Measurement of Cold Load Pickup-A Case Study

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Abstract— When a distribution feeder circuit is re-energized after a long period of power interruption, a sudden increase in power demand is observed due to inrush current and loss of diversity which is known as Cold Load Pickup. Field measurements was performed at two different 33KV/11 KV Power Substations(PSS) supplying 11KV feeder, one for residential load another for commercial load.
Key words: CLPU, PSS

I. INTRODUCTION

Cold load pick up (CLPU) is basically a phenomenon of excessive current owing to abrupt increase in power demand when a distribution feeder is restored after a long service interruption. Here long interruption means power outage for more than an hour. CLPU has two basic components as studied by Wilde [2]. The first one being transient in nature is caused due to transformer and magnetising current as well as motor starting currents while other is enduring demand component caused due to loss of diversity. Transformers draw inrush currents on power restoration because the core is likely magnetised in different polarity [19]. Apart from transformers, resistive lighting, heaters and motors also draw inrush currents. Motor starting peak currents are more than five times the rated value which last for around 5 sec. The duration of second component may last more than an hour depending upon the weather condition, the period of power outage and the nature of connected loads. Loads can be classified into Manually controlled loads such as florescent lights, fans, television set and Thermostatically controlled loads such as refrigerator, freezer, air conditioning. In latter case a thermostat automatically regulates the temperature inside enclosure. Load utilization by consumer is random since switching loads ON and OFF has no pre-determined schedule and is dependent on weather condition [3]. There comes the concept of diversity which is the difference between the sum of the maximum demands of individual customers' loads and maximum demand of the combined loads of the customers. Actual operating load in a feeder rarely equals the sum of all the connected loads. Diversity occurs because not all the loads connected to a feeder operate to their peak power at the same time. Normally diversity of load is calculated in terms of Diversity factor which is defined as the ratio of summation individual maximum demand and coincident maximum demand. Now the question arises how do thermostatically controlled loads contribute to CLPU condition. These loads during normal operation, cycle ON and OFF intermittently. During power interruption temperature inside a refrigeration equipment rise so that when power is restored all appliances that need to catch up energize at once leading to loss of diversity. Another reason is related to the physical behaviour of cooling as investigated by Agneholm [4]. A high temperature inside the cooling equipment will give a higher density of the vapour that is flowing into the compressor. This leads to increased power consumption due to increase in the mass flow, which gets normalised once temperature is decreased to the setpoint.

II. LITERATURE SURVEY

CLPU first appeared in the 1940s as a problem because of high inrush currents that were temporary in nature and prevented re-energization of distribution circuit. Starting from late 1970s, scholars took it more seriously by predicting and analyzing CLPU behaviour. In 1979, McDonald studied electrically heated homes to predict the magnitude and duration of peak demand following a power outage in cold weather [5]. In the year 1981 Wilde studied the effects of cold load pickup on distribution transformer. In 1995 Ukak and Pahwa studied the dynamics of the load for the enduring portion of CLPU and devised a suitable CLPU model. In 1999 Agneholm studied the load behaviour of the industrial and residential sector following different type of outages. Because of difficulties in performing field measurements, several authors have resorted to method of load modelling and predicted the CLPU conditions by statistical as well as stochastic methods. One such work is by Chong and Malhami [6]. In this paper cold load pick up condition has been presented for 11KV Feeders supplied to a residential ,commercial and an industrial area at two different substations under control of Essel Vidyut Vitaran Muzaffarpur limited(EVVML) at Muzaffarpur, a small town in north India.

III. RESIDENTIAL LOAD

The data were collected for 11KV Zero Mile feeder which emanate from 33KV/11KV 10 MVA Power transformer installed at Shree Krishna Medical College and Hospital(SKMCH) Power Substation. Zero Mile is a residential area in Muzaffarpur. The residential load consist of appliances like lights, fans, coolers, fridges, television, airconditioners, motors, washing machines and food processors. The readings were taken on hourly basis except after power restoration time interval was reduced to 15 minutes in order to get better load behaviour. The load on feeder normally ranged from 3.5 MW in daytime which increases to around 5 MW in the evening. Load shedding was done by utility at 8 pm for an interval of 3 hours. Load on feeder was 290 A (line current value) prior to outage while outdoor temperature was 30 degree celcius. When power was restored at 11 pm there was a sudden increase in current value to 380 A. The overcurrent setting was 400 A. Thus it was almost the condition of tripping. The current demand was normal in around an hour.

