SHORT CIRCUIT AND MOTOR STARTING STUDY OF SPINNING MILL

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Abstract: The Sri Vigneshwara Spinning Mill receives power supply of 11kV from the grid. The power house of the Spinning mill has only one 1000 KVA Transformer of 11/433V ratings. It has 20 outgoing MV panel from that the loads are activated. This paper looks at what happens when a spinning mill has a short circuit. It examines both symmetrical and unsymmetrical faults, which can result in very strong fault currents, causing significant problems in electrical grid. This study was carried out by International Electrotechnical Commission (IEC) 60909-2016 standard to determine how long different equipment like transformers, cables, motors, circuit breakers can handle short-term stress.

The Motor acceleration study is also executed in Spinning mill. It consist of 47 motors and to perform motor acceleration study, 295 HP motor is identified as high capacity motor in weaving looms section of Spinning mill. During the starting of the motors, it pulls a hefty starting current from the power line, typically ranging from 6 to 7 times the rated motor current, while ensuring that the voltage levels at other bus terminals remain within acceptable bounds.Therfore the motor bus voltage should be maintained approximately 20 percentage of normal rated voltage level. The Institute of Electrical and Electronics Engineers (IEEE) conducted a static motor acceleration study, outlined in IEEE 3002.7 – 2018 and 399 – 1997, to assess the voltage dip and drop within the existing system. Both these studies are performed on the DIgital SImuLation and Electrical NeTwork calculation program (DIgSILENT PowerFactory).

Keywords: short circuit study, faut analysis, motor acceleration study, horse power, DIgSILENT

I. INTRODUCTION

Power system studies are foundational for maintaining a secure and dependable electrical supply, offering critical insights into the behavior and performance of the system. Among these studies, load flow analysis stands out as a cornerstone. It meticulously examines the distribution of power within the system under normal operating conditions. By scrutinizing voltage profiles and identifying potential constraints within the network, load flow studies enable engineers to optimize the system's efficiency and plan for future expansions effectively.

Short circuit studies, meanwhile, delve into the system's response under fault conditions. By meticulously assessing fault currents, these studies play a pivotal role in selecting and configuring protective devices such as fuses, breakers, and relays. This ensures the swift isolation of faults, minimizing damage to equipment and enhancing overall system reliability.

Additionally, motor starting studies are paramount, particularly for systems with large motor loads. These studies meticulously analyze the impact of motor starting on system stability, considering factors like voltage dip, starting time, and potential instability. By understanding and mitigating these effects, engineers can ensure the seamless operation of motors without jeopardizing the stability of the broader power system.

Collectively, these studies serve as the bedrock of power system analysis, facilitating informed decision-making and proactive maintenance strategies. By conducting thorough and comprehensive analyses, power system engineers can optimize system design and operation, ensuring a safe, efficient, and resilient electrical supply for industrial and commercial applications.

II. LITERATURE REVIEW

PowerFactory operations and technology [1] this website explains about the methodologies used in the DIgSILENT software for the power system studies and also how to use the DIgSILENT controls for conducting those studies.C L

WADHWA [2] explains about the basic power system model, load and power flow methods, short circuit analysis, transient stability analysis and power system control in his Electrical Power Systems.[3] International Electrotechnical Commission (IEC) 60909-2016 standards - used to examine the average plant's short circuit characteristics. With the help of this standard only the short circuit study is performed for the Sri Vigneshwara Spinning Mill. This standard consists of many parts, among them here employing [4] IEC 60909-0 for short circuit analysis in DIgSILENT.[4] IEC 60909-0, Short-Circuit Currents in Three-Phase AC Systems Part 0: Calculation of currents, 2016.This standard gives crystal clear view on the fault currents in the three phase systems and it explains about under the conditions when the short circuit current is calculated and how to calculate it.Durgaprasad Bandaru [5] explains the Methods for Short Circuit Analysis in ANSI and IEC Standards. In this paper, the comparative studies of the IEC and ANSI standards are explained. Based on this comparison the switchgear selection is done.Akhila Chilakala, et al., [6] explains the short circuit analysis of IEEE 14 bus system. In here the author validated the obtained values with hand calculation. For IEEE 14-Bus system also the same process is repeated with faults at different buses. The highest short circuit current is used to find the breaking and making rating of the circuit breakers whereas the lower short circuit current used for protection relay co-ordination scheme.Akhilesh Mathur, et al., [7] gives detailed information about Unsymmetrical short-circuit analysis for the distribution system considering the loads of a particular system. The author explains about the system operating at various types of unsymmetrical faults.Dr. Aung Zaw Latt [8] describes about the motor starting study of a three-phase induction motor for a pump load. The motor acceleration study is conducted in three conditions namely normal operation, with Variable Frequency Drive (VFD) and with an auto transformer. Author compares the VFD with autotransformer starters and at last he concludes that the starting motor with VFD method is best than the autotransformer starter.Sand Mustafa Al-Refal [9] explains about the analysis of its electrical power system and to prevent change in process performance during the starting in equipment such as induction motor pumps. To examine whether the motor can be started successfully.Chi Su, Zhou Liu, [10] represents integration of distributed generation (DG) such as wind turbines into distribution. The result in the paper based on the mathematical analysis and simulation study in DIgSILENT PowerFactory[11] IEEE Std 3002.7-2018, Recommended Practice for conducting Motor Starting Studies and Analysis of industrial and Commercial Power System. This standard gives more information about the starting current during starting of the motor and it also talk about how calculate the current during starting and running of motor.Mohammed Abbas [12] describes about the Dynamic and Static Starting motor studies were conducted for the largest motor (13.2 kV, 32000KW) under worst case scenarios. The result of these motor simulation study indicates no motor starting problems in the peak load scenario. It was found to cause significant voltage dip that can be affect the plant operation. The Simulation result provides necessary remedial measures in worst case condition.

