Thermal Analysis Of Air Circuit Breaker

Major Project Report

Submitted in Partial Fulfillment of the Requirements for Degree 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 **Thermal Analysis Of Air Circuit Breaker**. submitted by **Mr. Hora Stavan (15MEEE09)**. towards the partial fulfillment of the requirements for award of Degree in 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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Acknowledgement

With immense pleasure, I would like to present this report on Thermal Analysis Of Air Circuit Breaker. I am very thankful to all those who helped me for providing valuable guidance throughout the project work. It is a pleasant aspect that I have now the opportunity to express my gratitude towards them.

I would like to express my immense gratitude to Prof. M.V.Gojiya (Assistant Professor, Department of Electrical Engineering, Institute of Technology, Nirma University, Ahmedabad) for his valuable guidance, motivation and encouragement throughout my project. His constant support and interest equipped me with a great understanding of different aspects. His supervision and direction right from beginning motivate me to complete this period of project.

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Abstract

Circuit breaker is a switchgear which carries rated current under normal operating condition protect system against fault conditions. Air circuit breaker is a type of breaker which is generally operated at low voltage and current range of 400-6300 Amp. Heat generated in CB, during normal operating condition which lead to increase its temperature. Metal parts in current path dissipate large amount of heat while carrying rated current because of eddy current losses. As a result, there is a rise in temperature of the breaker throughout the current path. These eddy current losses are dependent on the material used along the current path. Temperature rise test is conducted to check thermal performance of the product at rated operating current. Temperature rise in the breaker should remain within the standard specified limit as specified by the standard.

By use of different type of non-magnetic material, it is possible to reduce eddy current losses in the ACB, thereby reducing overall heat generation of the product. This may result into lower value of temperature rise. Therefore, thermal analysis is being carried out to study the effect of eddy current losses on temperature rise along the breaker current path and accordingly possible options to reduce eddy current losses are being worked out.

Contents

List of Figures

List of Tables

Chapter 1

INTRODUCTION TO LARSEN & TOUBRO LTD.

We make things that make INDIA proud

Larsen & toubro is a company which achieves a great success in the field of technology, engineering, construction and manufacturing. Holck-Larsen and Soren Kristian are the two engineers who started this private company which now one of the largest and most respected company in India. Outstanding achievements of Larsen & toubros company shows their daring of entrepreneurs and their effective blind faith on their work and decision.

During the second world war, they started their floating workshop on ship whose name is M.V.Hilda which is the damaged Italian ship. On 1st may they started firm in partnership named as Larsen & toubro in order to repair market denish dairy

product and euquipments. From 1941, they stared manufacturing dairy plant products and machinery. In 1944,they entered in construction business and established engineering construction company (E.C.C) and became Pvt. Ltd. In 1950, it became a public Ltd. Company.

Motto of L&T to provide good services to every INDIAN culture through strong customer orientation. Because of these companys product are making record business and maintain their top position in this cutthroat compition.

L&T strength and success is because of its dynamic management, wide range of products and services and positive attitude towards their employees.it has total 23 manufacturing units installed all our the country.

L&T has 25000 personnel , which involve 8000 about executive and supervisory staff. It has 19th manufacturing units which are spreads in 7 states if country. It has 4 regoinal office, 5 brance offices. L&T vadodara has total built up area about 27000 sq. meters. L&T is a international manufacturer of wide rang of electronic and electrical products. In electrical field, company hold leadership position in low voltage equipments and products.

1.1 INTRODUCTION TO SWITCHGEAR DESIGN DEVELOPMENT CENTRE (SDDC)

Switchgear and design development is a section which design complete assembly of switchgear and then develops its drawing for further development.

1.2 CLASSIFICATION OF SDDC:-

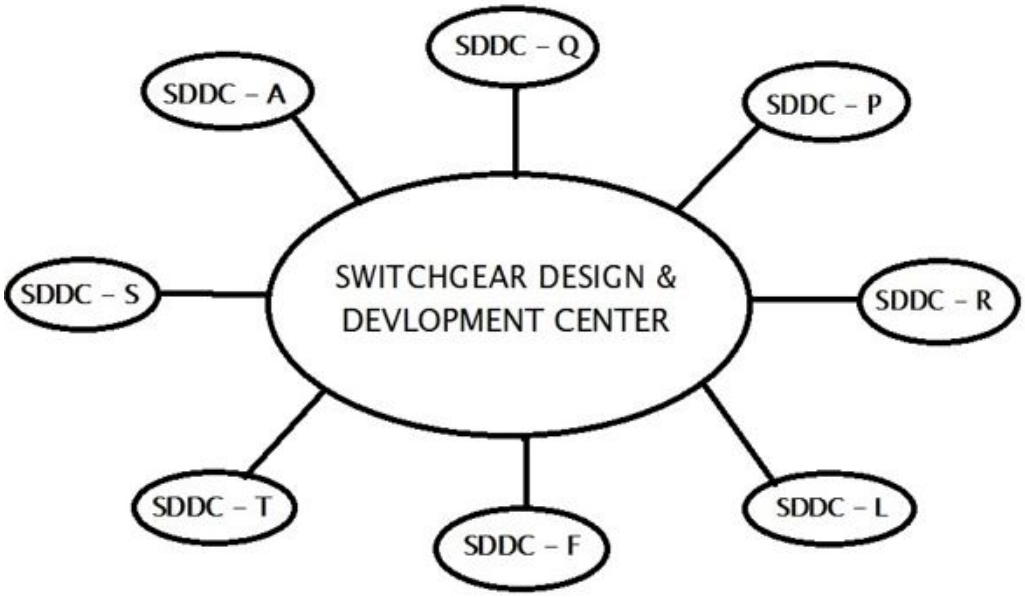


Figure 1.1: Classification of SDDC

1.2.1 SDDC - A: Analysis

It deals with products like MCCB, ACB and FUSES. Hear proposed designed product and existing products are compare and analysed.

1.2.2 SDDC - S: Starter

They work with release , starter such as DOL starter, star-delta starter.

1.2.3 SDDC - T: Switchboard

Switchboard groupdeals to get an optimum design of switchboards as per customer need. e.g.they can suggest different way of bus-bar mounting and it's arrangement.

1.2.4 SDDC - L: Electronics

any technical help and design of electronic product such as UV, CR are proposed by this department.

1.2.5 SDDC - R: Basic Research

It is a product research center which is not directly deal with any specific range of product but it deals with research of any new design.

1.2.6 SDDC - Q: Query: Life Cycle Management

It is directly customer oriented departemnrt to solve customer queries and probles related to product.they also works for product approval and certification of the product.

1.2.7 SDDC - F: Switch Fuse

This group deals on design and development of switches and fuse.

Chapter 2

INTRODUCTION TO AIR CIRCUIT BREAKER

2.1 What is circuit breaker?

Mechanical switching device, which is capable of making ,carrying and breaking current under normal circuit condition, and making, carrying , breaking current under abnormal circuit condition such as short-circuit. A circuit breaker is a device, which can,
circuit breaker is a switchgear which can use for both switching purpose and for protection purpose. circuit breaker makes and breaks current by making use of release, output from current transformer, etc. To make system stable and reliable with whole power system including transformer, motor, generator etc. circuit breaker is used for control of electrical quantity and for protection of power system.

There are different types of circuit breakers available in the market.

2.2 Features of air circuit breaker:

- High making and breaking capacity.
- High fault withstanding capacity.
- dimensio and robust design.
- mechanical and electrical life.
- resistance to electrodynamics forces of short circuit
- builtin ampere metric release(AMR) with wide range of setting. The ampere metric release is for overload and short circuit protection, volt metric releases for the under voltage..
- easy maintenance.
- Capability of accepting a wide range of accessories for signaling, interlocking and automatic control.

