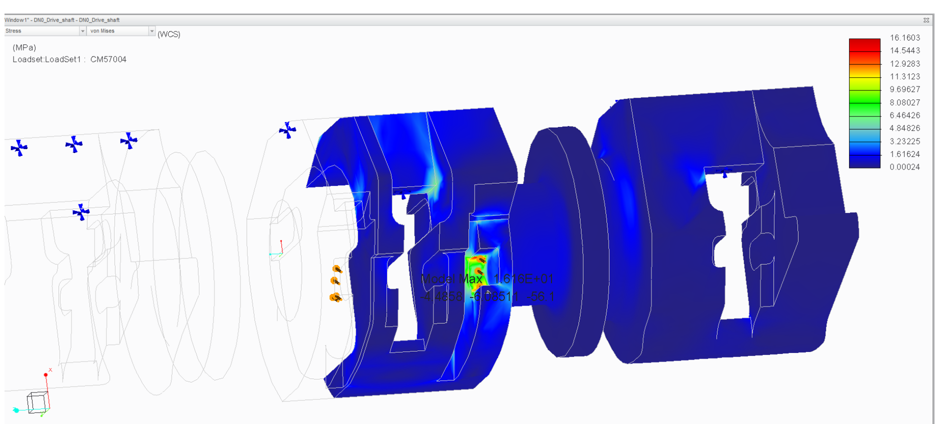

Figure 5.14: Stress analysis

5.11.2 On pivot pin slot of drive shaft in Dynamic condition considering Lorentz force. (15KA current)

Lorentz Force

$$F \propto \frac{i_1 * i_2}{d}$$

$$F = \frac{K * i^2}{d} (\because i_1 = i_2 = i)$$

$$K = \frac{\mu_0}{2\pi} = \frac{4\pi * 10^{-7}}{2\pi} = 2 * 10^{-7} (N/A^2)$$

$$\therefore F = \frac{2 * 10^{-7} * i^2}{d} \frac{N}{m}$$

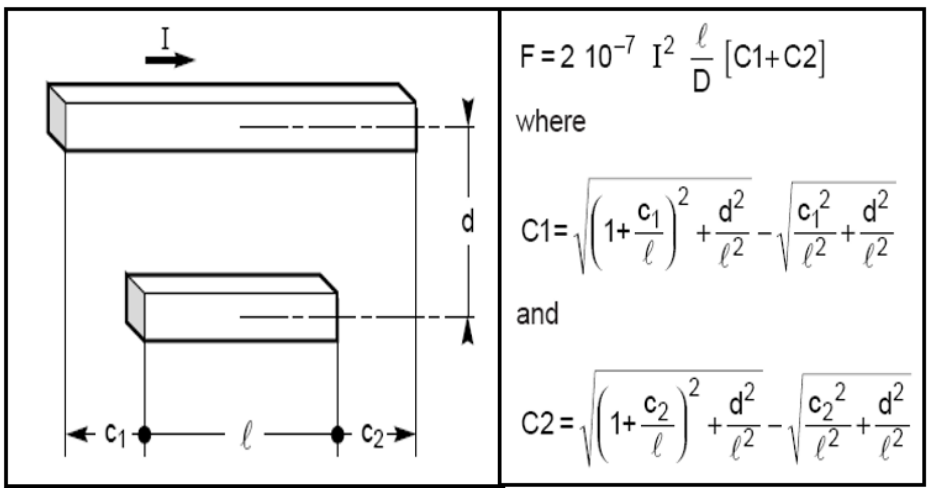

Figure 5.15: Lorentz Force

- Repulsion force (Only Lorentz Force Considered) calculation done with 15kA short circuit current at moving contact in fully repulsion condition and drive shaft in On condition
- Repulsion force acting at moving contact pivot surface in drive shaft is 16.88 kg

