International Journal of Engineering Research and Development (IJERD) ISSN: 2278-067X
Recent trends in Electrical and Electronics & Communication Engineering
(RTEECE 17th – 18th April 2015)

Islanding Operation of Captive Power Plant

Ranjan Bandyopadhyay[1]
[1]*Head, Engineering & Technology (L&T Power), Senior Member- IEEE Associate Member- IIE, Member of Expert Committee-CBIP*
[1]first.author@first-third.edu

Abstract:- Industries like Process Plants, Steel & Aluminum Industries, Petrochemical & Chemical Industries and Cement Plant etc. which are involved in critical operation during manufacturing or production process need reliable & quality power. Interruption of Grid power or disturbance in power supply due to voltage & frequency variation may cause severe damage and loss in production as well as revenue. Most of these industries have installed Captive Power Plant (CPP) and it operates in parallel to State Electricity Board's (SEB) supply system. This paper describes how islanding mode of operation can be beneficial during problems arising due to Grid Disturbances while CPP operates parallel with SEB / Grid Supply System.

Keywords:- Captive Power Plant (CPP), Islanding mode, Grid Disturbance, Critical Loads, Combined Cycle Power Plant (CCPP)

I. INTRODUCTION

HE electricity is one of the key factors to enhance the industrial growth in India. The efficient and most effective ways of power generation and distribution are essential for sustainable growth and performance of various industries. As on date the total power generation in India is around 240,000 MW and expected power addition of average 20,000-25,000 MW per year according to 12th, 13th & 14th Five Year Plan of Govt. of India. In addition to generation, it also calls for strengthening of power evacuation and distribution systems. The concerned departments of central and local Governments have taken necessary measures to upgrade and strengthen the present transmission & distribution systems. At present still there are quite a few zones in different states where transmission system is not so stable and frequent failures have taken place due to mismatch in generated power and the load demand. Most of the large industries (say, Petrochemical & Chemical process industries, Cement Plants, Steel & Aluminum Industries etc.) have installed their captive power plant to take care of uncertainty of Grid supply as well as to avail good quality of power. These captive power plants generally operate in parallel with the Grid supply within the permissible variation of voltage and frequency. In most of the cases, the requirement of power to various auxiliaries in the industry is shared by Captive power generation and the Grid power. However, during grid disturbances or failure, it is essential to maintain the supply to all critical or essential loads in the manufacturing or process industries, which are normally fed from CPP. Under this situation it is necessary to have continuous operation of Captive power plant by isolating the faulty Grid supply. It is called "Islanding Operation of Captive Power plant". Hence we may say that the "Islanding Operation" is the isolated operation of the CPP when there is a grid disturbance during the parallel operation of the plant with SEB/ Grid supply.

II. GRID DISTURBANCES & ITS EFFECT

In case of any sudden and major disturbances in the Grid /EHV network, it may happen that the entire power networks fail and most of the power stations trip one after the other in very short time. If the faulty element is not effectively & instantaneously isolated the fault may not remain localized but can result into successive overloading of the inter-connecting EHV lines which may cause cascading effect on all power stations including Captive generation. During the failure in Grid system the supply voltage and frequency tend to drop rapidly. Sustained grid under voltage is more severe as the industrial loads might cause drawing large current which can cause damage to the motors. In such cases CPP islanding can be restored with selected load shedding, if necessary, to improve the in plant power supply bus voltages. Due to severe low frequency of the Grid system, failure of critical drives in the plant increases. The low frequency also effects the CPP operation since its Generator may be operating near to under frequency protection limit. Turbine blades also get over stressed and blades may fail. Recurrent under frequency operation reduces the life of the turbine and generator to a great extent. An efficient islanding scheme will help survival of the process plants or manufacturing units from complete blackout condition. To isolate the CPP units during harmful frequency excursions either the 'Rate of change frequency relay (df/dt)' or discreet 'Under frequency relay (81)' or both are used. In certain variations even discreet 'Under frequency relay' combined with 'Reverse Power Relay' (32) have been used depending upon the option. While the islanding of CPP is using frequency relay during grid disturbances, further load shedding can be done using Microprocessor based relay system or PLC based schemes. In these schemes the power drawn from the Grid/SEB and captive power generation are monitored. Hence at any point of time, if the islanding mode of operation is implemented, the load quantum to be shed by PLC becomes the measured power immediately drawn from SEB prior to islanding. During islanding then the PLC can be programmed to shed the feeders which are not essential to the plant operation.