2.3 Application of Air Circuit

- Power stations
- Process plants like steel, cements etc.
- Almost invariably by all industries where there is a demand for high current.
- Some machines such as blowers, large motors, conveyors and cooling plants require a separate ACB because of thier high current requirements.

Chapter 3

INTRODUCTION TO U-POWER AIR CIRCUIT BREAKER

U-Power employ state-of-the-art technology to offer a comprehensive system solutionfrom intelligent protection to complete controlfrom installation to operating conveniencefrom user safety to system security, all this in the most modular design of optimized dimensions just like a beehive.

3.1 Classification of U-Power Air Circuit Breakers

U-Power Air Circuit Breakers are classified on basis of its mounting arrangement, its current carrying capacity and the number of poles present. This classification is detailed as follows.

3.1.1 On basis of mounting arrangement

On basis of the mounting arrangement, U-Power ACBs are classified as:

- **Fixed Breakers:**
  In fixed breakers, the breaker terminals are connected directly to the terminal adapters. low cost is the biggest advantage of this breaker.. But during maintenance, the power supply of the system must be cut off and the breaker must be disconnected from the terminal adapters. This is a major disadvantage of a fixed breaker.

- **Draw Out Breakers:**
  The breaker is mounted on rails through which breaker can easily rack in and rack out from the cradle. heance during maintenance their is no need to cut of complete power supply of system. Toprovide an electrical contact between

the cradle and the beaker, the breaker needs to be racked in the cradle with the help of racking assembly.

Advantages of a Draw out Breaker compared to a Fixed Breaker:

- During maintenance, the power supply need not be cut off, as the breaker can be racked out and locked in the ISOLATED position.
- If the breaker is being repaired, it can be replaced with a spare breaker of a similar rating.
- It is possible to check the operation of the control unit without switching ON the main power supply, by racking the breaker in the TEST position.
- For routine inspection, it can be totally racked out to the MAINTENANCE position.

3.1.2 On basis of its Current Carrying Capacity (Rating) and the Number of pole

Air Circuit Breakers are also differentiated on basis of its Frame i.e. its current carrying capacity and the number of poles.

- Frame 1: upto 1600 A
- Frame 2: upto - 3200 A
- Frame 3: upto - 6300 A

Chapter 4

Current path in air circuit breaker

4.1 Introduction

A circuit breaker is basically an electro-magnetic safety device which protects against overload, short circuit and ground fault. When the circuit breaker operates it attain high temperature due to internal heat generation by its conductors when current flow through it. As the current rises, the temperature of conductor increase. Heat is also generated due to arcing during contact making and contact breaking operation. This heats gets absorbs into the conductors causing increase in their temperatures. Excess of heat causes damage to the insulation of conductors. High level of heat can cause the insulation to breakdown and flake off, exposing conductors. Thus heat generated is to be dissipated to the atmosphere so that the temperature of breaker and component is remain within specified limits. In the current project temperature rise test were conducted on a breaker which determines temperature rise in various components along the current path of the breaker from source to load. The temperature rise limits are specified by IEEE and American national standard institute in IEEE C37.13 and IEC 60947-2.the temperature rise test involves application of rated current for long time till thermal equilibrium is achieved. Thermal design aspects of breaker involves desigining a breaker for low temperature rise. To avoid frequent test electro-thermal analysis are carried out with analysis tools in order to predict the effect of any change on temperature rise along breaker current path . for this, ANSYS 12 are used for the electro thermal analysis on air circuit breaker.

Temperature rise in switchgear is mainly as a result of the various losses in the conductor, contacts, magnetic circuit etc. Rise in temperature is mainly observed during development of new techniques of construction and operation of equipments.

Attention is drawn to the precaution to be taken for sets of components when they are grouped together in same enclosure. Temperature rise of any component is permitted by particular switchgear standards, these can be different from practical situation. Hence this is also encounted into temperature rise test.

4.2 Need of Temperature-Rise Test:

A circuit breaker is installed in order to provide protection to industrial machinery. If temperature in breaker is increase above some cirtical value it will affect the electrical life of breaker and damaged insulation provided on conductor. High level of heat generation will damage insulation to breakdown. Whenever a breaker is in closed condition, carrying current in regular operation, a heat is generated due to ohmic losses which needs to be dissipated effectively. If this heat is not dissipated appropriately, it will cause a rise in temperature.if it is beyond the safe operating temperature of the components of breaker, particularly electrical insulation, resulting in improper functioning of the components or sometimes equipmet failures. Ability of enclosed assembly of breaker to dissipate heat successfully so that equipments and machinery fitted with is can work as same as original equipments as specified by manufacturer is shows the success of temperature rise test.

4.3 Temperature Rise Test (Experimental setup):

Temperature rise test also referred to as continuous current test is performed in order to verify current carrying capability of the circuit breaker. During this test, based on the design of contact system and conductors, the temperature of current flow path will increase.

The current source provides continuous flow of rated current which, through the cables and the busbars, reaches the breaker. From the breaker the current, which normally goes to the load, is shorted using shorting links for the test purpose.

As the current flows through the conductor current flow path, the parts generate heat because of flow of current through them. This heat needs to be dissipated into the atmosphere as it may cause damage to conductors and their insulation. In order to measure the temperature, thermocouples are connected at various places along the current path.

These thermocouples sense the temperature throughout the duration of the test, which are recorded in a computer.A thermometer is kept at a distance from the tested device which shows the ambient temperature at any instant.

Temperature rise is measured with respect to the ambient temperature. The difference of temperatures from thermocouple and thermometer gives the temperature rise at a particular point in the current path with respect to ambient. The test is carried out over a period of time sufficient for the temperature rise to reach a stable value. The final temperature rise is reported as the difference between temperatures of thermocouple and thermometer at the end of the test after the temperature readings stabilize.

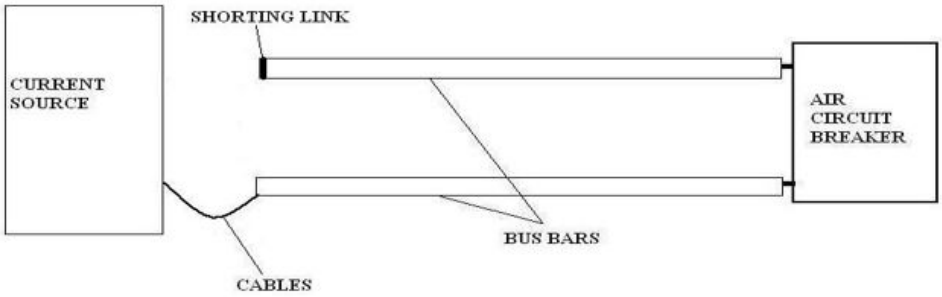


Figure 4.1: Exprimental setup

4.4 Setup requiremtens:

Let example of frame-1 1600A circuit breaker for temperature rise test.

Table I: Example for Frame-1 1600A breaker

Experiments/tools	Function and numbers of quantity
1.Bus bars(links)	2*100*5 (decided base on how much cross section needed)
2.bush and spacers	Depends on width of the top and bottom adaptor
3.data logger	Shows the diffrance between ambient temperature and thermocouple temperature.
4.breads	It is an one kind of cable carrying current of 450A and 200A depends on their size respectively.
5.set up time	Minimum 2:30 hours
6. current source	8V 7000A
7. readings	At every one hour till the temperature get stable

4.5 Standards:

IS/IEC 60947-2 is a standard that is developed of low voltage AC air circuit breakers, which gives the temperature limits of circuit breaker.