  Horizontal Component of force = 4.95 kg

  Vertical Component of force = 16.137 kg

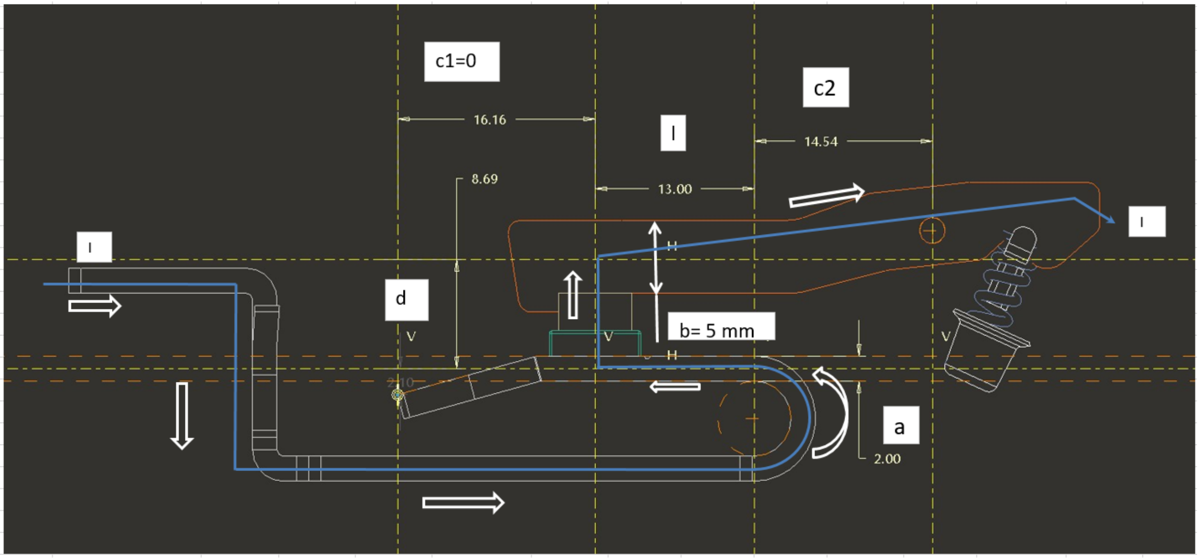

Figure 5.16: 100 A frame Lorentz force

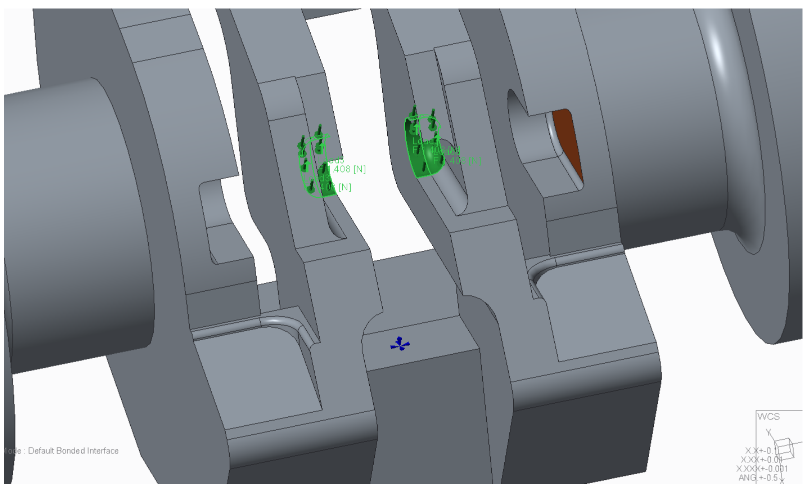

Figure 5.17: Stress direction in pivot pin position

- Drive Shaft Material: DMC 30% GF APPROVED GRADE: 655/30 (I) of Mahindra Composites
- UTS(Ultimate Tensile Strength) value: 84 Mpa
- 50 % Safety margin in UTS value: 42 Mpa
- Observed Stress Value: 22 Mpa
- Factor of safety(FoS): 42/22= 1.9

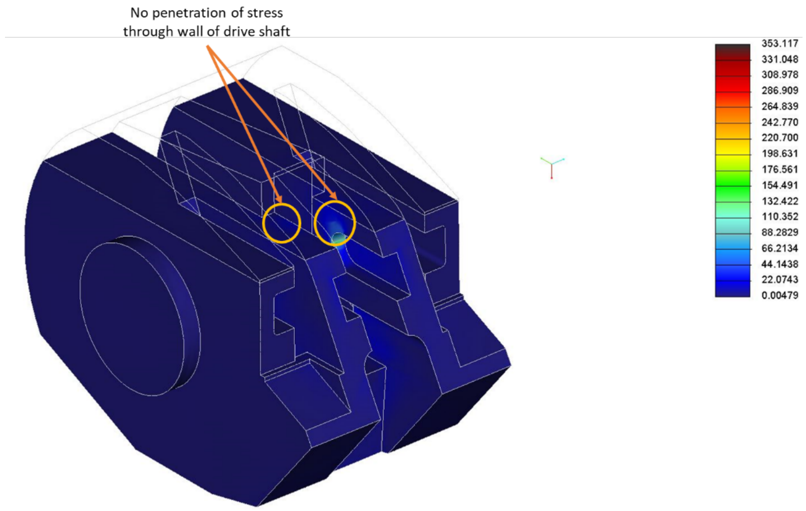

Figure 5.18: Stress analysis in pivot pin position

5.11.3 On moving Contact through Double torsion spring force:

There is two Condition when torsion spring force applied on moving contacts.