III. ABOUT SPINNING MILL

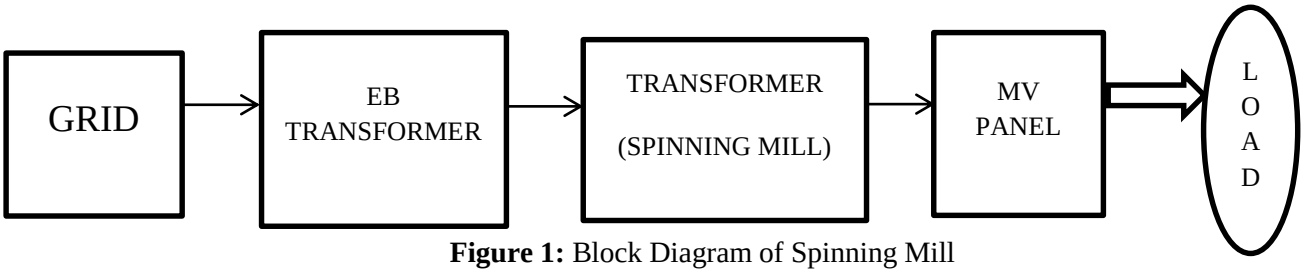


Figure 1: Block Diagram of Spinning Mill

The Sri Vigneshwara Spinning Mill located in Mill incorporated on 4th march 1991, which is located in Pollachi main road, Kamanaickenpalayam, Coimbatore. The block diagram representation of the Sri Vigneshwara Spinning Mill is shown in figure 2.1. It receives power supply from Tamil Nadu Electricity Board (TNEB). The permitted maximum demand of Spinning Mill by TNEB is 750 KVA.

The double tier panel board can safely receive power from both the grid and generators simultaneously without risking short circuits.It is having a double tier panel board in the Power house of the mill. From there, it will connect the transformer, generators and loads without any short circuit. The connection from transformer is given through MV Panel by Bus Duct (1800 A) with 75mm x 12mm.AL.FLAT 2Runs/Phase and 75mm x 12mm.AL.FLAT 1Run/Neutral. It consists of four Generator near the Power house. The four generator connected to MV panel with underground cables without any short circuit. The rating of the four-generator mentioned in table 1.

Table 1: Parameters of ICT with EV consideration

S. No	Name of the Generator	Ratings
1	Generator 1	380 KVA, 3 ph,415 V,50 Hz
2	Generator 2	125 KVA, 3 ph,415 V,50 Hz

3	Generator 3	380 KVA, 3 ph,415 V,50 Hz
4	Generator 4	125 KVA, 3 ph,415 V,50 Hz

In this Generator 1 and 3 connections are 2Runs of 3 1/2C x 400 Sq.mm AL.AR Cables. Generator 2 and 4 connections are 3 1/2C x 185 Sq.mm AL.AR Cables from the MV panel.

It has three capacitor bank is located in mill for power factor correction and it is an automated. Suppose, there is decrease in power factor it will make the correction automatically without any manual operation.

Table 2: Rating of Capacitors in Spinning Mill

S. No	Capacitor bank	Ratings
1	Capacitor bank 1	1000 KVAR
2	Capacitor bank 2	1000 KVAR
3	Capacitor bank 2	50 KVAR

From the table no 2, the three Capacitor banks are connected through the MV panel with cables. The cable rating of Capacitor 1,2 and 3 are 3C x 185 Sq.mm AL.AR Cables are used.

IV. LOADS IN SPINNING MILL

From the double tier panel board, there are totally 20 switchgears outgoing in the MV Pannel. These switchgears connect to the loads by the cables to overall spinning mill.

The spinning mill may consist of almost four types of loads being used in it.

The loads are as follows,

1) Machines
- Combing Machine
- Carding Machine
- Rotor Spinning Machine
- HDPE Spinning Can & Accessories
- Draw Frame
- Weighing Machine

2) Exhaust Fan and Ventilation loads
3) Conveyor motor loads
4) Auxiliary loads
5) Lighting loads

In the above loads, the MV panel that distributes the power for some specific areas alone by using cables. In here there are 4 spare motors are available and 4 generator, 8 large motors, 4 capacitor banks then 1 cable from MV panel which connects the 30 motors through Distribution Board-1.

Table no 3: Rating of Capacitors in Spinning Mill

S. No	Distribution board outgoing lines	Name of section
1	Line 1	CARDING - 6
2	Line 2,3	CARDING – 7.8
3	Line 4,5,6,7	CARDING – 1 to 4
4	Line 8	DRAW FRAME - 5
5	Line 9	Exhaust Fan
6	Line 10	DRAW FRAME - 3
7	Line 11	MCBDB - 1
8	Line 12	CARDING -5

In this Distribution board, Carding and Draw frame section are directly connected, but the MCBDB section connected through the cable, which rating is 4C x 6 Sq.mm Cu.AR Cable.

V. SHORT CIRCUIT

Definition of short circuit studies according to standards: Accidental or intentional conductive path between two or more conductive parts forcing the electric potential differences between these conductive parts to be equal or

close to zero. (Intentional short circuit-made while testing the equipment in laboratory; Accidental short circuits-different faults)

A short circuit study in a power system is a crucial analysis to evaluate the behaviour of the system under fault conditions, particularly when a fault occur. A fundamental accept of this endeavour is the study of short circuit within the power systems. Short circuits, or faults, are unexcepted events whereas sudden and substantial flow of electrical current occur, potentially leading damage of equipment, power outages, and even safety hazards. To address these concerns, short circuit play a crucial role in the power systems.