4.6 Termperature rise limit

As per IS/IEC 60947-2; limits of rise in temperature is specified for proper operation of air circuit breaker. As per the above standard, temperature of external parts (in our case cradle) should be less than 80 C. These limits of standard will decides success of temperature rise test.

4.7 Current path in air circuit breaker during temperature rise test:

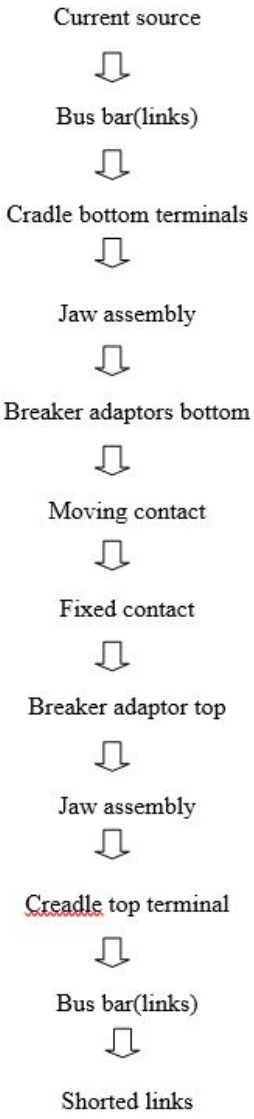


Figure 4.2: Current path in ACB

Chapter 5

Some important things about temperature rise test:

5.1 Preparation of surfaces:

Contact surface must be cleaned by machining if required. After cleaning the contact surface, it is advisable to cover that cleaned surface by making use of petroleum jelly in order to prevent re-oxidation. Petroleum jelly will help the joints from deterioration. The joint surfaces are bolted with each other. it is advisable to make the use of petroleum jelly which has higher melting point because it should have to deal with some degree of higher temperature then the normal ambient temperature.

5.2 Effect of pressure on contact resistance:

It is good to maintain the contact pressure in order to prevent deterioration of the joint. Figure shows the effect of pressure on joint resistance. Following graph shows the effect of pressure on the contact resistance of a joint between two copper conductors mm.

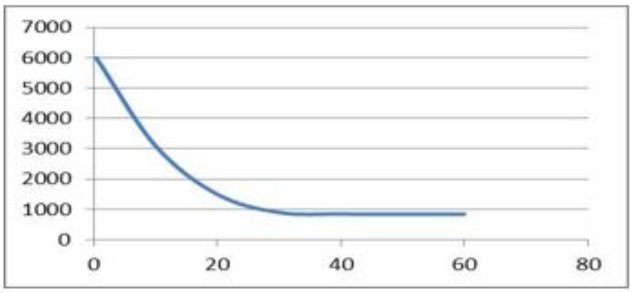


Figure 5.1: Effect of pressure on contact resistance

Joint resistance falls rapidly with increasing pressure.Under loading condition, bus bar starts heating up which results into increase in contact pressure in an joint made with steel bolt due to of difference in the expansion coefficient of copper and steel.

5.3 Current Path:

The solid model is prepared on 3D modelling tool Pro Engineer. The components are modelled individually and assembled as the current path. The dimensioning of the models is done in millimetres. The finger assembly contains Flexible, Moving contact, Ag-Ni Tip and Arc Runner. The Flexible is a copper foil welded at the ends. It is responsible for easy open-close movement of the finger assembly. Moving contact is the copper part which is pivoted in the middle through a pin. The Silver-Nickel tip is brazed on the moving contact in the slot provided. It is the point of making and breaking of the current. The arc runner is an extruded copper part which guides the arc away from the finger assembly during opening operation.

5.4 Terminals:

Top and bottom terminals are copper blocks. The finger assembly is always in contact with bottom terminal as it is bolted to the bottom terminal where as it makes and breaks contact with top terminal during operation. The current from source through the current path enters bottom terminal goes to fingers and then to top terminal. During opening operation, finger assembly moves away from top terminal interrupting the current flow.

5.5 Jaw Clusters:

Jaw clusters connect the draw-out part of the breaker with the stationary part and facilitate withdrawal of the breaker for inspection, maintenance or component change. They are limited to draw-out breakers. Clusters are spring loaded which provides continuous pressure on the terminals and universal pad, assuring their electrical and mechanical contact.

Chapter 6

Eddy current and eddy current loss

According to faradays law of electromagnetic induction, emf is induced in the material itself when alternating magnetic field is applied to a magnetic material. This induced emf circulates the current within body of material. This circulating current called as eddy current.

This occurs mainly when current conducting material experience changing magnetic field. These eddy currents are not useful for the system, and it produces losses in the form of heat in material which is known as eddy current loss (i.e. I2R loss. where I is value of eddy current and R is resistance of eddy current path). This additional heat generated results in increase in temperature of conducting material.

If core is made up of solid iron having large cross section area, magnitude of I will be large, hence losses will be high.

6.1 Reduction of eddy currents

Eddy currents can be reduced by:

- 1. Reducing magnitude of eddy current, by splitting core material with thin sheets called as lamination. Each lamination is insulated from nearby components. By doing this, total cross section area reduced and hence induced emf also reduced. As area for current path is reduced, resistance of that path is increase. Hence eddy currents produced will be reduced.
- 2. Effect can be reduced by using non-magnetic material, i.e. having higher value of resistivity and effective permeability.

Chapter 7

Eddy currents in breaker

When current is flowing from source to breaker it passes through busbars, cradle adaptor, cradle terminal, jaw assembly, breaker adaptor, breaker terminal to link and completes current path. During this period at cradle side, current is passed through adaptor to terminal through rectangular nut plate, bolt, plain washer, spring washer respectively. Adaptor and terminals are made from copper material and carry major portion of current and plays very important role in current path. Remaining components such as nut plate, plain washer, ring washer are made from mild steel. Mild steel is ferromagnetic material, i.e. it is magnetic. During current flow, due to changing flux, it induces emf in mild steel which set up the eddy current and these current in return produce a loss called eddy current loss, leading to heat generation.

In order to reduce this additional heat generation, it is possible to use material having higher resistivity and effective permeability. This can be achieved by using stainless steel in place of mild steel. Stainless steel contains less carbon and alloyed with chromium, nickel in order to improve its mechanical and chemical properties. Stainless steel gives effective performance against thermal expansion and thermal conductivity. Stainless steel has many advantage over mild steel as explained below.

Chapter 8

Mild steel Vs stainless steel

8.1 Mild steel

Mild steel is a metal alloy which contain carbon and iron that has low tensile strength and its surface hardness can be increased by adding carbon content. It is steel having carbon about 2% and no other alloying element.

Mild steel is less brittle than stainless steel. Mild steel is stiff and contain ferromagnetism. i.e. they are magnetic. During current flowing changing flux links with the core itself, it induces emf in the mild steel which set up the circulating current it is called as eddy current and these current in return produce a loss called eddy current loss. Eddy current loss is higher for larger cross section area as magnitude of current increase;losses will be increase.

In addition, the corrosion resistance of mild steel is poor and so they should not be used in a corrosive environment unless some form of protective coating is used. Due to its ferromagnetic nature it has wide application in motor and electrical appliances sector.

8.2 Stainless steel

Stainless steel is steel alloy with a minimum of 11.5% wt chromium content.it does not stain, corrode or rust as easily as ordinary steel and contain less percentage Carbon content.

Presence of carbon rusts when exposed to air and moisture.It accelerates corrosion by forming iron oxide. Stainless steel have sufficient amount of chromium present so it prevent further corrosion.It is less malleable and harder than mild steel. More resistance to corrosion.

It contain less carbon and alloyed with chromium, nickel in order to improve its mechanical and chemical properties.