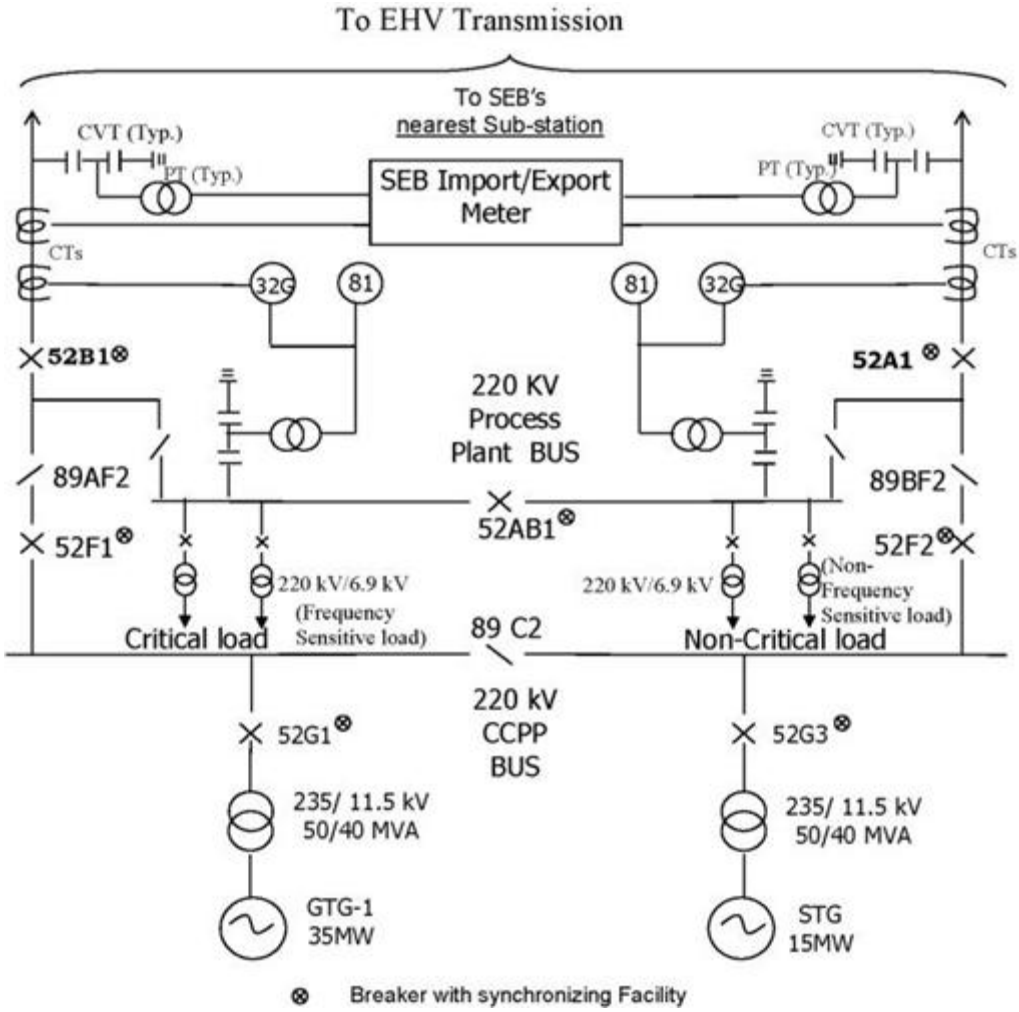
III. ISLANDING MODE OF OPERATION

Islanding of in-house CPP generation is necessary for the following major reasons:

1) To isolate the faulty or disturbed (voltage & frequency not within permissible limit) power sources from Grid supply and feeding the plants loads from CPP to improve the stability of the overall electrical system.
2) To avoid complete blackout situation in the plant and subsequent black start of the power plant. This will help to save the production loss, to reduce severe damages of equipment & process as well as to improve the life of plant machineries.
3) To control the power flow to grid from CPP, if at all any provision is kept.