OBJECTIVES OF SHORT CIRCUIT STUDY

- To find the Short Time Rating (STR) of all equipment's (transformers, cables, transmission lines, generators, motors, switchgears, Current transformer, circuit breaker etc.).
- Breaking, Making and DC breaking requirements of interrupting equipment's.
- To find the increasing of current during the fault.
- A complete short circuit study make it possible to calculate different types of fault currents at each location in the system and to select proper settings or size for relays, breakers and fuses.

STANDARDS

- ❖ International Electrotechnical Commission (IEC) 60909-2016: standard for short circuit current in three phase system.
- ❖ Among this standard there are different parts for different types of short circuit analysis. They are shown in table 4.

Table no 4: Different parts in IEC 60909

IEC 60909		
SHORT CIRCUIT CURRENTS IN THREE-PHASE A.C. SYSTEMS		
IEC STANDARD	**PARTS**	**TITLE**
IEC 60909-0	PART-0	Calculation of currents
IEC 60909-1	PART-1	Factors for the calculation of short-circuit currents according to IEC 60909-0
IEC 60909-2	PART-2	Data of electrical equipment for short-circuit current calculations
IEC 60909-3	PART-3	Currents during two separate simultaneous line-to-earth short circuits and partial short-circuit currents flowing through earth
IEC 60909-4	PART-4	Examples for the calculation of short-circuit currents

- ❖ In the above parts, here we are employing IEC 60909-0 and IEC 60909-2 for short circuit analysis in DIgSILENT.

VI. MOTOR STARTING STUDY

Studying of motor acceleration in power system is crucial for understanding how electric motor start and reach their operating speed, where the performance of the motor and the equipment around it may be adversely affected by huge motors. When starting from full line voltage, the starting current of the majority of AC motors is several times greater than the typical full rated load current.

The nuisance tripping of protection breakers as a result of these high current demands.

- Abnormally high running currents.
- The terminal voltage drops.
- Relay triggers for low voltage systems.
- Low starting torques that cause a start-up failure.
- The stalling of connected power system motors that are running elsewhere.
- Damage to heaters, power sources, and other electrical equipment.

To find out the voltages, currents, and beginning times needed to start large motors or a set of motors sequentially or concurrently, motor-starting research is conducted.

STANDARDS

❖ IEEE 3002.7-2018 – IEEE Recommended practice for conducting motor starting studies and analysis of industrial and commercial power systems.

Some of the criteria of motor acceleration study (As per IEEE 3002.7-2018) are,

- In general, a motor starting study should be made if the motor HP rating exceeds approximately 30% of the base KVA rating of the supply transformer.
- If a motor is to be started from an isolated generator, a motor starting study should be performed if the motor HP rating exceeds 10% to 15% of the generator KVA rating (depending on generator characteristics).
- Types of available motor-starting studies range from simple voltage drop calculation to a detailed waveform presentation of motor bus voltage; motor speed and motor torque; acceleration torque; load torque; power factor; rotor and stator currents; motor slip, real, reactive, and total power study that approaches a dynamic analysis in complexity.

Table 5: Critical system voltage levels while starting the motors

Voltage drop location or problem	Minimum allowable voltage (% rated)
System voltage	95% to 105%
At terminal of starting motor	80%
All terminals of other motors that must reaccelerate	70%
AC contactor pick-up (by standard)	85%
DC contactor pick-up (by standard)	80%
Contactor hold-in (average of those in use)	60% to 70%
Solid-state control device	90%

- The above table 4.1 represents the critical system voltage minimum allowable voltage at the time of starting of the motor.

VII. SIMULATION TOOL

DIgital SImuLation and Electrical NeTwork calculation program (DIgSILENT PowerFactory) is an electrical network modelling and simulation software tool. It is a leading power system analysis software application for use in analysis generation, transmission, distribution and industrial system.

DIgSILENT offers StationWare, a central protection setting database and assets and business process management system. It was designed for the analysis and system operation of commercial and renewable energy system. The transmission grid is facing lots of abnormal issues and major changes to good serve for increasing the amount of non-dispatchable resources. It will provide easy way to understand modelling features for studying and analysing all kind of electrical networks and also offers a vast array of functionality perfectly suited to the industrial sectors. It is an excellent tool for analysing all power generation components. Electrical engineers and operators can carry out the following investigations in offline or online mode using DIgSILENT PowerFactory
Both the short circuit study and motor starting study in this work is simulated by using DIgSILENT PowerFactory software. With the collected load data from the Spinning Mill, all the data are modelled and simulated and given to them.

VIII. SIMULATION AND RESULT

A. DIgSILENT MODEL OF SPINNING MILL

Sri Vigneshwara Spinning Mill is supplied with the voltage level of 11kV from the local grid. By using DIgSILENT PowerFactory, the power house of mill is modelled and simulated results detailed. The spinning mill consists of more than 25 motors. In this, the motor acceleration study is performed for large rating of motor and remaining motors are

considered as lumped loads. The data of these loads are collected from the spinning mill and then separated the data according to short circuit and motor starting study.

