[1.]S.G. JADHAV, [2.]Revti JADHAV

ANALYSIS OF THERMAL MAGNETIC RELEASE FOR MOULDED CASE CIRCUIT BREAKER

[1.] Department of Mechanical Engineering Veermata Jijabai Technological Institute Matunga Mumbai, INDIA
[2.] Electrical Engineering Department Smt. Indira Gandhi College of Engineering Navi Mumbai, INDIA

Abstract: Circuit breakers protect the equipment's from short circuit currents, overloads and fault currents. Moulded Case Circuit Breakers are used in applications where current rating ranges from 16A to 1600A. Moulded Case Circuit Breakers have fault current carrying capacity ranging from 5kA to 200kA at 415 volts. For fault current values exceeding the specified value, the MCCB gets tripped. The tripping action takes place due to latching mechanism. This fault current is sensed by the release assembly in MCCB. The objective of this study is to design the components of this thermal and magnetic type using finite element analysis and other analytical tools. We are performing a finite element analysis for safeguarding each component against failure before testing the actual prototype. After conducting FEA, design of all components was found to be viable for prototyping and testing. The prototyped components once assembled with the MCCB were manually tested and found to be functionally suitable for the intended operations.
Keywords: moulded case circuit breaker; trip force; thermal magnetic release; finite element analysis

1. INTRODUCTION

A Moulded Case Circuit Breaker (MCCB) is a device that is constructed in an insulating material enclosure and used to make, convey, and break currents in both normal and abnormal circuits. According to the design requirements, it must function satisfactorily under overload, short circuit, and earth fault conditions. Low voltage distribution systems are mostly protected by moulded case circuit breakers. MCCBs' main purpose is to safeguard downstream circuit components against overcurrent situations. Under prolonged overloads or short circuits, an MCCB automatically isolates the electrical circuit. The moulded housing of moulded case circuit breakers is constructed of an insulating material with excellent mechanical, thermal, and electrical qualities [1,7]. Additionally, the cover acts as strong interface barriers, which reduces the overall dimensions. Sintered contact tips, using a combination of silver and tungsten, provide stability of the contacts at higher temperatures and at the same time offer low contact resistance while carrying the current. As a result of this, the mass of the moving contact system is much lower. This makes the MCCB trip faster, within 10 to 20 sec in the event of a fault [1].

Circuit breakers rely on mechanical drives and linkages for many of their tasks, thus determining how reliable they are is crucial. By identifying and removing the primary causes of failures using a variety of pertinent techniques, he demonstrated how to evaluate and enhance the reliability of air circuit breakers (ACB) [1,2]. FTA (fault tree analysis), Ishikawa diagram, CE Matrix, and Pareto chart were used to identify root causes. The root cause of failures was determined using several tools, and methods to eradicate the root cause were implemented. The reliability of the ACB mechanism was tested before and after improvement based on failure data received from testing [19]. Although this work is specific to one product, the approach can be extended to any product that requires reliability analysis [2].

A dynamic model for design and analysis of high speed circuit breaker mechanism for rapid opening and closing operations. The author suggested that multi–body dynamics is effective way for modeling breaker mechanism containing of complex kinematics, friction and impact for closing and opening operations [3,4]. A thermally responsive trip means for circuit breakers. Electrical power distribution circuit breakers typically have a way to trip the circuit breaker mechanism, which starts the automatic contact opening process, when certain abnormal circuit conditions are detected. Among the trip mechanisms that are typically used are those that use elongate bimetallic elements that are thermally responsive and fixed and supported at one end but otherwise free to deflect when heated and initiate contact opening operations when deflecting to a certain extent, or, in other words, far enough. An adjustable screw that is placed directly on, or operating upon, the active section of the associated bimetallic element is a typical sort of adjustment for thermal trip means [4,5]. Each of the controls is independently and separately adjustable to provide for the accurate calibration of the circuit breaker for both sudden heavy overloads and under electro–magnetic control. The circuit breaker operates automatically under the control of thermal–current responsive means and also under electro–magnetic control [6,7]. Three components make up the thermally sensitive tripping mechanism: a bimetallic strip, an adjustable component, and a latch. When the bimetal is heated, it is known that the bimetal will bend in one direction, activating a number of mechanisms [8]. This will cause the latch to swivel, detach the actuator's end, and collapse the toggle,

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

tripping the circuit breaker. The air gap between the armature and the electro–magnetic means can be adjusted to change how the latching member responds to the current value. The electro–magnetic means is energised by the current in the circuit and has a member made of magnetic material and a moveable armature for electro–magnetic means [9].

Trip mechanism has two plunger–acting trip actuators: a bi–metal trip actuator and a magnetic trip actuator. Each trip actuator has the ability to independently move the plunger in response to the detection of either a thermal fault or a magnetic fault, tripping the circuit. Magnetic faults are short circuit faults, whereas thermal faults are long–term overload currents [10,11]. Trip actuator developed is capable of moving the plunger independently of the other trip actuator to cause the trip mechanism to trip in response to detection of either a thermal fault or a magnetic fault [6,9].

