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Motor Starting Analysis of Industrial Plant

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Abstract —*In the industrial process plant, several power system analysis is need be done during planning stage or during operation when remarkable change occurs in plant operating pattern. Motor starting study is also an integral part of power system analysis. Several induction motor ranging from 0.5 kW to 4000 kW is used in process plant. To check the operation feasibility without violating any parameter of motor or remaining power system, motor starting are performed. Motor starting analysis is performed with big motor only. In this paper, Motor starting analysis of H.T (6.6KV) motor of industrial plants is presented using Electrical Transient Analysis Program -7.5.5(ETAP). In industrial plant, plant operating philosophy has decided by load flow and short circuit analysis. Here, power is produced by two existing generators of 16.5 MW and one new generator of 11.8 MW is recently installed. To considering power import location of all three generators, G2+G3 operating philosophy are selected and motor starting analysis is done with big motor of 535kW. It is come to know that all parameter variation is within limit.*

Keywords- *Motor starting analysis, ETAP, H.T Induction motor, Dynamic motor acceleration analysis, Static analysis.*

I. INTRODUCTION

In process plant several a.c and d.c, motor are used to run mechanical load. Specifically for big H.T induction motor have low values of rotor resistance in range of ohms. Therefore, when motor is started, it is carried large inrush current almost 5 to7 times of rated full load current. Due to that huge voltage drop is occurred and it is affected to remaining power systems as well as motor itself. According to torque equations, motor initial accelerating torque is proportional to square of voltage. Due to heavy voltage drop, sometimes motor can't able to attain its rated speed. To ensure successful startup of big motor without violating operating parameters, motor starting analysis is performed. Additionally, one more objective of motor starting analysis is to investigate the effect of motor starting on remaining power systems [1, 2, 3].

Using Etap motor starting can be analyzed in two ways; (1) Dynamic motor starting (2) Static motor starting. In dynamic motor starting, motor is modeled considering its dynamic characteristics and analyses motor starting time as well as time is required to attain full speed, whereas in static model only analyze the effect of motor starting on remaining systems [1, 2, 3].

II. METHODOLOGY

Same simulation which is used in load flow analysis also can be used for Motor starting analysis with some addition modeling. Load and sources modeling is similar to load flow analysis and one more model such as motor starting static and dynamic modeling is required for motor starting analysis. Motors of which starting study is to be performed have been modeled with reference to the data provided. Modeling of motor Characteristic model, Load model and Inertia model have been done to ensure exact performance. Wherever exact data are not available, they are assumed under practical considerations and have been furnished in motor datasheets [1, 2, 3].
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For motor starting studies, similar to load flow study ETAP requires selection of mode of operation of power sources, which are Swing mode, Voltage controlled mode, Power factor controlled mode, MVAr controlled mode. After mathematical modeling of source model, load model and with appropriate selection of operating mode, different load flow method are used to find different electrical parameter at different bus. Methods are used for load flow and motor starting simulations to find different parameter are; (1) Accelerated gauss seidel (2) Newton Raphson method (3) fast decoupled method [1, 2, 4, 5].

Among three methods, Guess Seidel method is the simplest method but it is used for small networks. Numbers of iterations requires to converse it depends on number of bus and therefore it takes long time to converse and sometimes diverse also for big complex network. Newton Rapson method is the unique choice for large industrial networks. It only takes 3 to 5 iteration to converse irrespective of numbers of bus. Newton Rapson methods some assumptions are made to simplified Jacobean but it give approximate solutions. Fast decouple method is the simplified version of N-R method and give almost very approximate solutions [1, 2, 4, 5].

According to load flow analysis, buses are divided as generation and load buses where some parameters are specified such as power and voltage at generation bus and active and reactive power at load bus. One bus in the network keeps as swing or slack bus. Here, motor starting analysis is performed by simulating motor starting from 1 to 10 seconds to understand better starting scenarios. A system base of 100MVA has been used for all studies. Base values of 22kV, 6.6kV and 433V have been considered for various systems voltage levels [1, 2, 4, 5, 6, 7].