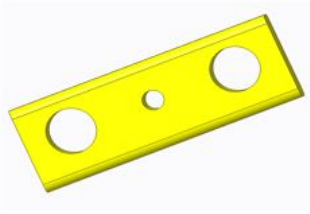
Stainless steel has two important physical properties which is thermal expansion and thermal conductivity.Lower thermal conductivity is important for retaining heat.

8.3 Comparison between mild steel and stainless steel

	Mild steel	Stainless Steel
Composition	An alloy of iron and carbon	Alloy of iron and chromium
Rusting property	Can rust	Doesn't rust
Strength	Hard and wear-resistant	Softer
	Brittle	Non-brittle
corrosion resistance	it is poor. It is not suitable in a corrosive environment; some form of protective coating is used.	Corrosive resistance of SS is good.it is also called corrosion resistant steel
Density	Higher density as no any alloying elements	It has less density because of chromium alloyed .
Thermal conductivity	Mild steel has higher conductivity	having lower conductivity and it goes on decreasing with increasing in alloying level.
Electrical Resistivity	Lower because of no alloying content	It is higher and it increase with increase with content of alloying elements.
Magnetic Properties	It is ferromagnetic and it is affected by flux when conductor carrying current	less affected to magnetic effect so eddy current loss is less

Figure 8.1: Comparison between mild steel and stainless steel

8.4 Components used in cradle throughout current path



Cradle nut plate

Volume: 10 cm^3

Material: - existing- mild steel

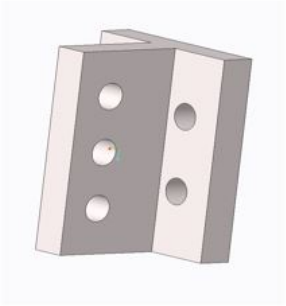
Proposed- stainless steel 314LN

Hexagon socket head cap screw

M12 Allen bolt

Material: - existing- mild steel

Proposed-stainless steel 314LN



Cradle adaptor

Material: copper

Cradle terminal

Material: copper IS:6912

Figure 8.2: Components used in cradle throughout current path

Chapter 9

Assembly of circuit breaker

9.1 Cradle Assembly of circuit breaker

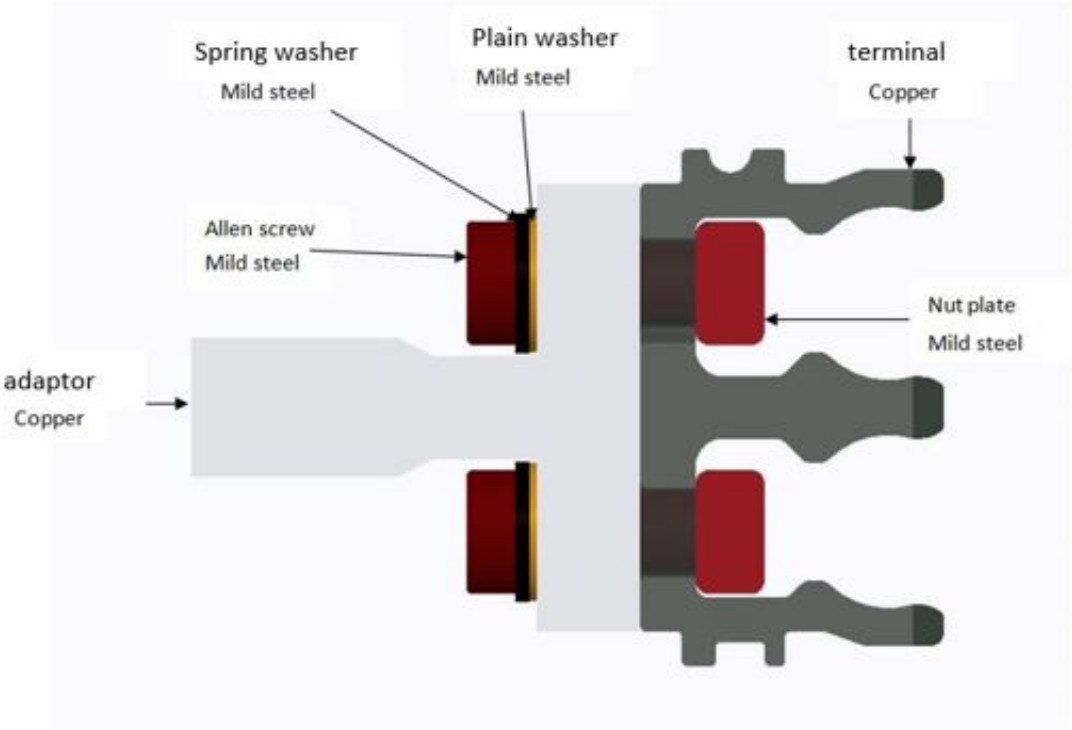


Figure 9.1: existing assembly of cradle terminal-adaptor

figure shows actual existing terminal-adaptor of cradle and proposed terminal-adaptor of cradle.

We can clearly see that Allen screw, spring washer, and plain washer are made up of mild steel which having properties of ferromagnetism that means during current flow its magnetic field oppose causes of its production and due to this circulating current is produce in itself which is not useful for any work hence it is dissipated in the form of heat.

It heats up the terminal and adaptor of cradle and because of this addition heat is generated which increase overall temperature of terminals.

In order to overcome this situation, it is better to use material having less affected by magnetism but having equal strength as same as mild steel. Best option to solve this is to use stainless steel in place of mild steel. This is shown in below figure.

Stainless steel also produces heat but it is negligible in comparison with mild steel and also in absence of carbon it has very high corrosive resistance. Also it may not require to galvanization which prevents corrosion as compared to mild steel. By making nut plate, Allen screw, spring washer, ring washer from stainless steel result of temperature rise can be reduced up to some amount.

Currently temperature at cradle terminal is about 60 degrees Celsius and temperature at cradle adaptor is about 55 degrees Celsius. By making use of stainless steel it is possible to reduced value of temperature and reduce heat dissipation.