Multi–body dynamic analysis for Spring Operating Mechanism (SOM) to predict, estimate and validate forces occurring during the working conditions. ADAMS was used for multi–body dynamic analysis of MCCB with SOM. Many components were sequentially added and reliability of modelling was validated through experimental data [12–13].The wire's path into the ends should be smooth and gradual to prolong the spring's lifespan. Reduce the amount of tool marks and other stress concentrations. It is advised to choose a bend radius that is at least 1.5 times the wire diameter. The spring ends frequently experience higher stresses than the spring body. Reduce the end coil diameter in relation to the body coils and use forming radii that are no larger than half the I.D. to reduce hook stress. In torsion, hook stresses shouldn't be more than 40–45% of tensile strength, and in bending, hook stresses shouldn't be more than 75% of tensile strength [14,15].

A thermal overload release and a magnetic short circuit release make up the breaker's tripping mechanism. The bi–metallic element used in the thermal overload release creates heat when current travelling through the conducting path of a circuit breaker passes across it, causing the bi–metal to deflect and trip the breaker. The amount of current running through the bi–metal and how long it is flowing for determine how much heat is produced in the bi–meta [16–17]. In a short circuit, the increased current running through the circuit breaker activates a magnetic release, which trips the breaker significantly faster than bi–metal heating[18,19]. There was a need to develop TMR components for the DZ7 Moulded Case Circuit Breaker with a rating of 800A. The objective of this paper is to design the components of this TMR using finite element analysis and other analytical tools [13,20]. We are performing a finite element analysis for safeguarding each component against failure before testing the actual prototype. The designed components must be suitable for conducting mechanical endurance test with the MCCB.

2. DESIGN METHODOLOGY

In this stage of design, features are modelled to achieve the intended functionality. This step involves incorporation of ideas and different concepts each of the components by iterating the design step by step to meet the design objectives.

Preliminary Design

These designs are only based on initial calculations and some are even made by trial and error and therefore do not represent finalized work. Detailed study and rigorous analysis will be done at a later.

— Modification in Design of Trip Plate

Trip plate is the component mounted at the rear end of the mechanism which interacts with the release assembly and receives the trip command. Upon receiving the trip command it rotates about its pivot and de–latches the operating mechanism which brings the breaker to trip position. CAD modelled developed for designed components [18].

- To design trip plate such that it receives trip input from tripper while maintaining factor of safety $(F.O.S.)_T$ > 2.

Where $(F.O.S.)_T$ = (Force required by trip plate to trip main mechanism)/ (Force delivered by TMR Tripper)

It is important to have an $(F.O.S.)_T$ greater than 2 because practically the force delivered by release assembly by means of tripper will be less than the theoretically calculated value due to frictional losses between moving components and variations in spring force. Therefore, many iterations were made to trip plate in order to achieve this objective as depicted in the figure .

- Material addition should be such that C.G. stays close to the pivot

There is a fault condition in breakers known as 'delatching'. When the breaker is operated, vibrations occur as the mechanism reaches its end positions (i.e. ON or OFF). These vibrations can cause the trip plate to rotate from its position and trip the operating mechanism in an erroneous manner. This is known as

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

delatching. If the C.G. of trip plate is not close to the pivot, it will increase the chances of delatching. Therefore design modifications of trip plate are done such that C.G. is as close as possible to its pivot.

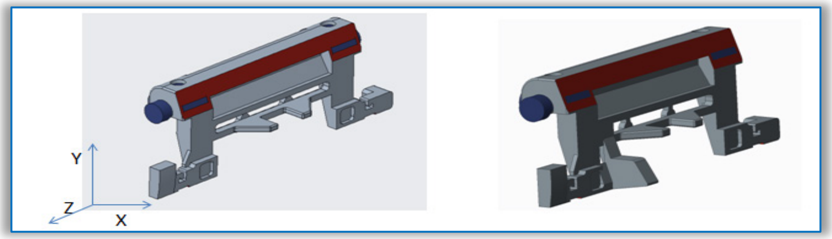

Figure 1 (a). Trip plate– Existing and (b) Trip plate –Modified

While assessing the change in centre of gravity (C.G.) position, it should be noted that only X and Y co–ordinate values of C.G. are of significance since variation of Z co–ordinate value won't contribute towards the delatching issue.

Table 1. Position of center of gravity for Trip plate in existing and modified model

Design of Trip plate	X Co–ord. of C.G. (mm)	Y Co–ord. of C.G. (mm)
Existing	–1.04	–0.32
Modified – Iteration 1	–1.38	–0.91
Modified – Iteration 2	–1.24	–0.7

As seen from Table 1 there is no significant change in C.G. position, hence the modifications made to tripper can be considered acceptable at this stage subject to further testing. The change in C.G. position does not contribute adversely towards delatching as far as the C.G. values are near to pivot with an ideal distance of 1mm from pivot, as has been observed experimentally.