The following points are to be considered prior to islanding operation of CPP:

1) Segregation of essential/critical (i.e. Frequency sensitive) and non-essential (i.e. less frequency sensitive) loads of the plant. The essential loads are fed from CPP and the non-essential loads can be catered by grid supply.
2) Switching off the excess load and keep the part loads on healthy units, during part CPP operation.



IV. CASE STUDY FOR ISLANDING OPERATION

The case study for a process plant having a critical production process line up has been carried out. Any interruption in power supply calls for inferior quality of product as well as tremendous loss in production and revenue. This industry has gone for captive generation with combined cycle power plant (i.e. CCPP with Gas Turbine & Steam Turbine generators) and operates parallel with the Grid i.e. SEB's EHV (at 220kV) supply. This CCPP operates in parallel with SEB supply under normal condition when the variation of Grid voltage & frequency are within the permissible limits and catering the process plant loads & auxiliaries. However, during the grid disturbances or failure, the CPP is isolated from Grid supply to go for Islanding mode of operation. To optimize the uses of existing plant system as well as for effective utilization of captive generation and the available SEB's supply this plant has implemented successfully the 'Islanding Operation'.

Some of the salient features of implemented scheme are as follows:

1) The critical loads (i.e. sensitive to voltage & frequency variation and tripping of the same will cause production loss as well as decaying life of plant machineries) and non-critical loads (i.e. not very sensitive to voltage and frequency variations say, normal plant auxiliaries, heaters, HVAC & lighting loads etc.) have been segregated. The power supply bus arrangements inside the plant are made accordingly.
2) The critical loads are connected to the supply bus fed from Gas Turbine generator (GTG) and non-critical loads are powered from the bus connected to SEB supply as well as Steam Turbine generator (STG).
3) The capacity of GTG is decided based on the total critical loads of the plant and total non-critical loads are shared by STG and Grid supply. During islanding operation, the GTG operates in 'Isochronous Mode' (i.e. constant frequency mode) and STG operates in 'Droop Mode'. During this situation, some of the non-critical loads are switched off to meet the installed capacity of STG.
4) Under frequency Relay (81) will trip EHV breaker (52A1 or 52B1) and CPP will run under islanded mode of operation. The frequency relay shall be coordinated with Generator Side frequency relay.
5) Power Management Relay (32G) is provided in SEB's 220kV incoming lines to prevent power flow from CPP to EHV grid as specified by the SEB.
6) The normal operation (i.e. availability of both CPP and Grid supply for parallel operation) is restored to cater all the plant auxiliaries as soon as the voltage and frequency are within the acceptable limits.
7) This plant is in operation with this islanding scheme without any major problem.

V. CONCLUSIONS

The selection of scheme for operating Captive Power Plant (CPP) paralleling with the Grid supply should be carefully chosen depending upon factors such as power demand of the industry, nature & type of loads & operation in industry, installed capacity of CPP, reliability of grid supply etc. Some of the industrial units in India forced to 'Islanding Operation' of their CPP due to the fact that the disturbances in the grid have been quite frequent. The need of parallel operation of captive generators with the grid supply has increased due to the innumerable advantages of generating captive power. One of the important advantages to industries having in house generation is to avail good quality and reliable power supply to its auxiliaries. It improves plant's performance and life of plant machineries. The proper selection of captive generator and its associated excitation system will help CPP's successful parallel operation with the grid under specified condition. Appropriate and comprehensive protection of the captive generator and its associated excitation & control systems will help in ensuring reliable electric supply and continued power supply to the essential and critical loads even in the event of grid supply failure. Recent time implementing state of the art microprocessor based and numerical relaying and PLC/DCS control system most of the industrial installation in India are operating their CPPs in parallel with the grid. They have managed to isolate their CPPs to feed the essential loads successfully with islanded mode of operation, during disturbances in the grid.