1. MCCB in ON condition
   Figure shows the section view of ON Condition in MCCB.

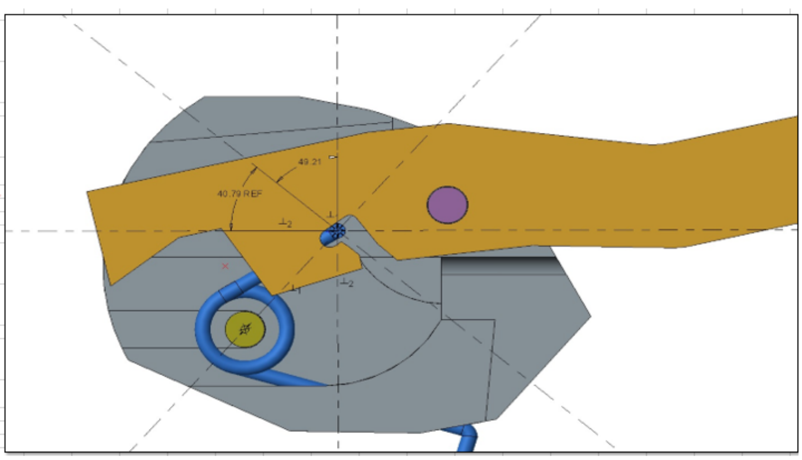

Figure 5.19: MCCB in ON condition

Below figure shows the free body diagram of ON condition of MCCB from this diagram we get direction and angle of force which is apply on moving contact in ON condition.

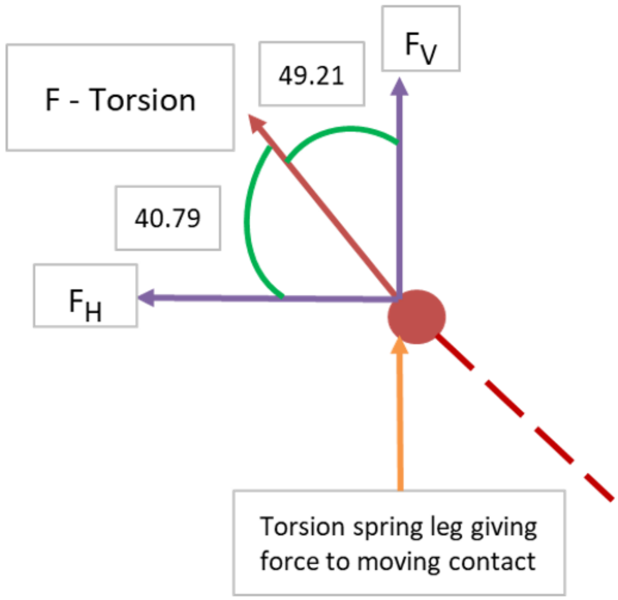

Figure 5.20: Free Body diagram of MCCB in ON condition

- In ON condition of MCCB, Assemble Angle of Torsion Spring = 32.4 deg. Now,
- Torque at Assemble Angle M_1 = 7.58 Kgmm
- Torque at repulsion Angle M_2 = 6.57 Kgmm Now,
- Torque of torsion spring M = F * R Where,
  R = length of arm at load is to be applied = 5.5 mm.
  F = Spring load
- For ON condition Torsion Spring Force on moving contact = M_1/R= 0.704
- And for double torsion spring = 0.704 * 2=1.408 kg
- Vertical component of force F_v = COS (49.21) *1.408 = 0.91983
- Horizontal Component of force F_h = COS (40.79)* 1.408 = 1.06601

2. MCCB in Repulsion Condition
   Figure shows the section view of Repulsion Condition in MCCB.

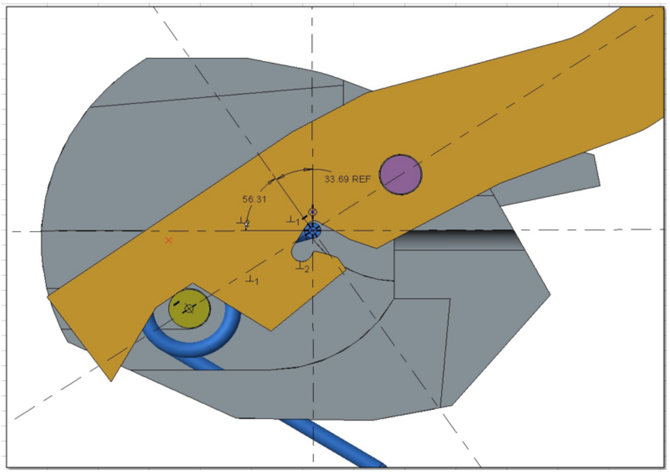

Figure 5.21: MCCB in Repulsion condition

Below figure shows the free body diagram of Repulsion condition of MCCB from this diagram we get direction and angle of force which is apply on moving contact in Repulsion condition.