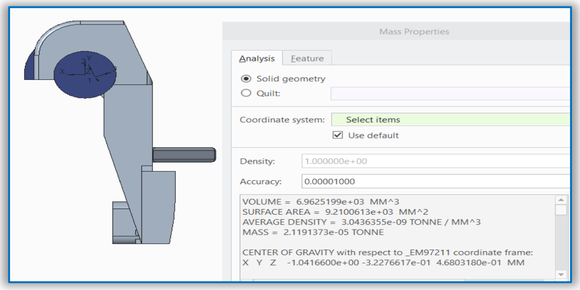

Figure 2. Centre of gravity for existing Trip plate

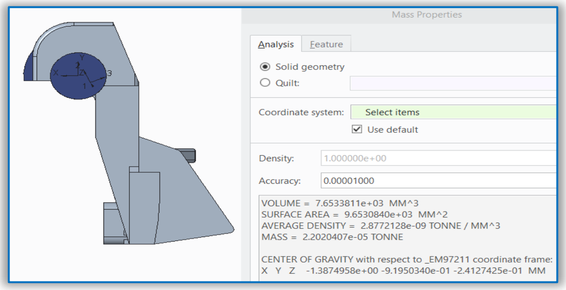

Figure 3. Centre gravity for modified Trip plate– Iteration 1

— Design of Tripper

This is one of the most critical components in TMR as ultimately this component alone will interact with trip plate to initiate trip operation. As the latch is rotated and the tripper is free to move, it rotates forward on account of the torque provided to it by compression spring. As the tripper moves and hits the trip plate, trip plate delatches the operating mechanism and brings the breaker in trip position.

≡ Deliver trip command to trip plate by cam action while maintaining $(F.O.S.)_T > 2$

In order to maintain this $(F.O.S.)_T$, the point of contact between tripper and trip plate is chosen such that moment arm for force delivered by tripper is as low as possible. This is achieved by lowering the follower profile downwards.

— Design of Tripper

This is one of the most critical components in TMR as ultimately this component alone will interact with trip plate to initiate trip operation. As the latch is rotated and the tripper is free to move, it rotates forward on account of the torque provided to it by compression spring. As the tripper moves and hits the trip plate, trip plate delatches the operating mechanism and brings the breaker in trip position.

≡ Deliver trip command to trip plate by cam action while maintaining $(F.O.S.)_T > 2$

In order to maintain this $(F.O.S.)_T$, the point of contact between tripper and trip plate is chosen such that moment arm for force delivered by tripper is as low as possible. This is achieved by lowering the follower profile downwards.

≡ Adding features for latching operation

In order for the tripper to remain latched (locked) in the reset position another component called latch is designed. This latch interacts with a feature on top portion of tripper and keeps the tripper locked such that compression spring at the base remains compressed.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

≡ Including features for resetting operation

Once the trip operation is complete, the tripper needs to be brought back to its latched position. This is achieved by another component called 'resetter'. During reset operation resetter takes input from fork and pushes tripper backwards and finally tripper gets locked in latch as shown in the figure 5.

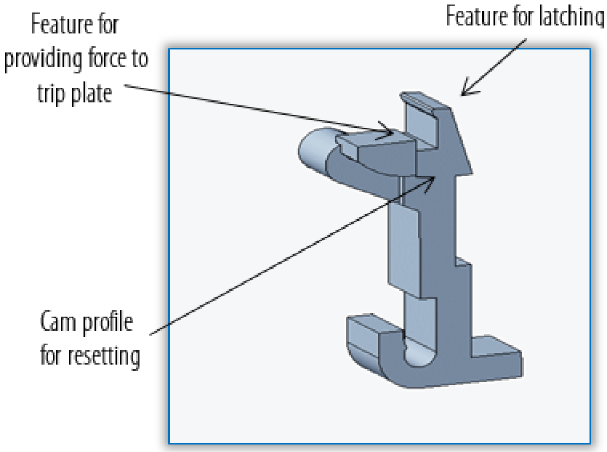

Figure 4. Tripper– iteration 1

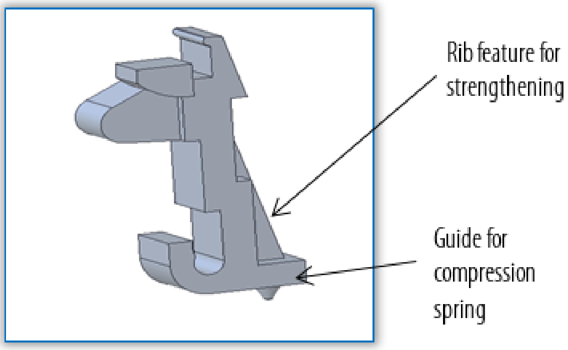

Figure 5. Tripper– iteration 2

≡ Providing guide for compression spring

Figure 6 shows a conical feature is provided at the base of the tripper for keeping the spring aligned in correct position at initial and final positions of tripper. It essentially prevents spring from slipping away from its intended position.