Each load system is modelled by the bus bar connected with the main power house bus bar with the help of the cables of suitable ratings. In these connections the circuit breaker is also included with appropriate rating for the protection of the both motor and the lighting load. From the power house 2 cables which connected to Distribution board. In the Distribution board, 12 cables are connected to Carding and Draw Frame but it is connected directly without any cables. On carding and draw frame section the motors are directly to bus bar terminal. But only one cable among the 12 no's, it is connected with the MCDBD section through the cable and that cable also modelled

All the loads in the spinning mills are running now, which will be extended future. All the loads are connected by the switchgear with the ratings of 250 kA and among these loads further there are many distributions for several loads based on the demand of the loads. Two capacitor bank of 1000 KVAR and 50 KVAR capacity is also included in the power house bus to control the reactive power in the system.

Figure no 2 represents the single line diagram of the modelled spinning mill power house using DIgSILENT PowerFactory tool. The short circuit study and motor starting study is performed and the results are tabulated. The detailed view of each load is also shown in the upcoming section.

B. METHOD OF MODELLING OF SPINNING MILL

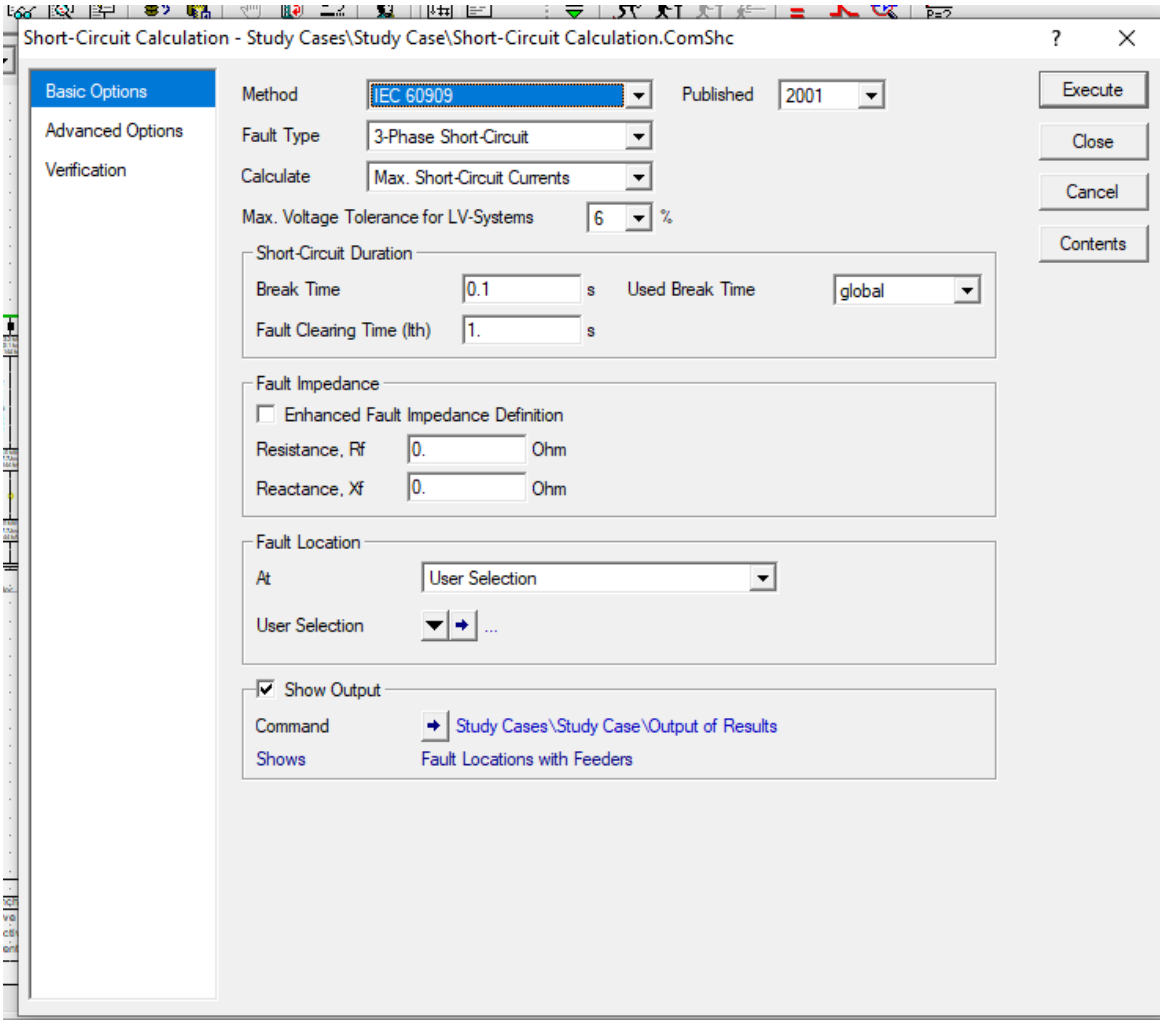


Figure 2: Modelling of Short circuit study based on Standards

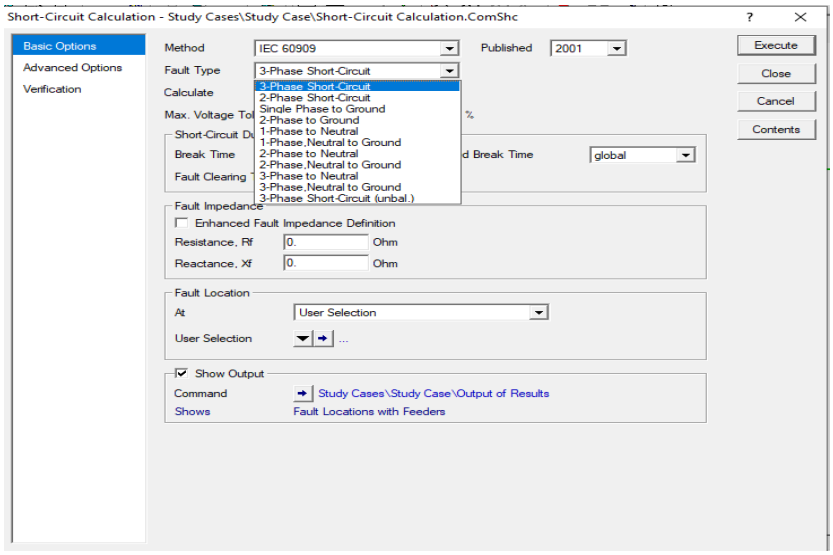


Figure 3: Modelling of Short circuit study for different types of fault

C. SIMULATION VIEW

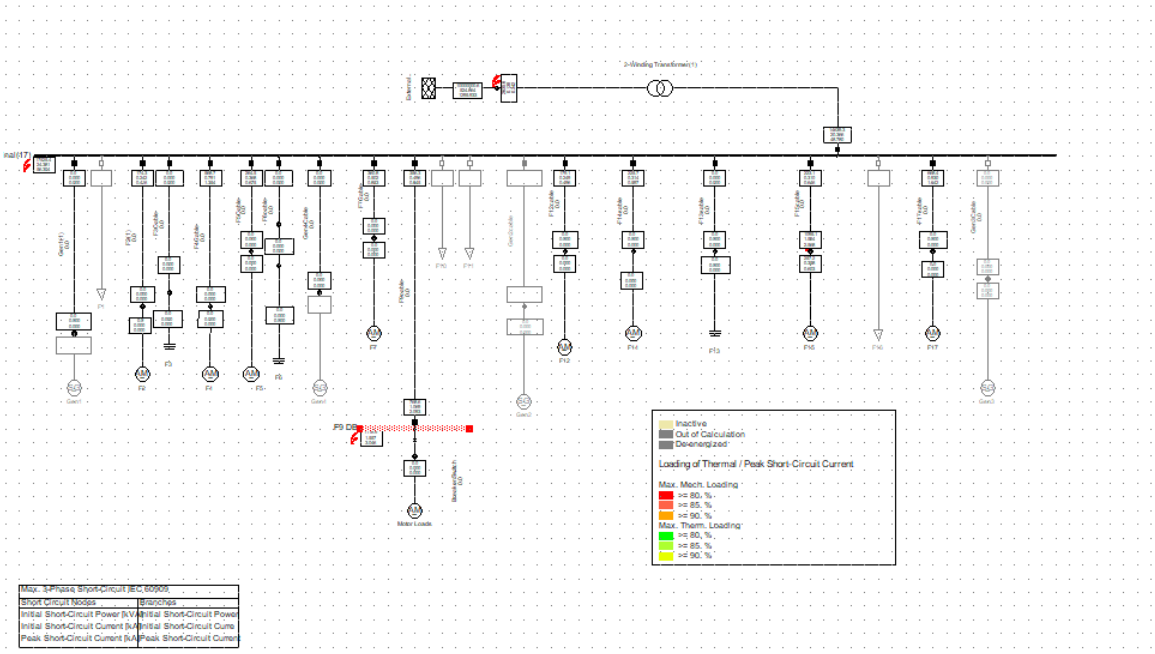


Figure 4: Simulation view of Spinning mill

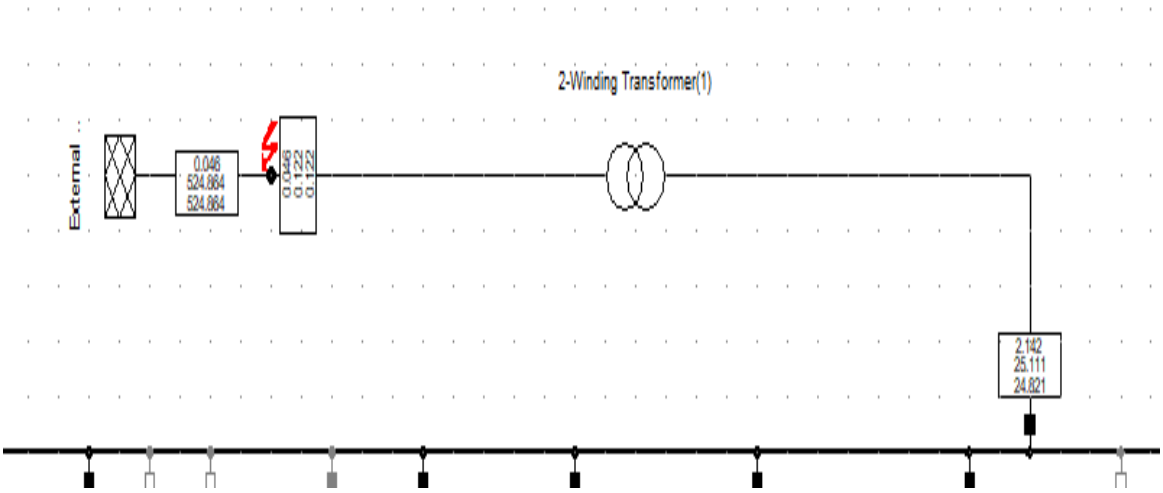


Figure 5: Detailed view of simulation of short circuit study at incoming feeder side