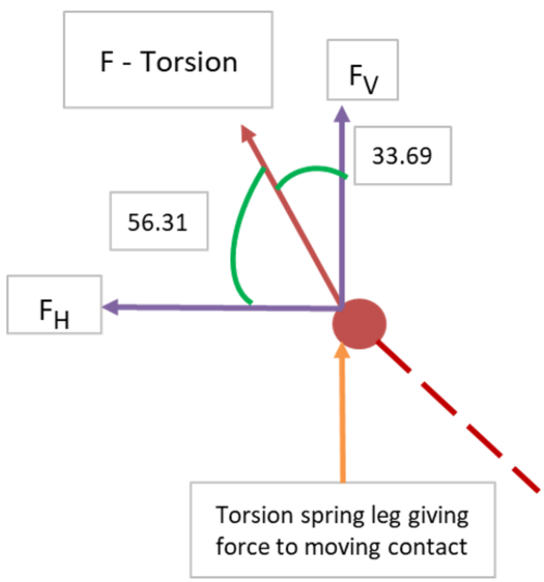

Figure 5.22: Free Body diagram of MCCB in Repulsion condition

- In Repulsion condition of MCCB, Angle at contact repulsion = 17.3 deg.
  Now,
- Torque at repulsion Angle M_2 = 6.57 Kgmm
- Torque of torsion spring M = F * R
  Where,

  R = length of arm at load is to be applied = 5.5 mm.

  F = Spring load
- For ON condition Torsion Spring Force on moving contact = $\frac{M_2}{R}$= 1.031
- for double torsion spring = 1.031 * 2= 2.062 kg
- Vertical component of force F_v = COS (33.69) * 2.062 = 1.715689
- Horizontal Component of force F_h = COS (40.79) * 2.062 = 1.14379

Chapter 6

Improvement in Short circuit performance in I_n=100A,I_{cs}=18KA MCCB

- During short circuit there is arc quenching time must be as minimum as possible. Arc quenching phenomena depends upon the how fast arc run to the arc chute and for run the arc there must be more force produce in direction of arc chute.
- When arc produce between two contacts there is some electromagnetic gases produce and flux linkage through the slot motor and force generate in direction of arc chute.
- **Slot motor**:- Slot motor is the part which made of ferromagnetic (mild steel) material which is help to produce flux linkage easily compare to air because its dielectric strength is less then air.so with slot motor there is more flux linkage and therefore more force produce in direction of arc chute and arc run fast.But its position is very important in MCCB.
- **Problem in Existing design**:- In existing design of MCCB there is slot motor placed behind the arc so it is not generating that much force in direction of arc chute. This is proved through simulation of 3D model in JMAG electromagnetic software.

6.1 Calculation of force on arc and deion plates of Arc chute

6.1.1 Analysis with slot motor

In this simulation electromagnetic force on arc and arc chute in particular direction.
Step-1:Import .sat file (3D model) in JMAG software.
Step-2:Choose Magnetic analysis and assigned materials to all the parts.

- Deion plates, Slot motor, Arc runner:mild steel.
- Fixed and moving contact:copper

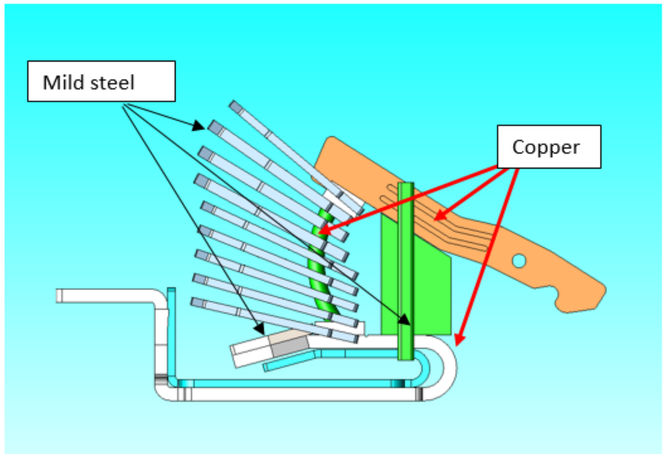

Figure 6.1: 3D-Model/Materials

Step-3:Assign Boundary condition in model for generate boundary. Red surfaces are indicating boundaries.

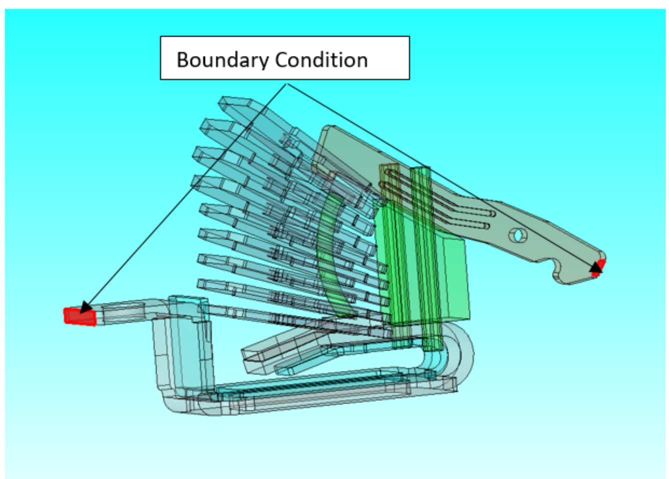

Figure 6.2: Boundary condition

Step-4:In 100A MCCB 18KA is short circuit current capacity. In this MCCB pick of the current during short circuit test is 16KA. So 16KA current apply through the inflow surface and all current caring parts are shown in below figure. All red parts are current caring parts.