— Design of Resetter

As mentioned earlier resetter accomplishes resetting operation by taking input motion from fork and brings the tripper to its initial locked (latched) position is depicted un the figure 7. As the fork is moved to reset the breaker the resetter moves along with it by cam action. This motion rotates the resetter about its pivot and finally it engages with tripper and pushes it back to its latched position.

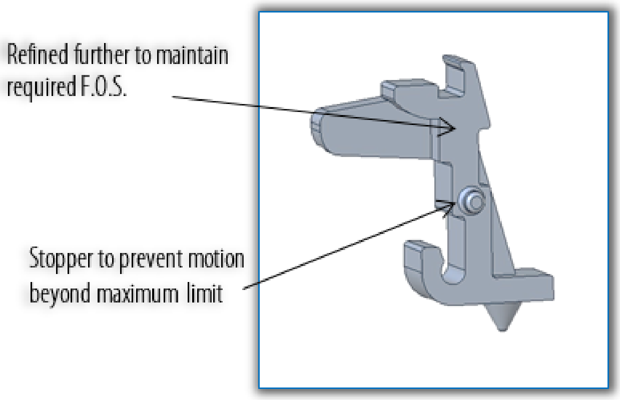

Figure 6. Tripper– iteration 3

≡ Design of cam profile to take input from fork

A protruded part from fork engages with resetter to provide it input rotational motion as depicted in figure 8. The initial and final limits of angular rotation for resetting operation are noted first. Then distance of resetter pivot from fork limb is noted. Based on this data an approximate design of cam profile is initially modeled. This profile is refined further in successive iterations are depicted in the figure 9 (a and b) such that it provides the required motion to the resetter limb.

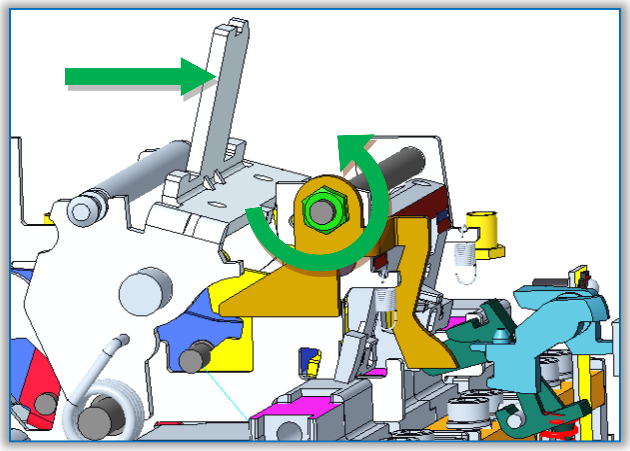

Figure 7. Resetter operation

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

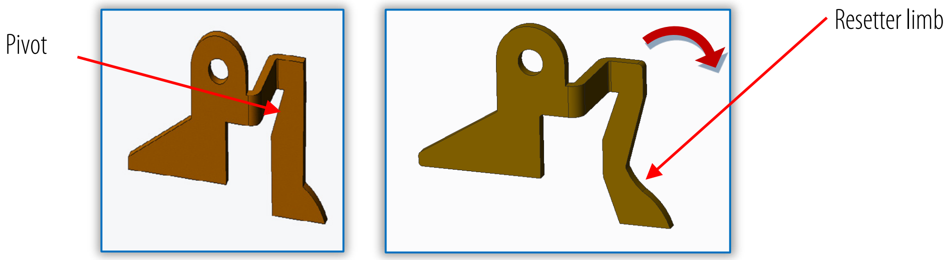

Figure 8. (a) Resetter– iteration 1, (b) Resetter – iteration 2

≡ Design of resetter limb to interact with tripper

The resetter limb is essentially designed by bending the main component such that it is aligned correctly adjacent to the plane of tripper where it interacts with resetting feature on tripper as shown in figure 9 (a and b) .While designing these bends care must be taken to provide correct bend radius in order to maintain uniform thickness of the sheet metal component. Excess material from limb was removed which caused interference with chassis and other components during its motion.