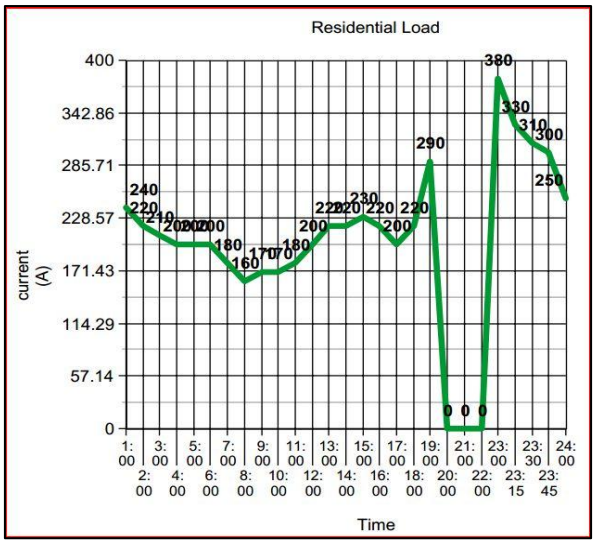

Fig. 1: Daily Load Curve for Residential Load

IV. COMMERCIAL LOAD

The data were collected for 11KV Rewa feeder which emanate from 33KV/11KV 5 MVA Power transformer installed at Maripur Power Substation. Rewa is a commercial area in Muzaffarpur having retail outlets, banks, small hospitals and firms engaged in wholesale supply of drugs and pharmaceuticals. The load on feeder normally ranged from 1.8 MW in daytime which increased to around 2.3 MW in the evening. Breakdown occured in distribution network at 6:20 pm. Load demand on feeder was 120 A (line current value) prior to outage while outdoor temperature was 28 degree celcius. When power was restored at 7:40 pm there was a sudden increase in current value to 154 A. The overcurrent setting was 200 A.

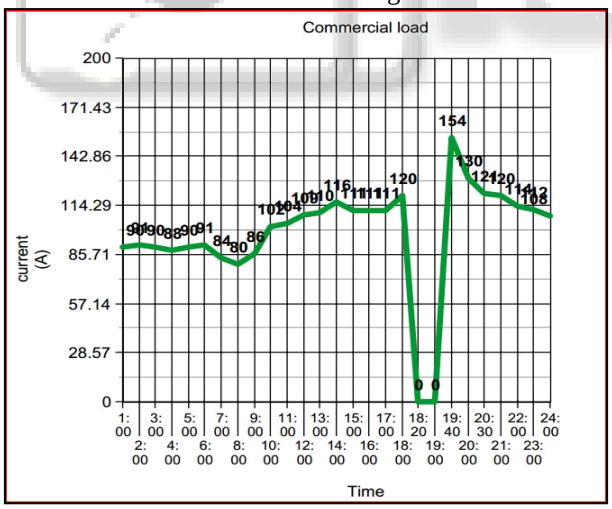

Fig. 2: Daily Load Curve for Commercial Load

V. INDUSTRIAL LOAD

Similar work was done in the chiller plant at Samdariya Mall, Civic Center, Jabalpur. The Chiller Plant is supplied through a feeder originating from 1600KVA ,33KV/0.4KV dry type transformer. The Plant consisted of three sets of Water Cooled Screw Chiller, one set of Twin Circuit type(315 TR/226.3KW) and remaining two sets of single circuit type(225TR/163KW). Apart from these it has Condenser Pump(22KW) ,Primary Pump(11KW), Secondary Pump(18.5KW) four sets of each and three sets of Cooling Towers having two sets of cooling fans(3.5KW) on top of each tower. Chilled Water type Screw chillers comes in category of Central Air Conditioning Plants that are installed in the place where whole large buildings, shopping malls, airports, hotels etc comprising of several floors are to be air conditioned. The refrigerant (R-22) first chills the water, which in turn chills the confined spaces. The inlet cooler water temperature is 54 degree F while the outlet cooler water has temperature 44 degree F. In a screw chiller circuit, the compressor is designed to work on varying capacity by employing valves. The different working states of a compressor are given below.[20]