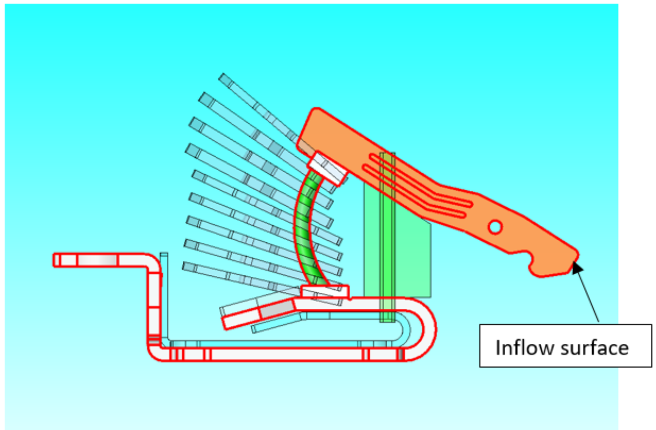

Figure 6.3: Current caring parts and inflow surface

Step-5:Now define the parts and force. On deion plates there is nodal force and on arc path there is Lorentz force.

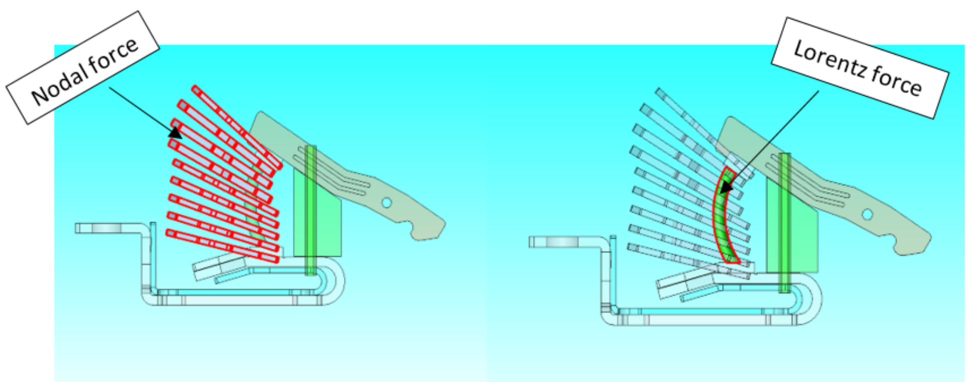

Figure 6.4: Lorentz and nodal force

Step 6:Generate mesh which is divide model in small sections. Here size of mesh is 4.48mm.

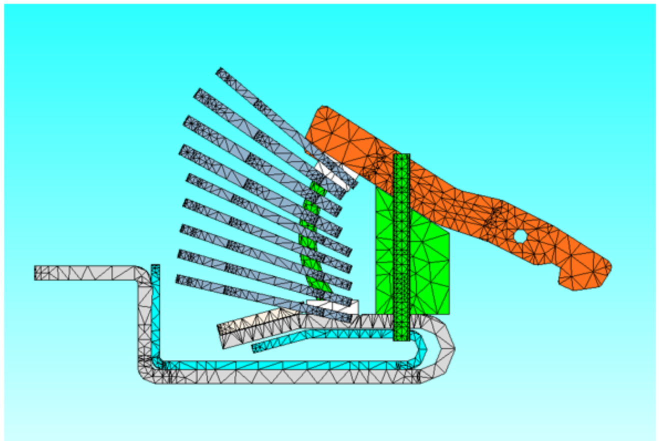

Figure 6.5: Mesh generation

Step-7:In result measure force in all direction as well as absolute force in newton(N). From vector plot flux lines and flux density measure at all parts.

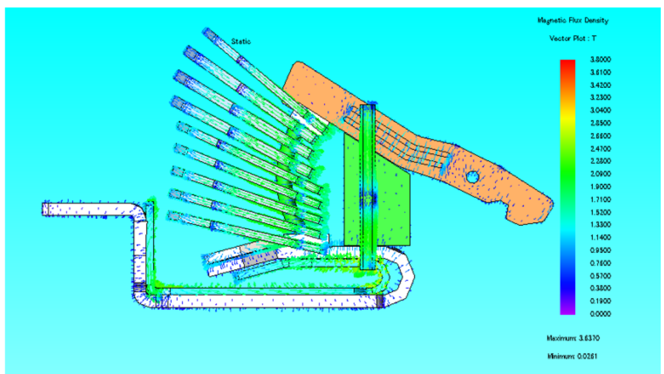

Figure 6.6: Flux Density(with slot motor)