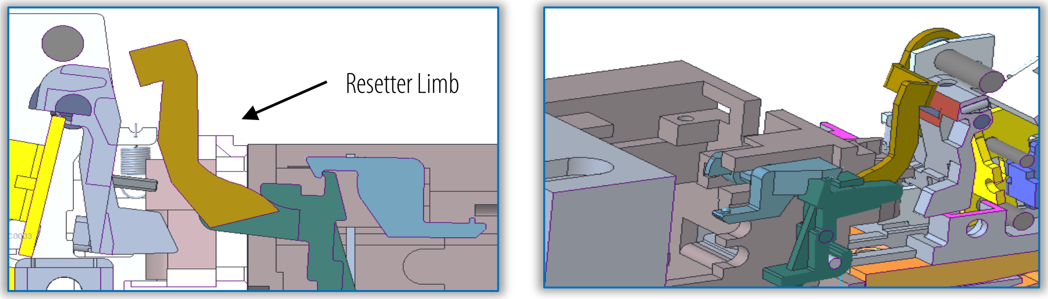

Figure 9. (a) Cross sectional view of resetter operation; (b) Interaction of resetter with tripper

FINITE ELEMENT ANALYSIS

Finite element analysis can be used for determining the stresses using Ansys software and predicting the failure of the body under study. Finite element analysis is the method of discretizing the domain into finite elements and then using numerical techniques to evaluate the results. Discretizing the domain into finite elements is important part of these analyses called as meshing. Boundary conditions must be provided in the form of loads or constraints to solve the mathematical model of discretized system. The results then produced can be post processed as per our requirements. In order to ensure that the outcomes of the FEA simulation are adequate, it is crucial to employ a mesh that has been sufficiently developed. When employing implicit or explicit methods for analysis, coarse meshes can produce unreliable results. As mesh density is raised, the model's numerical solution will trend towards a single value. As the mesh is improved, more computing power is needed to execute simulation. As seen in figure 10, the mesh is deemed to have converged when further mesh refinement results in a small change in the solution.

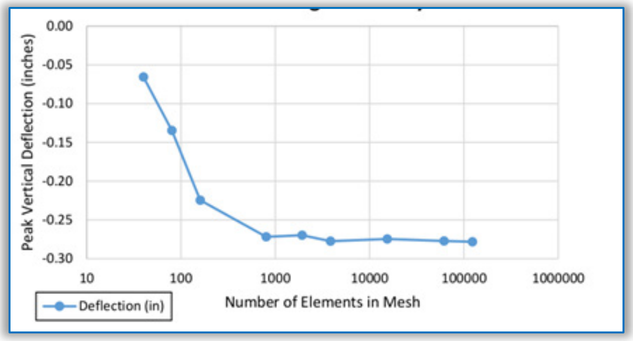

Figure 10. Mesh convergence study

4. RESULT AND DICUSSION

Stress analysis of tripper

Tripper is the most critical component in the release assembly as it is the component which will finally interact with the operating mechanism and deliver the tripping force to the trip plate [2]. The material used for tripper is 40% Glass filled PPS (Poly–Phenylene Sulphide) with S_{ut} = 165 Mpa

The mesh type used for this model is Tetrahedrons with a minimum element size of 0.5mm. Further refinement was done in areas of relatively higher stresses to achieve convergence. The average aspect ratio of this mesh setup is 2.1as depicted in the figure 12 which is close to one (aspect ratio of one is considered ideal). Also most elements have an aspect ratio close to the average value. Hence this mesh can be considered to have good quality. Boundary conditions for tripping operation are as shown in the

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

figure 11. The tripper performs pure rotation and is pivoted at the bottom in its support. It is acted upon by spring force on the guide provided at bottom. It is analyzed when spring force is maximum i.e. reset condition. Using Maximum Principal Stress Theory [16] for Poly–Phenylene Sulphide as:

$$FOS = S_{ut} / \sigma_{max} = 4.4$$

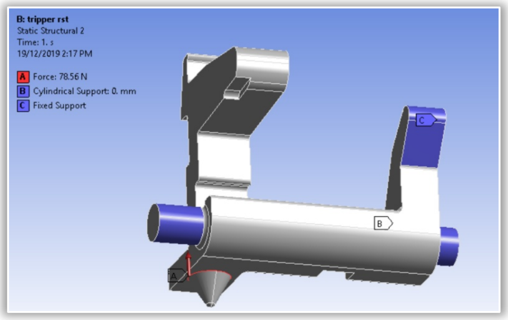

Figure 11. Boundary Conditions for Tripper

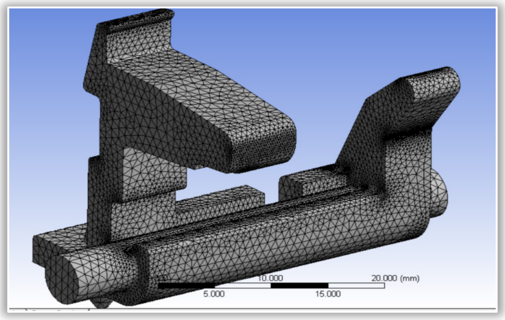

Figure 12. Mesh model for Tripper

The model was analyzed for various iterations to reduce high stresses in localized regions and remove redundant features [20].