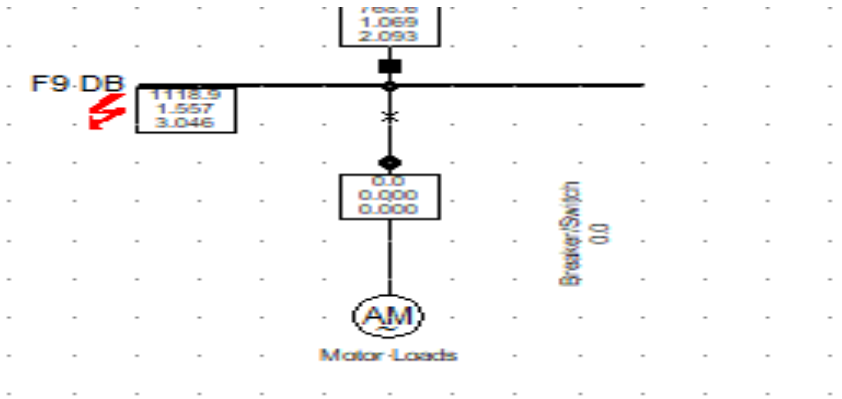


Figure 6: Detailed view of simulation of short circuit study at MCCB section

D. SIMULATION RESULT OF SHORT CIRCUIT

After the detailed modelling of the spinning mill consisting of all the loads, short circuit study is performed for this model. Both the symmetrical fault and unsymmetrical fault are performed separately and the fault current values are noted the maximum short circuit current for the input of relay co-ordination study and compared. DIgSILENT PowerFactory is user friendly software that user can select the type of fault based on his requirements. The display can be changed to view the fault current and short circuit voltage of the load.

All the values are tabulated and the comparison with the switchgear rating is mentioned.

E. INFERENCE I

Table 5: Symmetrical fault current and the circuit breaker selection

S. No.	Terminal name	Three phase symmetrical fault current(kA) **IK**" (kA)	Switch gear Fault rating	Replacement of circuit breaker needed?
1	TERMINAL (17)	24.38	55	NO
2	F9 CABLE	0.50	15	NO
3	F4 CABLE	0.79	15	NO
4	F2 (1)	0.24	15	NO
5	F5 CABLE	0.37	15	NO
6	F7 CABLE	0.50	15	NO
7	F12 CABLE	0.25	15	NO
8	F14 CABLE	0.31	15	NO
9	F15 CABLE	0.31	15	NO
10	F3 CABLE	0.0	15	NO
11	F6 CABLE	0.0	15	NO
12	F13 CABLE	0.0	15	NO
13	2-WINDING TRANSFORMER	20.57	55	NO
14	F17 CABLE	0.93	15	NO
15	TERMINAL (11)	1.78	15	NO

16 F15 CABLE 1.52 15 NO

Table 5 represents the symmetrical fault current observed on performing three phase symmetrical fault in DIgSILENT. The fault is applied at all the terminal and fault current values are noted. It is observed that all the fault currents are within the limit and the circuit breaker rating also sufficient to bear the fault current (but for only few seconds). Therefore, no replacement of circuit breaker is needed for both the loads and power house

F. SIMULATION OF MOTOR STARTING STUDY

After the detailed modelling of the power house consisting of all the loads, the highest capacity motor is selected from the loads and the motor starting study is performed in that high-capacity motor alone. Remaining all other loads are considered as static base loads. Among the 55 motors in the institution, the highest capacity motor is identified as 211.42 kW motor in electrical engineering laboratory and the motor acceleration is performed on that motor.

In DIgSILENT, for performing motor starting study a time-slider will appear for changing the time in order to study the motor acceleration current for every time instant. By using that, current at various instances are noted and tabulated. The motor starting time and accelerating time is given to the motor and the motor is started.

G. CASE SCENARIO

Table 6: Details of the motor for which motor starting study is performed

Motor under consideration	295 HP, 0.415kV, motor at M.G. in Spinning Mill
Starting method	DOL
Grid	ON
Transformer	ON
Bus coupler	CLOSED
Emergency Generator	OFF

Table 6 represents the selected motor for the motor acceleration study. The transformer, generator and grid conditions are mentioned. In the 295 HP induction motor on which is motor acceleration study is performed and the name plate details of the motor. It also performed the detailed view of the motor that is considered for the motor acceleration study.

H. MODELLING OF MOTOR STARTING STUDY

In the modelling of the motor starting study, identify the high-capacity motor in the spinning mill and then model the particular motor by using its data.