With slot motor force in direction of arc chute is,

- On path of arc:151 N
- On deion plates:74.4 N

6.1.2 Analysis without slot motor

Same steps to be followed for this simulation

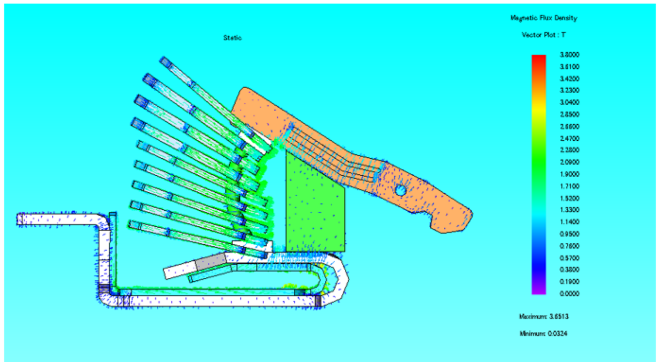

Figure 6.7: Flux density(without slot motor)

Without slot motor force in direction of arc chute is,

- On path of arc:160 N
- On Deion plates:84.4 N

So without slot motor there is higher force (10 N) hence it is proved that position of slot motor is not right in existing design.

Chapter 7

Testing of MCCB

7.1 Test sequences of MCCB

There is three Type test sequence for 100A MCCBs as per Standard IEC 60947-1 and IEC 60947-2.

7.1.1 Test Sequence-1

1. **Tripping limits and characteristics (1.05In/1.3 I_n, Magnetic threshold):** In this test Thermal and Magnetic performance of circuit breaker has to be verified. In thermal tripping there is 1.05 times rated current pass for 2 hours and then 1.3 times rated current supply to the breaker subsequently and it must be tripped by bimetal in next 2 hours.
   Now in Magnetic Tripping in 100A MCCB 9 times rated current supply between two poles which is connected in series so there is three combination of poles (RY, YB, and RB). In this test Breaker must trip between band of in 80% and 120% of tripping current.

2. **Dielectric properties (Impulse and HV test):** In this test Uimp (Impulse voltage) 8kv voltage apply for 1.2/50 micro seconds. Impulse generator output connected to equipment to be tested and impulse applied five times for each polarity at intervals of 1 second minimum.

3. **(Mechanical operation and operational performance capability (MET/EET):** In this test Operational performance of Circuit breaker verified. There are two operational tests conducted on breaker i.e. Mechanical Endurance test/ Electrical Endurance test.
   Mechanical Endurance test:In this test 8500 operations of Circuit breaker without rated current.
   Electrical endurance test:In this test 2500 operations of circuit breaker with rated current.

4. **Overload performance (where applicable):** In this test 6 times rated current apply and 12 operations conducted (9 manually and 3 automatically).

5. **Verification of dielectric withstand (HV + Leakage):** As per Insulation voltage Ui for 100A MCCB 1.89 kv applied for 60 seconds at different points. Leakage current was measured through each pole with the contacts in open position at AC test operational voltage.

6. **Verification of temperature-rise:** In this test 1.45 times rated current supply to the breaker for 8 hours and measure absolute temperature at different points.

$$Temperaturerise = Absolutetemperature - Ambienttemperature.$$

To pass this test Temperature rise must be stable. Temperature rise should not exceed 80^o degree.

7. **Verification of overload releases (2In):** In this test 2 times of rated current supply through the breaker it must break through thermal release.

8. **Verification of main contact position (for circuit breakers suitable for isolation) (Positive Isolation):** This test verified indication of upper contact is right or wrong as per condition.

7.1.2 Test Sequence-2

1. **Rated service short-circuit breaking capacity (Ics)**:Short circuit test for 100 A MCCB Ics=18KA and power factor is 0.2 at operational voltage Ue.
   The sequence of test,

$$O - t - CO - t - CO$$

   where t=time delay=3 min
   O=Open
   CO=Close subsequently Open.

2. **Verification of operational capability (75 operation 100A EET):**75 operations with rated current.

3. **Verification of dielectric withstand (HV+ Leakage):** As per Insulation voltage Ui for 100A MCCB 1.89 kv applied for 60 seconds at different points. Leakage current was measured through each pole with the contacts in open position at AC test operational voltage.

4. **Verification of temperature-rise (TR 1.45 In):**:In this test 1.45 times rated current supply to the breaker for 8 hours and measure absolute temperature at different points. Temperature rise = Absolute temperature- Ambient temperature. To pass this test Temperature rise must be stable.

5. **Verification of overload releases (2.5 In)**:After above tests it will check overload performance of MCCB by supply $2.5I_n$.