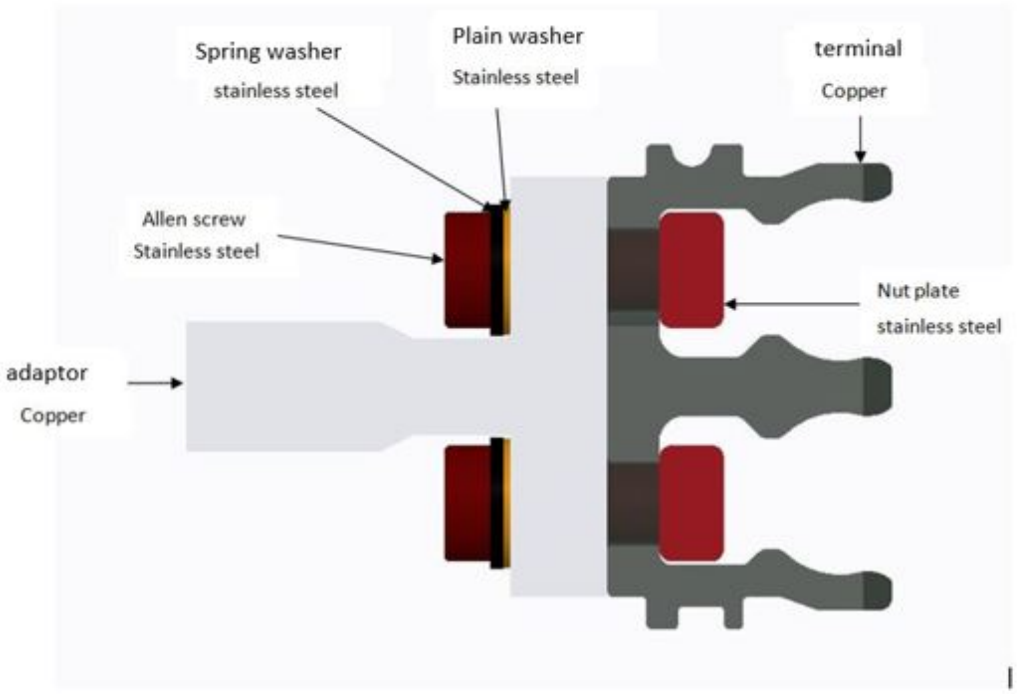


Figure 9.2: proposed assembly of cradle terminal-adaptor

9.2 Moving contact assembly of circuit breaker:

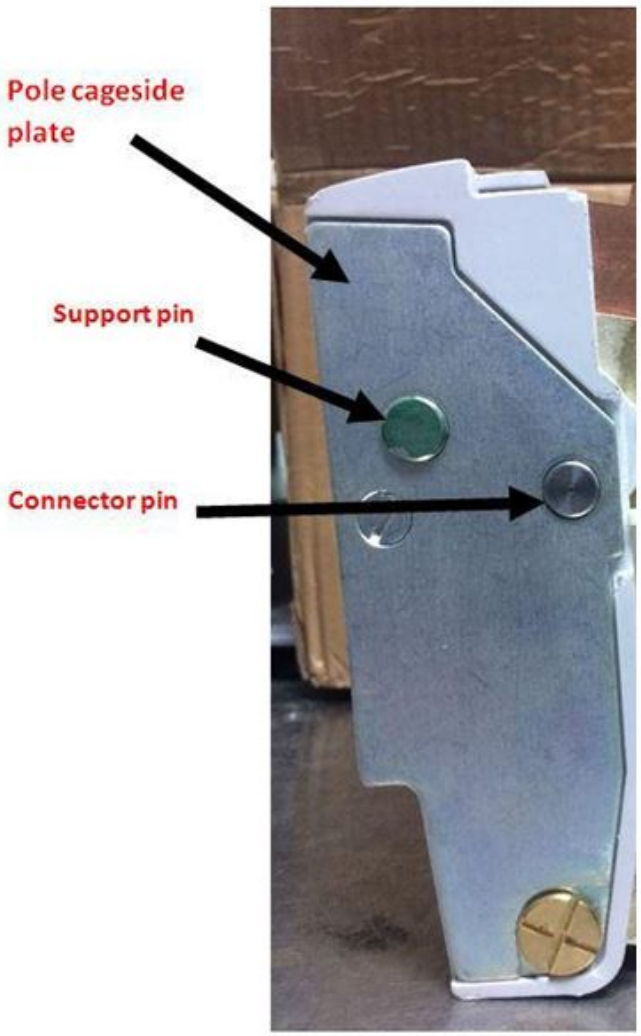


Figure 9.3: Moving contact Assembly

In order to get better temperature rise test result, some of material made from mild steel in moving contact assembly is changed by austenitic steel.as we know that austenitic steel is nonmagnetic material and is less affected by eddy current compare to mild steel. Hence heat dissipation by austenitic steel is also less than the mild steel.

9.3 Bolting arrangement:

In order to create necessary contact pressure to give high joint efficiency bolting arrangement is also very much important in both electrical and mechanical aspect. Contact pressure should be high which helps to preventing deterioration of joint. And therefore numbers of bolt used, size, material of bolt plays an important role. Strength of bolt is depending on material of bolt and maximum operating temperature. Therefore, comparing the mechanical and electrical property of mild steel an austenitic steel we can conclude that bolt made from stainless steel material gives very effect performance during temperature rise test.

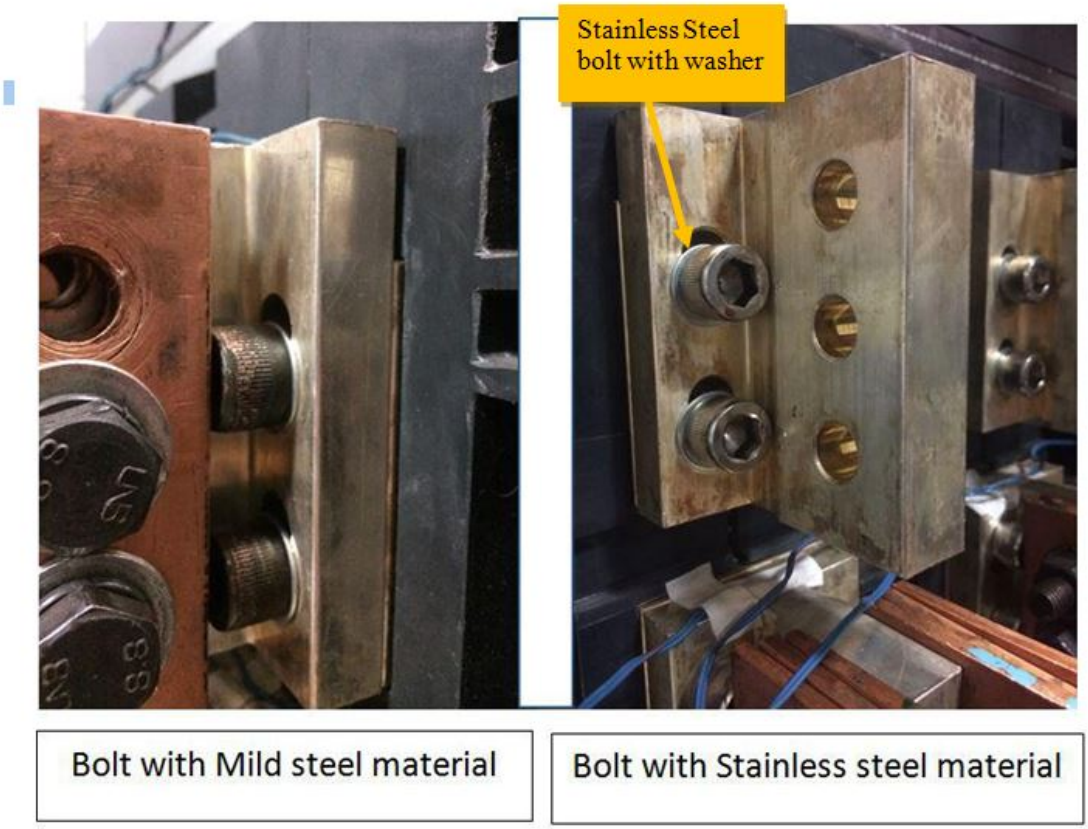


Figure 9.4: MS bolt and SS bolt

Chapter 10

mV drop test

Value of mV drop test is also important factor for temperature rise test. Value of mV drop test must be less than 1.4 at breaker adaptor-terminal for good current path.it is depends on value of joint resistance.

If joint resistance is lower than value of mV drop is also less and it is good sign for completing close current path. In this test 100-volt Dc supply is given to breaker top and bottom terminal-adaptor. Value of millivolt is measured in multi-meter.

mV DROP TEST			
	R	Y	B
Cradle adaptor	1.78	1.75	1.79
Cradle terminal	1.75	1.7	1.76
Breaker adaptor	0.96	0.91	0.92
Breaker terminal	0.88	0.85	0.87

Figure 10.1: Result fot mV drop test

Chapter 11

Result Analysis

Frame-2 2500A 12 fingure with 24 bus-bar(link) 100*5*4

11.1 Current path in existing material

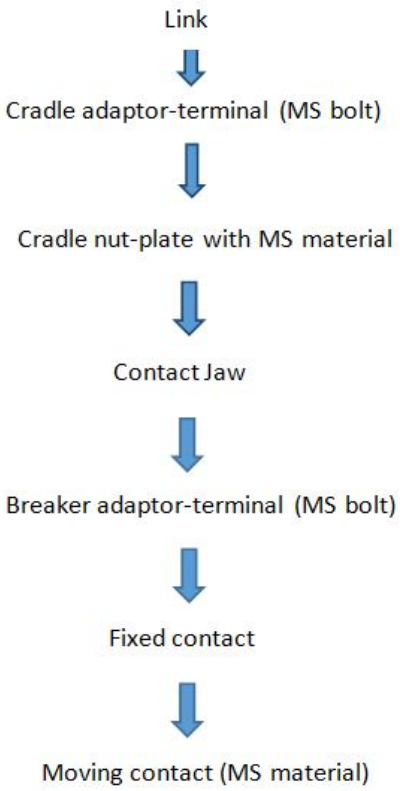


Figure 11.1: Current path in existing material

As per experimental setup, Temperature rise test is conducted for existing component having mild steel material.