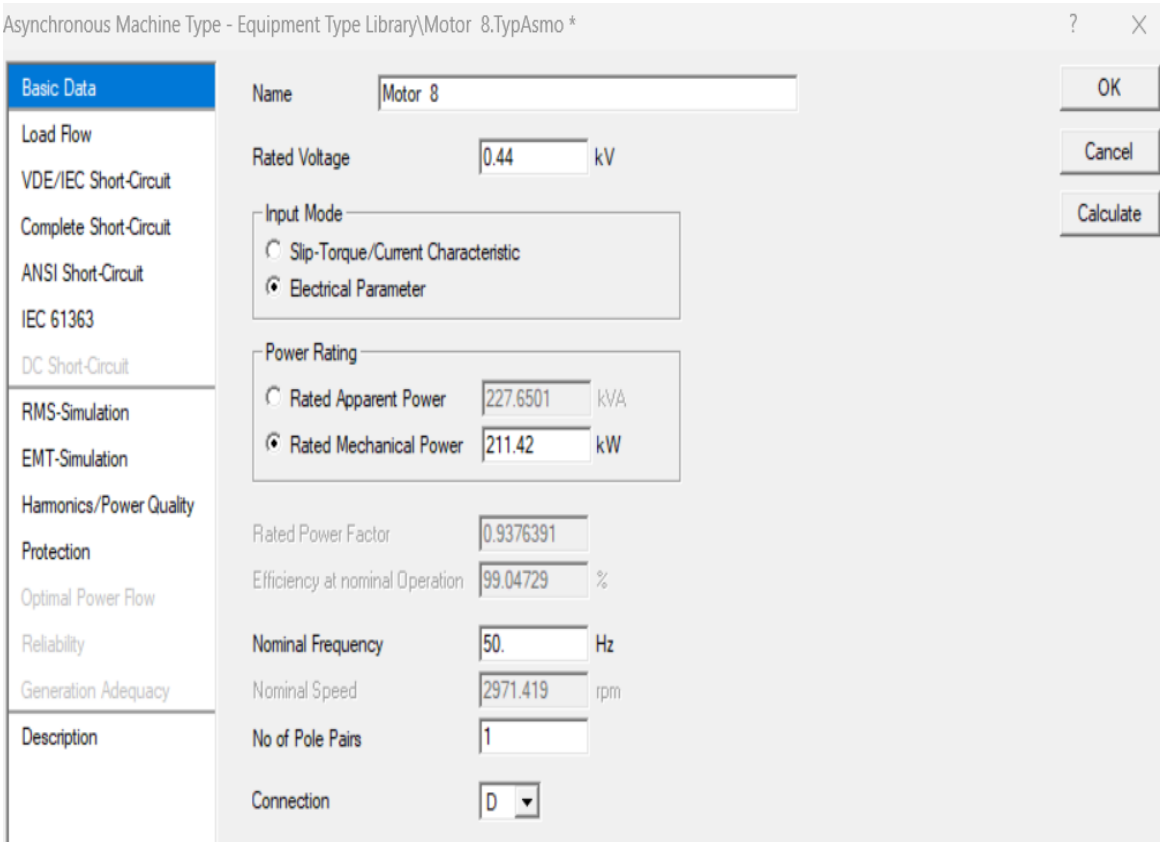


Figure 7: Modelling of the high rating motor in Spinning Mill

From the figure 7 the data of high-capacity motor is simulated in the DIgSILENT software. The rated voltage of the motor 440 V, rated mechanical power, nominal frequency, connection and also no.of.pole.pairs are given as basic input data for motor starting study.