III. OUTCOMES AND PARAMETER SETTING

Primary outcome of motor starting simulation are; (1) Voltages at every buses, active and reactive power flow, line loading, generation and loading parameters, switch event etc. (2) Simulated result of motor starting analysis such as current is taken by motor, starting and running torque, slip, acceleration torque, real and reactive power, power factor, bus voltage and variation of all this parameter with respect to time etc. (3) Additional notification of operating parameter variations [1, 2, 4, 5, 6, 7].
Different tolerable parameter variations limit are; (1) steady state frequency and voltage variation should be in range of ±2% and ±5% to ±10% respectively.(2) permissible voltage drop at H.T and L.T circuit during normal condition is 5% , whereas, during motor starting it must be less than 20%.(3) Transient voltage deviation must be maintained in between 80% to 120% [1, 2, 4, 5, 6, 7].

IV. RESULTS ANALYSIS

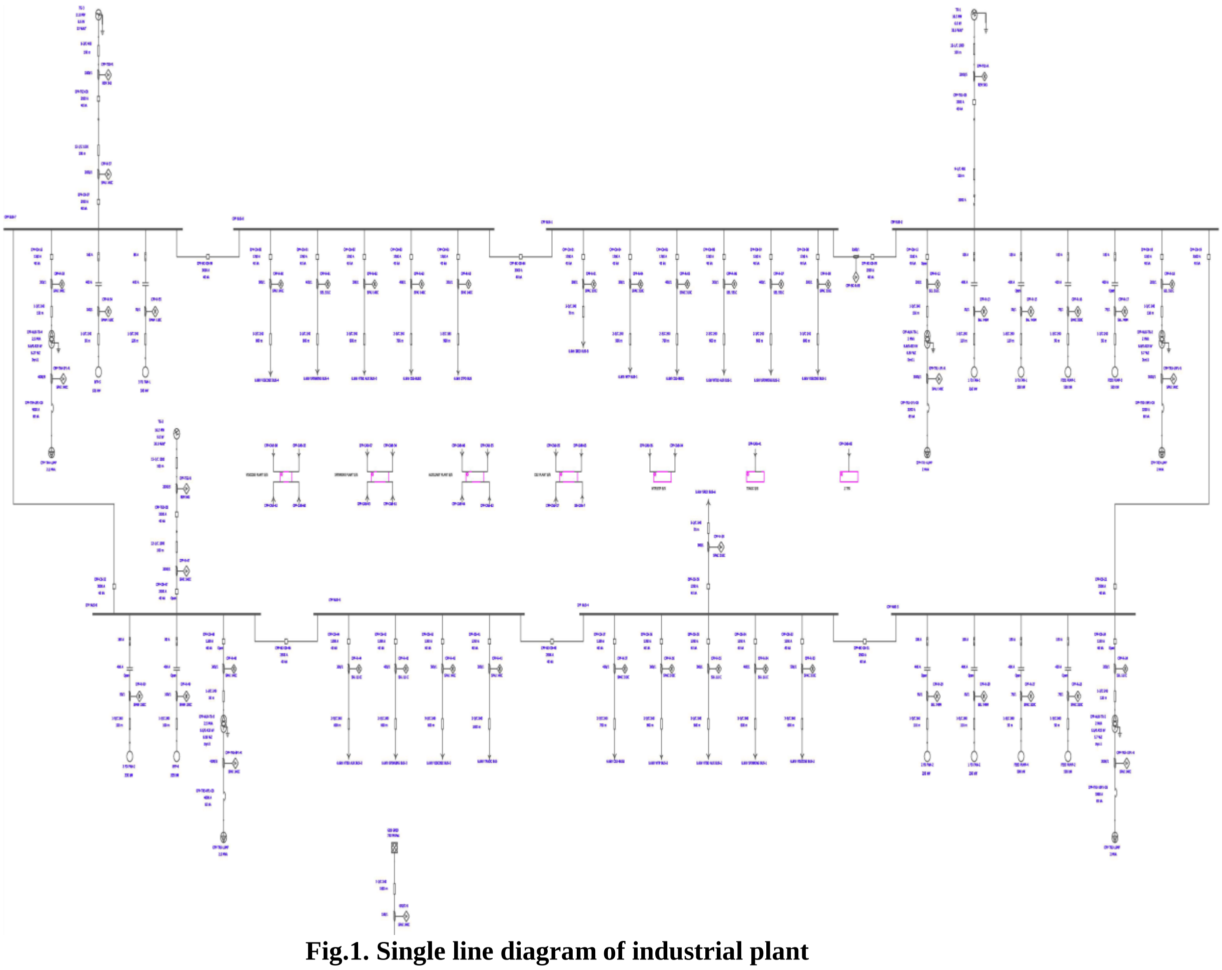

Fig.1. Single line diagram of industrial plant

Industrial palnt is 175 bus system within plant steam based generation (by three generator 2*15.6MW &1*11.8 MW, G1/G2=15.6 MW, G3=11.8 MW) with 22kV Grid support for black start and emergency. Total 175 branch of the plant formed by 37 transformer (distributions & furnace), 74 line/cable, 64 tie circuit. Load flow analysis conducted using ETAP-7.5.5 & selecting Newton Raphson method with precision of 0.0001.as single line diagram are shown in Fig.1.

We have performed motor starting analysis of biggest motor of the plant such as 535kw and 6.6 kv. There are two this type motor in this PCC but we only performed motor starting study for one motor only with G2+G3 philosophy are taken in considerations. Motor is connected to H.T panel for with using Xlpe cable of 240 sqmm three core. Total available generation of G2+G3 is 27.4 MW and total load is 24 MW. Simulation result of motor terminal voltage, current, voltage deep, slip, torque, reactive power and motor as well load torque are show in fig 2 to Fig 7.Simulation results are presented for from 1 to 10 second. It is found that voltage deep is occurred of 97% and which is more than lowest limit.

Furthermore reactive power required is lesser than generator capacity curve limit and motor torque are greater than load torque. Motor is start successfully without violating any operating parameters and attained rated speed in 4 second. All other parameters are within prescribed limit.