7.1.3 Test Sequence-3

1. **Verification of overload releases (2In):** In this test 2 times of rated current supply through the breaker it must break through thermal release.

2. **ultimate short-circuit breaking capacity (Icu):**Short circuit test for 100 A MCCB Icu=36KA for this power factor is 0.2 at operational voltage Ue.
   The sequence of test,

$$O - t - CO$$

where t=time delay=3 min
O=Open
CO=Close subsequently Open.

3. **Verification of dielectric withstand (HV+ leakage):**As per Insulation voltage Ui for 100A MCCB 1.89 kv applied for 60 seconds at different points. Leakage current was measured through each pole with the contacts in open position at AC test operational voltage.

4. **Verification of overload releases (2.5 In):**After above tests it will check overload performance of MCCB by supply $2.5I_n$.

7.2 Contact button analysis and validation testing with new drive shaft concept

Contact buttons: Contact buttons are very important parts of any circuit breaker because at any faulty condition there is arc produce between this contact buttons.It is made of Ag alloys. So choice of appropriate contact button material is help to withstand against excessive heating and its arcing time.
Problem Definition: Excessive Contact button erosion and less MV drop post short circuit test in existing contact button materials.
Proposed solution: Erosion of contact buttons depend on hardness and melting point of contact buttons. MV drop is depending on contact conductivity and contact resistance after arcing.
So selection of contact button with high hardness and high melting point i.e. Carbon(C) and Tungsten(W). This two has high hardness and high melting point,
In selection of Ag alloys composition there must be take care of conductivity because if conductivity less MV drop of post short circuit test is high so there will be a problem in Temperature rise test.
Below table shows different Ag alloys as per its different properties on scale of 1 to 4.

Scale	1	2	3	4	5
Meaning	Very bad	Bad	Average	Good	Very good

Table 7.1: Scaling

Contact button	**Silver Combination**	**Hardness range in Hv**	**Arc Erosion Resistance**	**Anti Welding Property**	**Contact Conductivity after arcing**
Moving contact	AgC 97-3	48 - 55	2	4	4
	AgWC 60-40	110 - 135	3	4	3
	AgC 98-2	55-60	2	4	4
	AgC 95-5	55-60	2	4	4
Fixed Contact	AgNi 80-20	60-65	3	2	3
	AgWC 50-50	130-170	4	5	3
	AgNi 60-40	110-130	2	2	3

Table 7.2: Properties of different Ag alloys

7.3 Short Circuit testing with different contact button

Combination	**Moving contact**	**Fix Contact**	**Remark/Analysis**
E-Existing	AgC (97%-3%)	AgNi(80%-20%)	High contact button erosion
1	AgWC(60%-40%)	AgWC(50%-50%)	Results in High mv drop post Electrical operations (>130 mV) Test
2	AgC(95%-5%)	AgWC(50%-50%)	High contact button erosion of AgC 95-5
3	AgC(95%-5%)	AgNi(60%-40%)	High contact button erosion of AgC 95-5
4	AgC(98%-2%)	AgWC(50%-50%)	Good mv drop (<120 mV) post Electrical operations Test

Table 7.3: Comparison of different Ag alloys post short circuit test

As per above table combination-4 is most reliable in terms of MV-drop post electrical operation and short circuit test.
Above analysis indicate in below graph form with its hardness.It also shows the different combinations and their hardness of contact button materials and indicates post short circuit testing effect.

So As per the testing and properties of different combination AgC(98%-2%) Moving contact and AgWC(50%-50%) Fixed Contact is very suitable for 100A MCCB for 18 KA short circuit capacity.