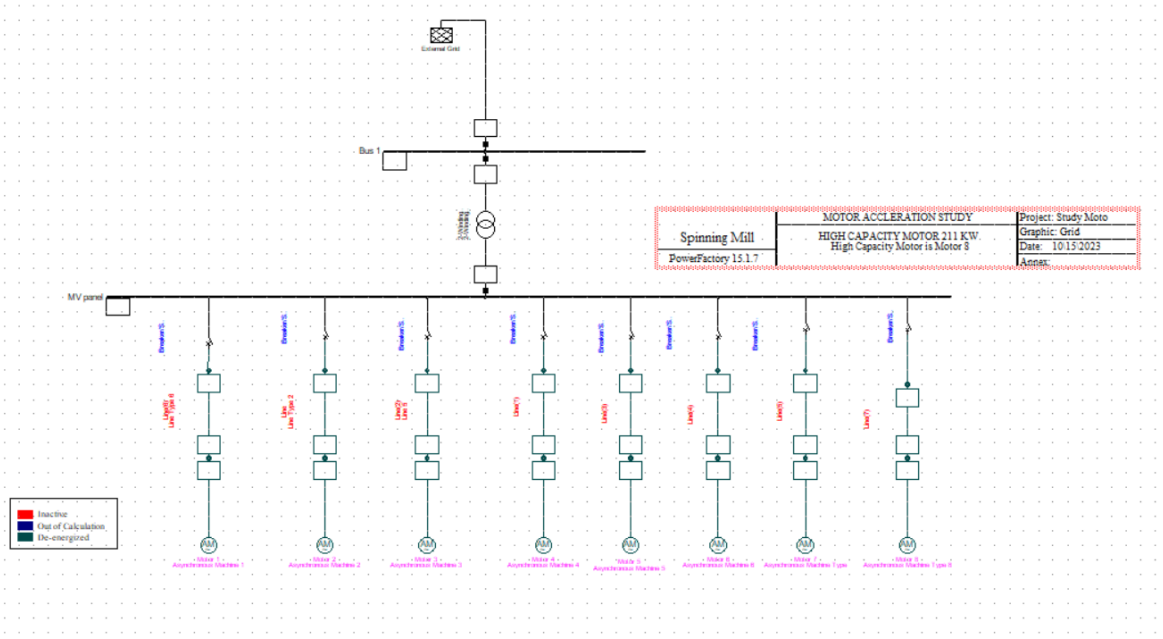


Figure 8: Overall Simulation view of Motor Starting Study

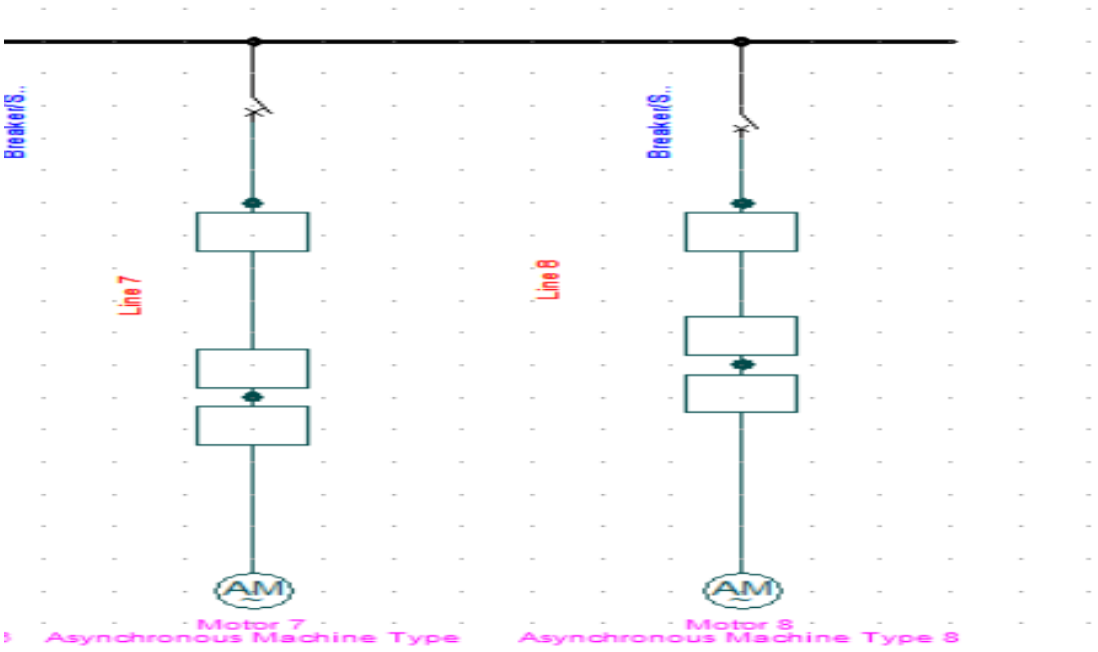


Figure 8: Detailed view of high rating Motor 8

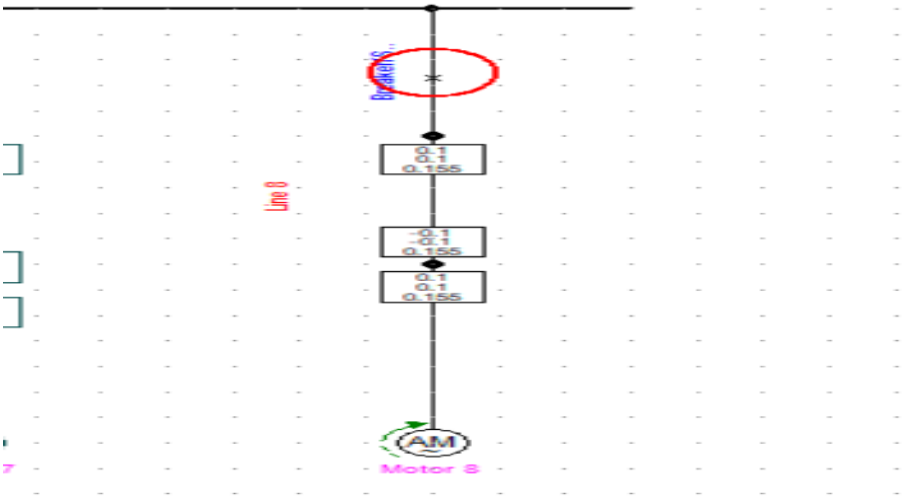


Figure 9 : Motor Starting study performed successfully on motor 8

From the fig .9, the red colour represents the motor starting study performed for particular motor. The green arrow mark visible near the motor 8, it shows that motor started successfully without any disturbance according to IEEE 3002.7-2018 Standard norms.

I. INFERENCE II

Analysis of motor starting study says that when to power on and power off motors in the spinning mills

Table 7: 4 Details of the motor starting safely

MOTORS STARTING PROCEDURE	MOTOR 8 (ALONE)	OTHER MOTORS (EXCEPT MOTOR 8)	TERMINAL VOLTAGE WITHIN THE LIMIT OR NOT
INDIVIDUALLY MOTORS STARTED	YES	YES	Within the limit (if motor 8 started first this condition will exist)
SIMENTOUSELY MOTORS STARTED	YES	YES	Not Within the limit (if first auxiliary motors started means this condition will occur)

From the table, it shows that in spinning mills, typically the large capacity motor often referred to as the main drive motor starts first. This motor is responsible for driving the primary machinery and providing power to the overall spinning process. Once the main motor is running, smaller motors for auxiliary function or specific machinery can be started as needed. This sequential start-up helps distributed the load and prevent power surges.

IX. CONCLUSION

The short circuit study is one of the most important studies for both industrial and commercial power systems. In order to know the short circuit current to design the suitable circuit breaker for protecting the electrical equipment. In this thesis, spinning mill is considered as Industrial load and the short circuit study is performed on loads which are present there. Both the fault condition is performed on the terminal voltage of the buses, the values of fault currents are tabulated and checked whether the available circuit breaker rating is sufficient not and also any other possible ways to change Electromechanical Relay to Digital Relay.

The motor starting study is also Mandatory in power systems to identify whether the voltage dip of the loads and the motor starting current (high inrush current) at the time of starting the high-capacity motor causing any impact in the other loads in the spinning mill and to check the available switchgear is sufficient or not.

X. FUTURE SCOPE

The relay co-ordination for the spinning mill should be done by the comprehensive modelling of protective devices, circuit breakers and switchgears. It may be performed by selecting proper plug setting and time multiplication setting of the relay, considering maximum and minimum fault current at the relay location. This study will help in designing the good power system and also tripping and protecting the electrical equipment in case of any malfunctioning in the power system network.

The Short Circuit and Motor Starting Study may give lots of information about Spinning Mill present performance. By analysing these we can improve the stability and reliability of the mill. These studies are very useful for them, to increase or decrease their loads and demands and installation or replacement of motors with different rating by a proper way without affecting the already existing systems.

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