Cradle nut-plate, Breaker nut-plate, pole care left-right side plate,support pin,connector pin,fulcrum pin of moving contacts are made from mild steel material.

Result for MS components	
CR ADP TOP	45.5
CR ADP BOT	43.1
CR TER TOP	51.5
CR TER BOT	45.3

Figure 11.2: Result for Mild Steel components

Figure shows variation of temperature along current path. It is clear that temperature is highest at interphase of moving and fixed contact. This is because of resistant at that point is higher. We can clearly see that temperature at cradle terminal is about 51.5 degree Celsius and temperature at cradle adaptor is about 45.5 degree Celsius.

In order to reduce this temperature rise up to some amount material properties are analysed and corrective actions are must taken. Mild steel material having magnetic properties because of this it is affected by eddy current loss and external eat heat is generated and it increase overall temperature of TR test.

11.2 Current path for proposed material:

Cradle nut-plate, Breaker nut-plate, pole care left-right side plate, support pin, connector pin, fulcrum pin of moving contacts are made from austenitic steel 304LN material.

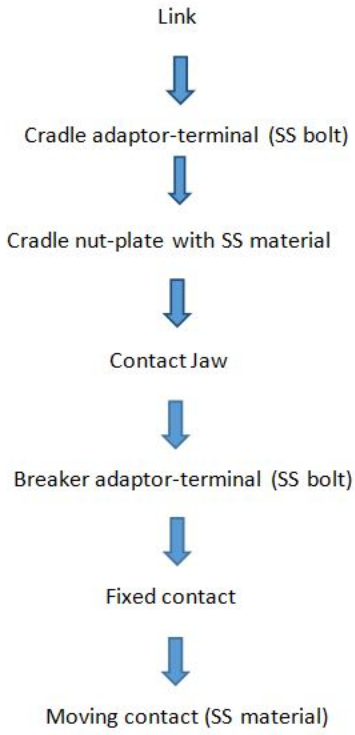


Figure 11.3: Current path in proposed material

Figure clearly shows that at cradle terminal temperature is about 48.7 degree Celsius and at cradle adaptor temperature is about 43.3 degree Celsius.

Result for SS components	
CR ADP TOP	42.9
CR ADP BOT	43.3
CR TER TOP	48.7
CR TER BOT	44.7

Figure 11.4: Result for Stainless Steel components

11.3 Experiment setup for Frame-2 2500A:

Figure 11.5: Experimental setup for TR test

Chapter 12

Comparision of results

Comparison of results		
	SS	MS
CR ADP TOP	42.9	45.5
CR ADP BOT	43.3	43.1
CR TER TOP	48.7	51.5
CR TER BOT	44.7	45.3

Figure 12.1: Comparison of result

By comparing TR result for mild steel and stainless steel, we conclude that value of temperature at cradle terminal and adaptor is reduce about 2 degrees Celsius. Hence we can say that effect of eddy current is reduce as we replace mild steel component with stainless steel components.
Comparison of temperature rise value conclude that new design with proposed material is within the thermal limit and doing change in existing material did not affect design thermally.

Chapter 13

Electro Thermal Analysis

13.1 Significant of electro thermal analysis

Basic requirement for temperature rise test is to supply continues high current from current source for several hoursup to 5-6 hours continuously. Hence we can say that it is costly and time consuming process.

It is possible to make numbers of minor changes in current path, in breaker assembly, at joining of components etc. Therefor testing for temperature rise test for all possible minor change is not logical.

Thus, electro-thermal analysis is carried out which predict the temperature rise due to minor change.
As analysed result is achieved by assuming some parameter and minor changes, this result is compared with standard result.

Once analysed and standard result are matched, theassumed parameters are recoded. And that minor change for design is taken for actual development of assembly for actual experimental test.

As new designed geometric is ready, it is tested in temperature rise laboratory and result is compared with Anasys result.

Hence, we can say that electro-thermal analysis saves time, testing cost for each and every minor change in assembly.

13.2 Ansys analysis procedure

The solid model is developed with the help of pro-engineer is imported into Ansys 15 classic multiphasic by converting it into IGES format. Before applying voltage, current; properties of material and meshing is done.

First of all, material property of element is specified which includes thermal con-

ductivity and resistivity of material which are includes in current flow path.

For thermal electric analysis, first step is to choose the elements on the basis of inputs given and output required. Each material have its own degree of freedom and property.

For our analysis thermal electric SOLID 69 is selected, it is having 3-D thermal and electrical conduction capability. It provide two degree voltage and temperature at each node of elements.

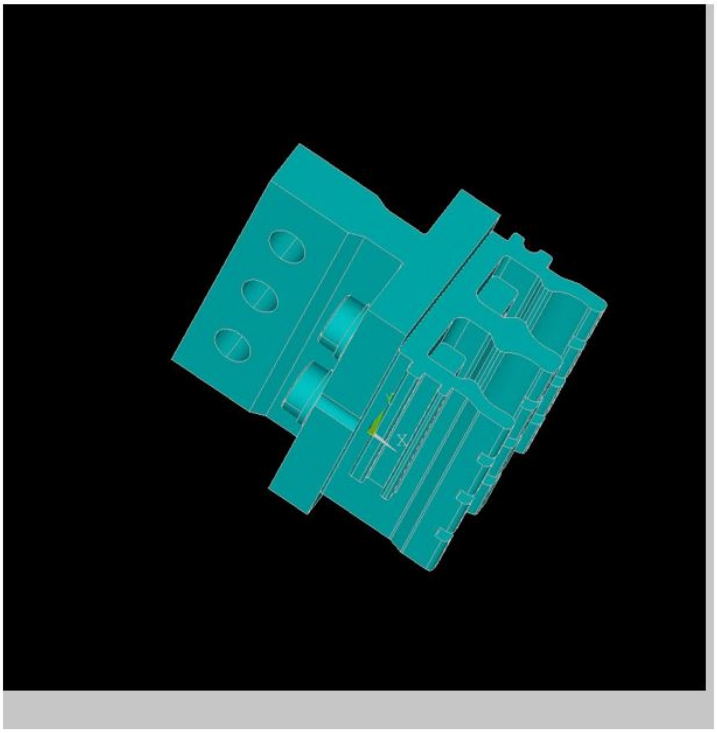


Figure 13.1: current path assembly for cradle terminal -adaptor in ANSYS

Once the element, material properties are chosen next step is to select meshing. Meshing mainly done on basis of what amount of accuracy we needed in final result.

It is time taking procedure, which depends on value of meshing we selected. Smaller is the value, longer is the time.

When meshed model is ready, loads are applied on it which includes current, voltage and convection.

Current is applied by selecting nodes and coupling them into entire surface. current path is depends I size, shapes and numbers of components involve in breaker.