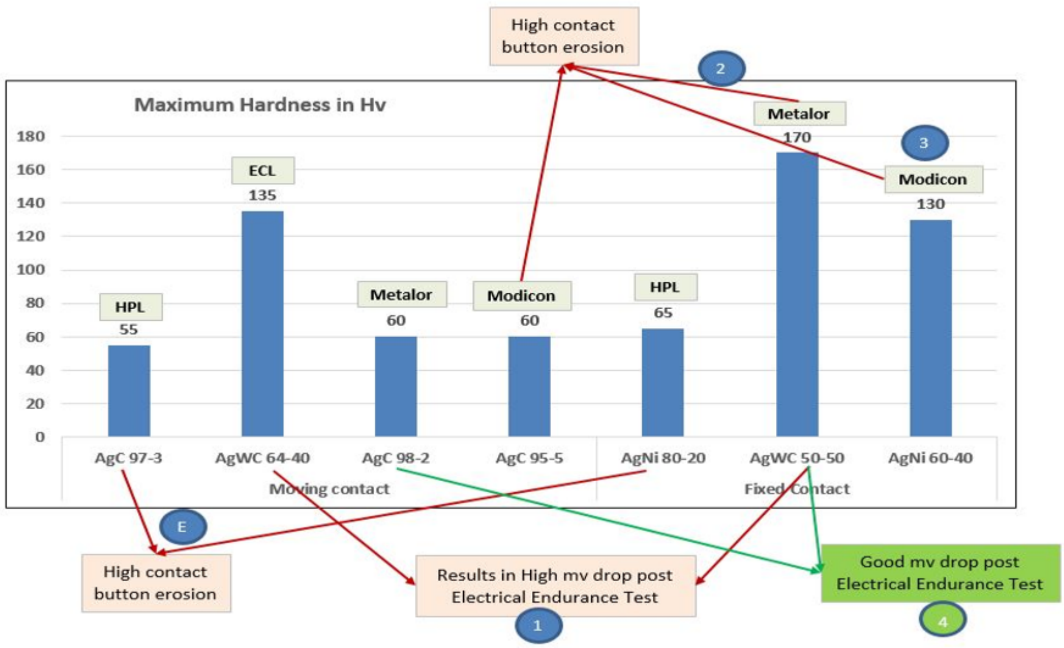

Figure 7.1: Comparison of different Ag alloys post short circuit test

Ag Alloys composition	Density (Mass/Volume)	Melting Point or Range	Electrical Resistivity	Electrical Conductivity	Hardness
AgC(97%-3%)	9.1	960	1.92-2	45-48	80-120
AgNi(80-20)	10-10.1	960	1.92-2.08	48-52	41-43
AgWC(50%-50%)	13	1200-1500	3	22-39	150
AgC(98%-2%)	9.5	960	1.85-1.92	48-50	42-44

Table 7.4: Different properties for Ag alloyes

Existing Contact button material	Proposed Contact Button material
Upper Contact - AgC (97%-3%)	Upper Contact - AgC(98%-2%)
Lower Contact – AgNi(80%-20%)	Lower Contact – AgWC(50%-%)

Table 7.5: Existing and proposed contact button Ag alloys

7.4 Validation Testing of 5 MCCB with new drive shaft and proposed contact button material

MCCB No.	Combination	Ics at 18 kA	75 operations with current	HV+ Leakage	Max. TR (C)
MCCB1	Moving contact AgC 98%-2%) Fixed Contact AgWC (50%-50%)	pass	pass	pass	Max. mV drop: 90 mV at 50 A dc
MCCB2		pass	pass	pass	Max. mV drop: 120 mV at 50 A dc
MCCB3		pass	pass	pass	Max. mV drop: 87 mV at 50 A dc
MCCB5		pass	(welding after 26 operations in Y pole)	NA	Max. mV drop: 89 mV at 50 A dc

Table 7.6: Validation testing and results

7.5 Vidt/Let through energy Comparison

Let through Energy (I^2t): Let through energy is the energy pass through the MCCB at faulty condition at the particular time interval. It is measure in joule.

$$\int i^2 dt$$

Vidt Voltage and current multiply with interval of time, in ON time of MCCB is call Vidt.It is also energy dissipated by MCCB at ON time of MCCB

$$\int Vidt$$

Seq. II- Ics at 18 kA 415 Vac	Existing drive shaft			New drive shaft concept			% Reduction in Peak Vidt	% Reduction in total Vidt
	R	Y	B	R	Y	B		
O	11.41	18.42	2.43	11.65	17.16	1.92	6.84%	4.74%
CO1	18.86	5.88	9.72	10.7	15.9	1.76	15.69%	17.70%
CO2	16.62	7.83	8.3	10.3	12.6	2.95	24.19%	21.07%

Table 7.7: Vidt\Let through comparison

As per above comparison Reduction in Vidt and Let through energy by increasing opening of contact in new drive shaft assembly.

Chapter 8

Future scope and Conclusion

8.1 Future Scope

- Develop new concepts related Slot motor position.
- Totally eliminate internal flash over in whole breaker by changing design of cover and housing.

8.2 Conclusion

This project is on Reliability performance of 100A Moulded case circuit breaker. MCCBs are given protection against Overload and short circuit condition so MCCBs must give isolation between two electrical circuit in abnormal condition in LT lines or distribution side.
In this 100A MCCB,18KA is the short circuit capacity. In existing Drive shaft assembly there is deformation of double conical spring (contact spring) because of excessive heating while short circuit test so it is replaced by Double-torsion spring with new drive shaft design and drive shaft link. Because of this new drive shaft link mechanism become non-live and current would not flow from mechanism. Non-live mechanism is help to prevent flash over through pole to pole.This project also includes stress comparison of both springs and Analysis of contact button selection.In existing contact button there is high erosion because of less hardness and melting point so analysis of different Ag alloys and its properties have been done.
At the end validation testing has been done with new drive shaft Assembly and new contact button. Results shows that ON(Ton) time of breaker and let through energy of breaker while short circuit test reduced in compare to existing drive shaft assembly.

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9. Accurate Spring Manual In this manual discuss about all spring and its calculations.