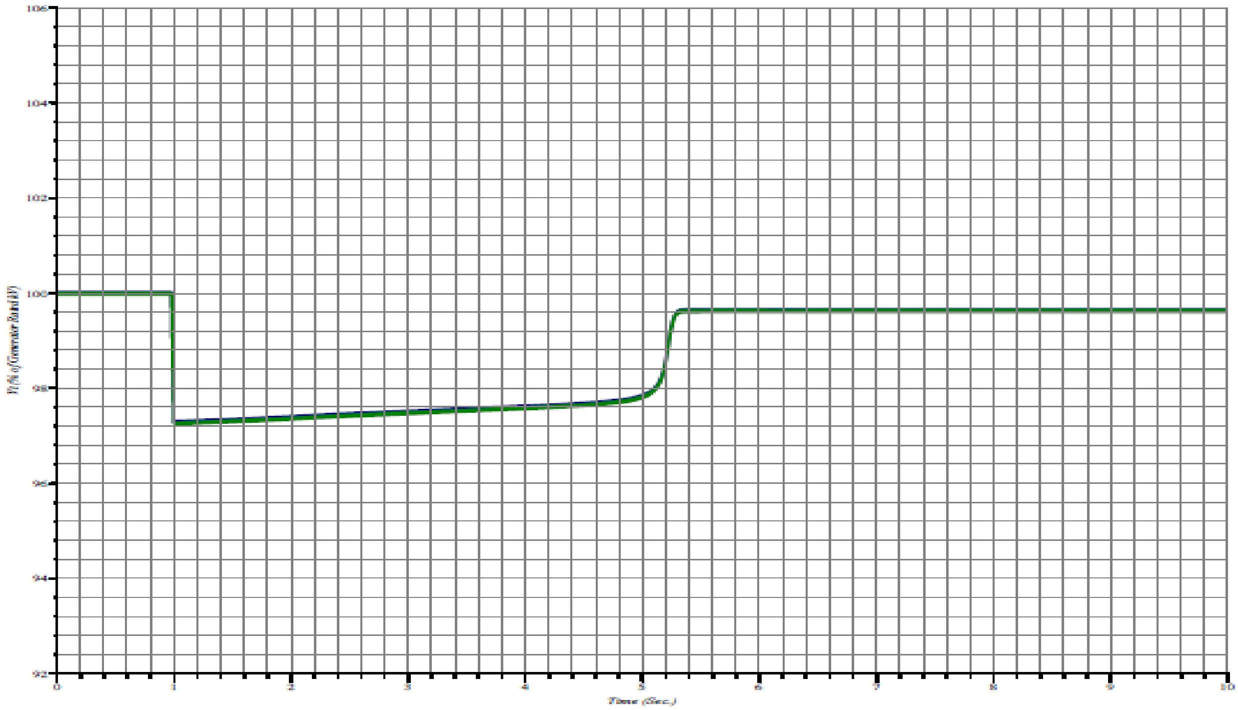

Fig.2. Grid voltage/Time

Fig.3.Terminal Voltage/Time

Fig.4. Current/Time

Fig.5.Torque/Time

Fig.6. Slip/Time

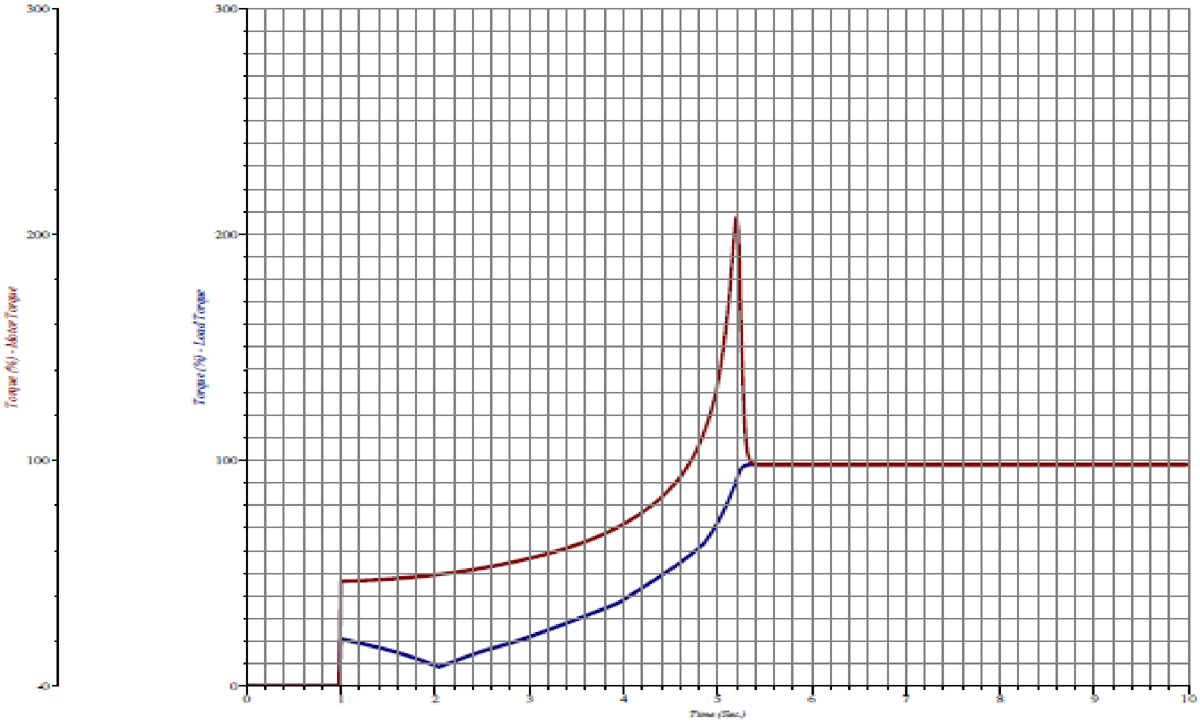

Fig.7. Motor Torque/Load Torque

V. CONCLUSION

Motor starting study of the industrial plant have performed to check effect of motor starting on remaining power systems and also ensure successful start up of big motor without violating any operating parameters. Motor starting analysis have performed with big motor of 535kw and it is found that motor is started successfully within proscribe starting time and all other operating parameter such as voltage, current, power, torque are within limit.

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