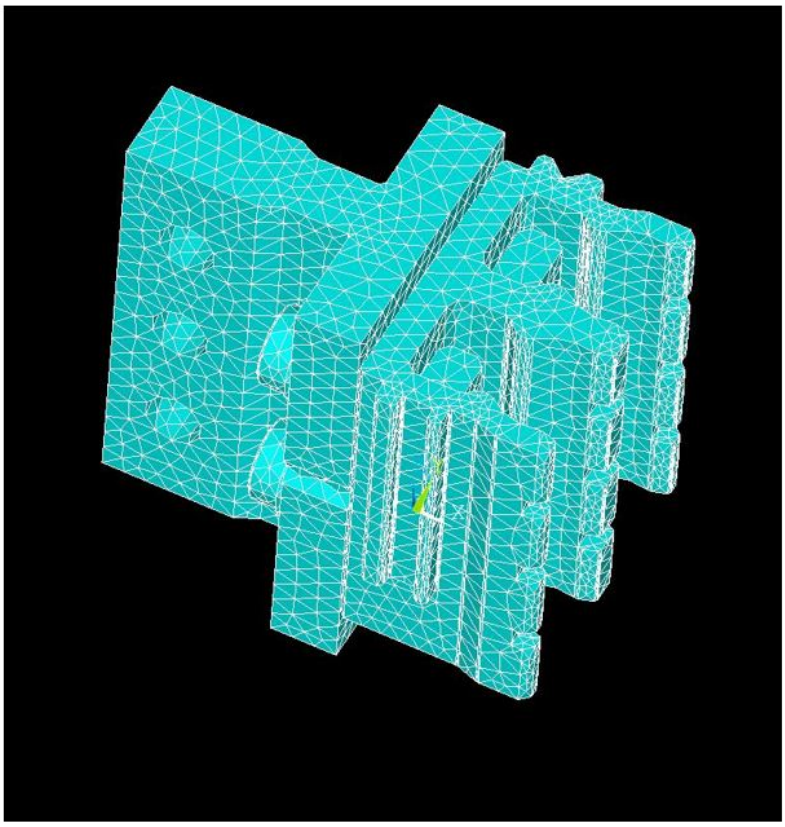


Figure 13.2: Meshed model for cradle terminal -adaptor in ANSYS

All current path is modeled into pro-engineer so they can easily import into Ansys for analysis.

After doing meshing properly, loading condition is given for voltage, current, thermal convection, ambient temperature. Developing model in ANSYS workbench, simulation is done for cradle adaptor terminal component made from both mild steel and stainless steel.

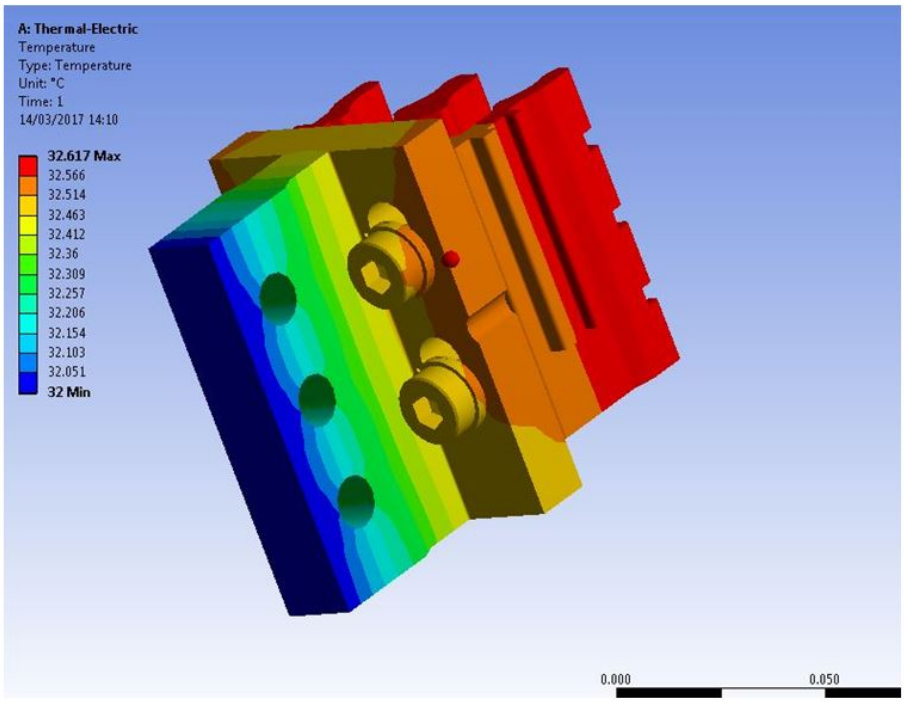


Figure 13.3: Analysis with MS material

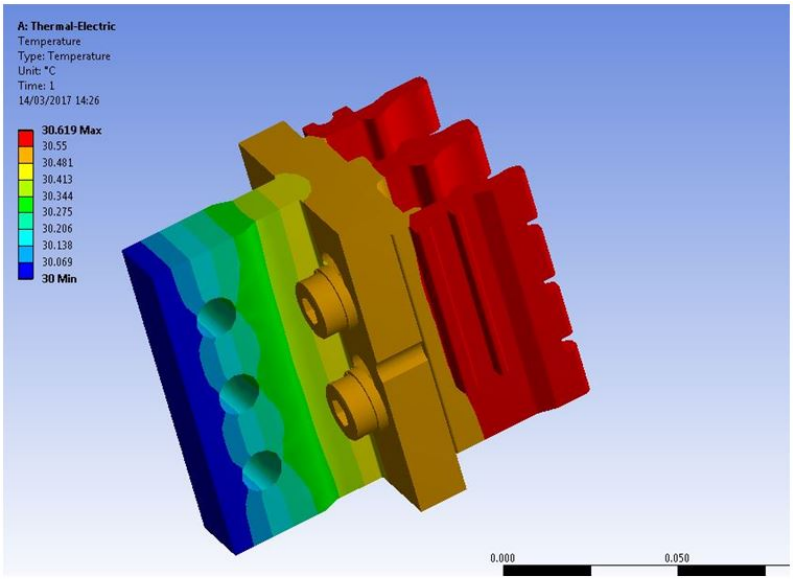


Figure 13.4: Analysis with SS material

From figure value of temperature for mild steel material for frame-2 2500A current is about 32 degrees Celsius and it is about 30 degrees Celsius for stainless steel material. We can easily identify by simulation of this small model that temperature value is reduce for new proposed material and it is also possible to reduce heat dissipation because of magnetic material.

Comparing both ANSYS analysis and experimental test it is clear that temperature rise value for cradle adaptor terminal is reduce using stainless steel material. Below table shows that use of stainless steel material instead of mild steel matrial gives effective reduction in value of temperature rise test

	Result from experimental setup		Result from ANSYS analysis	
	SS	MS	SS	Ms
Cradle adaptor	42.9	45.5	30	30
Cradle terminal	44.7	45.3	30.9	32.6

Figure 13.5: Comparision of ANSYS and Actual results

Chapter 14

Thermal-Electric Analysis of standard ACB

For our analysis thermal electric Copper alloy is selected, it is having 3-D thermal and electrical conduction capability. It provides two degree voltage and temperature at each node of elements.

Copper Alloy Material Properties	
Density	8300 kg m^-3
Coefficient of Thermal Expansion	1.8e-005 C^-1
Specific Heat	385 J kg^-1 C^-1
Thermal Conductivity	401 W m^-1 C^-1
Relative Permeability	1
Reference Temperature C	22

Figure 14.1: Material Properties

Once the element, material properties are chosen next step is to select meshing. Meshing mainly done on basis of what amount of accuracy we needed in actual result. It is time taking procedure, which depends on value of meshing we selected. Smaller is the value, longer is the time. When meshed model is ready, loads are applied on it which includes current, voltage and convection.
After applying all necessary condition and requirements for simulation some results are achieved. For Ansys simulation, to obtain accurate value some trial of simula-

tions are taken using different conditions.