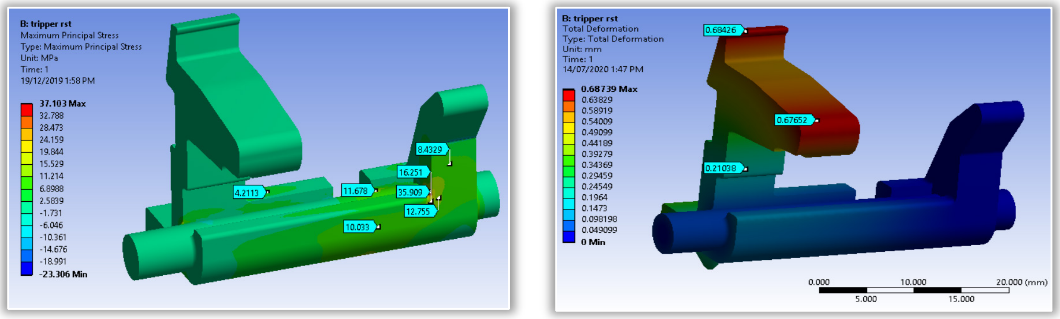

Figure 13. (a) Maximum Principal Stress distribution in tripper; (b) Deformation in tripper

Stress analysis of latch

From figure 14 (a) latch is held in its place in the release box on its shaft by means of a cylindrical support. It is restricted to undergo only a small amount of rotation by means of stopper feature. Firstly, these boundary conditions are applied to the latch in this analysis. Figure 14 (b) mesh used for this model is of Hex–Dominant type with a minimum element size of 1 mm. Further refinement was done in areas of relatively higher stresses to achieve convergence. The average aspect ratio of this mesh setup is 1.9 is depicted in the figure 14 (b) which is close to one (Aspect ratio of one is considered ideal). Also most elements have an aspect ratio close to the average value. Hence this mesh can be considered to have good quality. The loads acting on the latch are normal force due to tripper when it is in latched condition and a frictional force corresponding to this normal reaction. Another force due to the compression spring also acts on the latch. Secondly, all the values of loads calculated previously are applied to the component. Maximum load is sustained on the latch when it is in latched condition therefore the same is simulated in this study. The material used for latch is same as that of tripper; 40% Glass filled PPS (Poly–Phenylene Sulphide) with S_{ut} = 165 Mpa. The material used here is a glass filled polymer which will have a brittle failure. Thus, using Max. Principal Stress Theory as; $FOS = S_{ut} / \sigma_{max}$;FOS = 5.5.

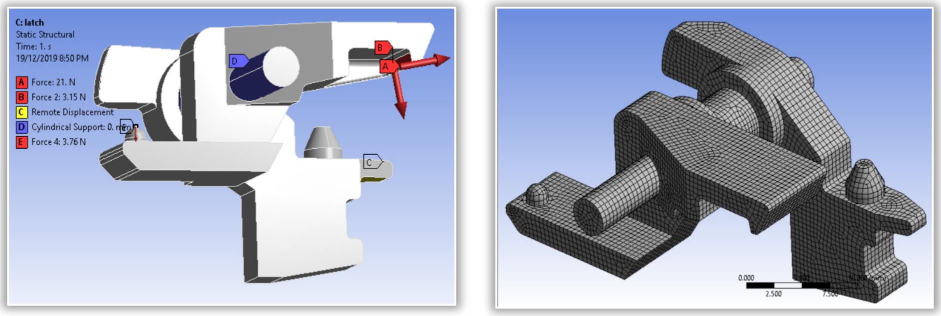

Figure 14. Boundary conditions for latch; (b) mesh model for latch

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

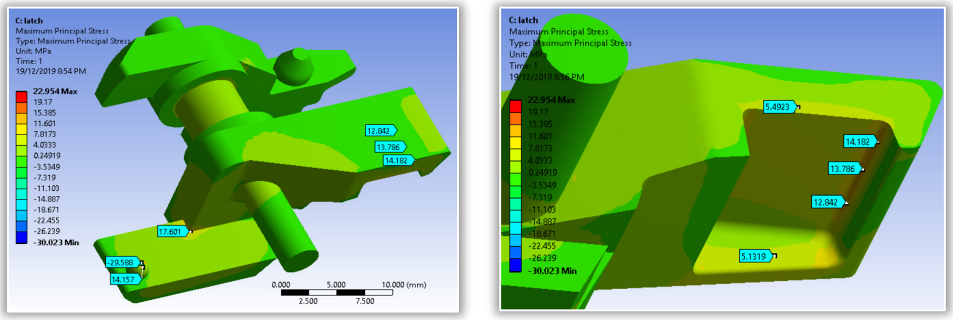

Figure 15. Maximum Principal Stress for latch

Stress analysis of resetter

The resetter is a sheet metal component made from EN9 alloy steel. It is mounted on the side plate by means of a step screw. It can rotate about its hole on this step–screw. This is simulated in the software by using a cylindrical support in the inner surface of the hole. The mesh used for this model is of Hex–Dominant type with a minimum element size of 0.5 mm. Further refinement was done in areas of relatively higher stresses to achieve convergence. The average aspect ratio of this mesh setup is 2.8 as shown in the figure 16 (b) which is close to one (Aspect ratio of one is considered ideal). Also most elements have an aspect ratio close to the average value. Hence this mesh can be considered to have good quality. The resetter will sustain a maximum load when it is in a locked state (when it has undergone the full rotation). In this condition the face on the left side where it receives the input motion can be considered to be in a fixed state. While the face on the output side receives normal reaction force due to its contact with the tripper. These conditions are applied to the model on the software.

Table 2. Material properties are applied on the model

Parameters	Values
Material	EN 9
Density	7850 kg/mm^3
Modulus of Elasticity	206 GPa
Ultimate Tensile strength	1030 MPa
Yield strength (S_{yt})	400 Mpa

Since it is a metallic component, it will have a ductile failure. Thus, using von Mises Theory as; FOS = S_{yt} / σ_{VM}; FOS = 1.2

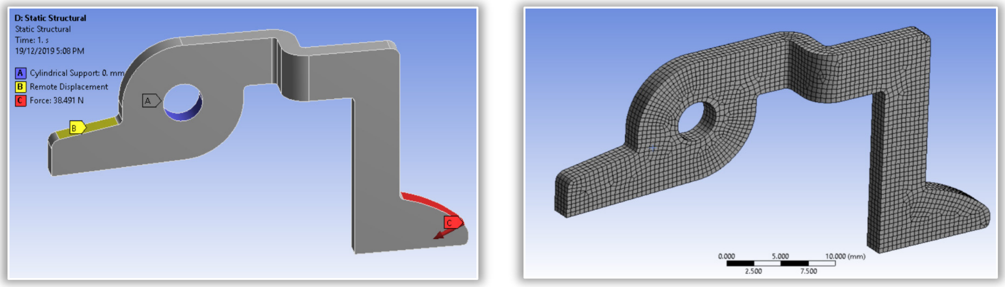

Figure 16. (a) Boundary conditions for Resetter; (b) Mesh model for Resetter

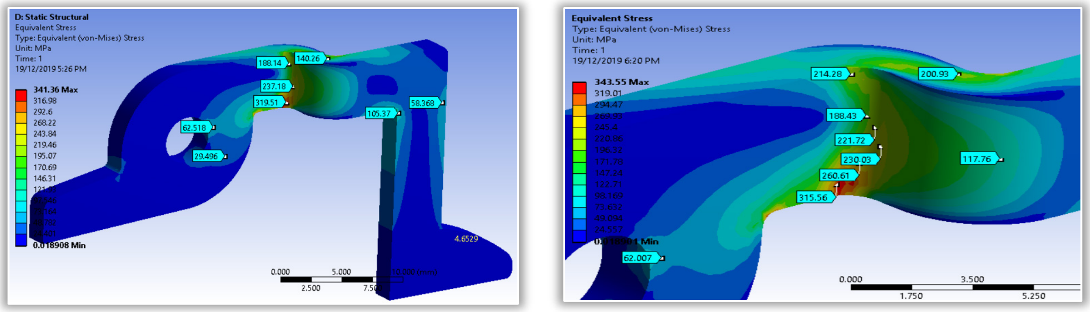

Figure 17. Maximum Principal Stress for latch

Results from finite element analysis are presented in Table 3. For the structural integrity of the system it is required that FOS ≥ 1.2 for all components. Since all components meet this requirement, the system is deemed safe from structural standpoint and the components can be prototyped using these designs for testing purpose.

Along with these, $(F.O.S.)_T$ was found to be 3.55 at 'trip initial' position and 3.43 at 'trip final' position(see Table 3), which is higher than the required value of '2' .

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

Table 3. Finite element Analysis for designed components

Sr no.	Component	Tensile Strength (Mpa)	Max. Stress(MPa)	FOS
1	Tripper	S_{ut} = 165	45.01	3.6
2	Latch	S_{ut} = 165	16.02	10
3	Resetter	S_{yt} = 355	330	1.2
4	Compensation Bimetal	S_{yt} = 275	109.9	2.5
5	Overload Shaft	S_{ut} = 165	15	11
6	Main Bimetal	S_{yt} = 275	200	1.375

5. CONCLUSION

A novel design of tripper was proposed as the conventional design approach lead to an interference issue with the front cover of the MCCB. This was achieved by modifying the tripper body such that tripping and resetting operations are achieved in distant planes (as opposed to nearby planes in previous models of DZ series MCCB). Consequently, the design of resetter was also modified such that it provides a satisfactory reset operation for this newly proposed tripper. After conducting FEA, design of all components was found to be viable for prototyping and testing. The prototyped components once assembled with the MCCB were manually tested and found to be functionally suitable for the intended operations. Further testing and optimization can be carried out for achieving a more robust design. The designed components can be suitable for conducting mechanical endurance test with the Moulded Case Circuit Breakers.