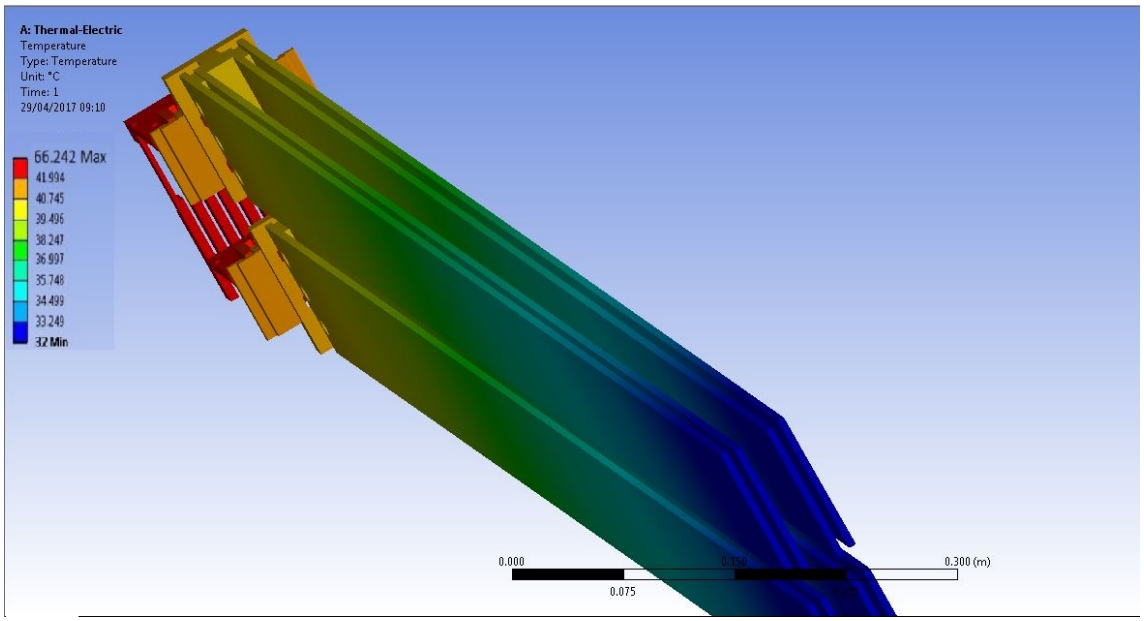


Figure 14.2: Simulation of standard ACB

Result shows the temperature variation along the current path for Frame-2,2500A breaker with 12 fingure and 8 copper bus bar (links).

We can observe that temperature is maximum at the interphase of contact making and breaking. This is because of highest value of resistance at that point.

After analysis, result shown by the plot is the absolute temperature at surface of particular component. Actual temperature rise is calculated by subtracting ambient temperature from absolute temperature which is shown by Ansys plot.

Actual Temperature =Absolute Temperature-Ambient Temperature

Result Comparison			
	Experimental setup	ANSYS analysis result	As per Standard
Cradle Top	42.9	40.7	<80
Cradle Bottom	44.7	41.9	<80

Figure 14.3: Result Comparison

Above table shows a comparison of experimental data and Ansys analysis result.

Analysis of result is done at cradle adaptor-terminal and at breaker moving contact as this part is contain majority of mild steel component which are replaced by stainless steel components.

Here, Analysis is done for standard air circuit breaker assembly with bus-bar(links) connected and then it is compared with experimental result of Frame-2,2500A having standard component.

From the result, we can clearly seethat, temperature rise at top bus bar terminal according to experiment is 42.9 degree Celsius. And according to Ansys analysis is 40.7 degree Celsius.

Similarly, we can see that temperature rise at cradle bottom terminal according to experiment is 44.7 degree Celsius and according to Ansys analysis it is 41.9 degree Celsius.

Chapter 15

Literature survey:

(1) Syed Ibrahim dilawer , Md. Abdul raheem junaidi , mohd abdul samad , dr.mohd. mohinoddin , steady state thermal analysis and design of air circuit breaker, international journal of engineering research and technology(IJERT) , november 2013.

-It is important to encounted the effect of temperature rise test in air circuit breaker.
- How test set up done which function play an important role are well described in this paper.
- Why we need temperature rise test,standards and limits of temperature rise test are considerable point for success of temperature rise test.
-Effect of contact pressure, Preparation of surface, effect of heat on terminals and cluster are observed.

(2) Yi ZHANG, Guogang ZHANG, Jie WU, Weiguang YUAN, Yingsan GENG ; Development of Intelligent Design and Simulation Platform for Medium Voltage Circuit Breakers ; 2011 1st International Conference on Electric Power Equipment Switching Technology Xian China

-Development of small model using properties of busbar , surface , current path
-development of practical model and imporvment of overall performance by making use of ANSYS.

(3)CEI IEC 943 ; TECHNICAL REPORT on GUIDE FOR THE SPECIFICATION OF PERMISSIBLE TEMPERATURE AND TEMPERATURE RISE FOR PARTS OF ELECTRICAL EQUIPMENMTS, IN PARTICULAR FOR TERMINALS.

-It is very usefull manual to understand effect of temperature rise test during practical situation.
-How set up is done in practice, which components are needed of which size are very well described.
-How theoretical values are differ then practical values and procedure of temperature rise test in company are given.

(4)L & T U-Power Omega ACB catalogue

(6) IEC Standard 60947-1 and 60947-2

Chapter 16

Conclusion and future scope

16.1 Future scope:

Steady state thermal-electric analysis is conducted considering constant resistance but in actual practical application. As value of resistance is directly depends on temperature. Therefore transient analysis is needed to be conducted assuming resistance variation.
Current path having numbers of minor changes. Experimental setup for all possible situation will results in time consuming and costly process. Therefore direct simulation of any minor change can be possible using software simulation which is time saving and cost saving process.

16.2 Conclusion

From the literature survey, existing termination schemess study, electrically aecting factors study and thermally aecting factors study it is concluded that success of temperature rise test depends on generation of eddy currents which are further dependent on type and properties of materials used in the current path of the breaker. Therefore it is necessary to study effect of eddy currents on temperature.

Heat Generation in current path can be reduced by changing component material properties. i.e. replacing mild steel component with stainless steel component. This is achieved by using reducing eddy current losses. For cradle adapotor-terminal assembly, we can be reducing up to 2 degrees Celsius by making use of stainless steel material.

Second task is to do electro-thermal analysis of standard air circuit breaker assembly using Ansys software. After analysis, result clearly shows that it is possible and convenient to make analysis for all minor change in current path to reduce cost and time for testing.

References:

1. Syed Ibrahim dilawer , Md. Abdul raheem junaidi , mohd abdul samad , dr.mohd. mohinoddin , steady state thermal analysis and design of air circuit breaker, international journal of engineering research and technology(IJERT) , november 2013.

2. Yi ZHANG, Guogang ZHANG, Jie WU, Weiguang YUAN, Yingsan GENG ; Development of Intelligent Design and Simulation Platform for Medium Voltage Circuit Breakers ; 2011 1st International Conference on Electric Power Equipment Switching Technology Xian China

3. CEI IEC 943 ; TECHNICAL REPORT on GUIDE FOR THE SPECIFICATION OF PERMISSIBLE TEMPERATURE AND TEMPERATURE RISE FOR PARTS OF ELECTRICAL EQUIPMENMTS, IN PARTICULAR FOR TERMINALS.

4. L & T U-Power Omega ACB catalogue.

5. IEC Standard 60947-1 and 60947-2

6. Wikipedia