References

[1] Parmar, D. and Gojiya, M., Analysis and improvement in repulsive force of 630 A frame Moulded Case Circuit Breaker (MCCB). Perspectives in Science, 8, pp.424–427, 2016.
[2] Rane, S. B., & Narvel, Y. A., Reliability assessment and improvement of air circuit breaker (ACB) mechanism by identifying and eliminating the root causes. International Journal of System Assurance Engineering and Management, 7, pp.305–321., 2016.
[3] Ahn, K.Y. and Kim, S.H., Modelling and analysis of a high–speed circuit breaker mechanism with a spring–actuated cam. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 215(6), pp.663–672., 2001.
[4] Maurelli, L., Mazzoleni, M. and Previdi, F., Modeling and simulation of bimetallic strips in industrial circuit breakers. IFAC–PapersOnLine, 54(7), pp.803–808., 2021.
[5] Lei, C., Tian, W., Zhang, Y., Fu, R., Jia, R. and Winter, R., 2017, March. Probability–based circuit breaker modeling for power system fault analysis. In 2017 IEEE Applied Power Electronics Conference and Exposition (APEC) pp. 979–984.,IEEE.2017
[6] Kralik AJ, inventor; Siemens Energy, Automation Inc, assignee. Circuit breaker combination thermal and magnetic trip actuator. United States patent US 6,087,914. 2000 Jul 11.
[7] Klein, K.W., General Electric Co, Multiple circuit breaker assembly with common tripping. U.S. Patent 3,288,965., 1966.
[8] Choi, G., Sohn, J., Kim, H., Yoo, W., Bae, B., Kim, J. and Kim, J., Performance improvement of a gas–insulated circuit breaker using multibody dynamic simulations and experiments. Journal of Mechanical Science and Technology, 27, pp.3223–3229., 2013.
[9] Kanthal AB. Thermostatic bimetal handbook. KANTHAL. 1996.
[10] Lee, K.A., Cho, Y.M. and Lee, H.J., 2020. Circuit model and analysis of molded case circuit breaker interruption phenomenon. Electronics, 9(12), p.2047.
[11] Leone, D.A., Ferree, J.E. and Dimarco, B., Siemens Energy and Automation Inc, 2001. Bi–metal trip unit for a molded case circuit breaker. U.S. Patent 6,181,226.,2001.
[12] Lv, S. and Zong, M., April. Ambient temperature influence on temperature of MCCB bimetal. In 2017 IEEE International Magnetics Conference (INTERMAG) (pp. 1–1). IEEE., 2017.
[13] Shephard, M.S., Flaherty, J.E., Jansen, K.E., Li, X., Luo, X., Chevaugeon, N., Remacle, J.F., Beall, M.W. and O'Bara, R.M., Adaptive mesh generation for curved domains. Applied Numerical Mathematics, 52(2–3), pp.251–271., 2005.
[14] Xia, H., Guan, Y., Yu, Z., Cai, S., Wang, X., Peng, Z., Gao, S. and Huang, Z., 2019. Temperature rise test and analysis of high current switchgear in distribution system. The Journal of Engineering, 2019(16), pp.754–757., 2019.
[15] CODE, P.,High–voltage switchgear and controlgear–Part 102: Alternating current disconnectors and earthing switches., 2001.
[16] Talu, M., The influence of the corrosion and temperature on the Von Mises stress in the lateral cover of a pressurized fuel tank. Hidraulica, (4), pp.89–97., 2017.
[17] Ţălu, M. and ŢĂLU, Ş., Analysis of Temperature Resistance of Pressurized Cylindrical Fuel Tanks. Hidraulica, (1). , 2018.
[18] Ţălu, Ş. and Ţălu, M., A CAD study on generating of 2D supershapes in different coordinate systems. Annals of Faculty of Engineering Hunedoara–International Journal of Engineering, Hunedoara, Romania, 8, pp.201–203., 2010.
[19] M.C. Ghiţă, C.Ş. Ghiţă, Ş. Ţălu, S. Rotaru, Optimal design of cylindrical rings used for the shrinkage of vehicle tanks for compressed natural gas, Annals of Faculty of Engineering Hunedoara International Journal of Engineering, Hunedoara, Tome XII, Fascicule 3, pp. 243–250, 2014.
[20] Ţălu, M. and Ţălu, Ş., 2018. Optimal engineering design of a pressurized paralepipedic fuel tank. Annals of Faculty of Engineering Hunedoara–International Journal of Engineering, Hunedoara, Romania, 16, pp.193–200.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN–L 1584 – 2665