1) Compressor is at 25%: This state is when the compressor is providing 25% of its capacity. In this state, the relay output to activate the 25% valve is turned ON.
2) Compressor is at 50%: This state is when the compressor is providing 50% of its capacity. In this state, the relay output to activate the 50% valve is turned ON.
3) Compressor is at 75%: This state is when the compressor is providing 75% of its capacity. In this state, the relay output to activate the 75% valve is turned ON.
4) Compressor is at 100%: This state is when the compressor is providing 100% of its capacity. In this state, the relay output to activate the 100% valve is turned ON.

When plant was started at 10 am at the time of opening of mall, load was 173A. Pumps were started 30 minutes prior to the starting of the chiller plant. The outdoor temperature was 22 degree celcius. A fault occured in the network due to which there was power interruption at 1:50pm. When power was restored at 2:15pm load was only 62A.

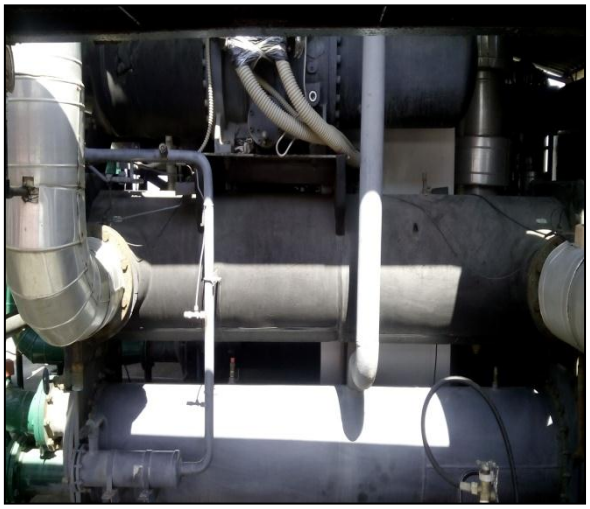

Fig. 3: Water Cooled Screw Chiller, Single Circuit Type (225TR/163KW).

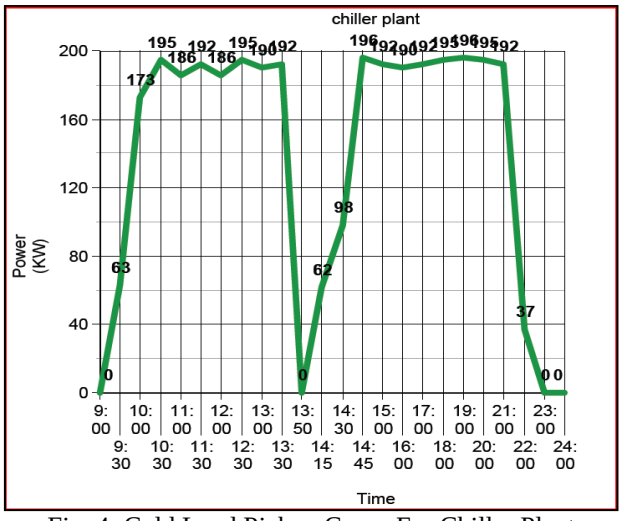

Fig. 4: Cold Load Pickup Curve For Chiller Plant

VI. Conclusion

As evident from previous section, cold load pick up was a concern for residential feeder as it may cause false operation of relay followed by power interruption. In case of commercial load cold load pick was not a concern as the current demand was well within protection range. We can consider any measure from options cited below [17].

1) Sizing or limiting the normal loading of the feeder to accommodate the increased load due to CLPU.
2) Temporary adjustment of protective device settings to prevent tripping for the duration of CLPU peak.

It is proposed to install a new transformer of 5MVA having voltage ratio 33KV/11KV in the SKMCH substation. The Residential Load can be divided into two sections .First section be connected to the 10 MVA transformer, while other one being supplied from 5MVA transformer. Cold load pickup is not a problem in industrial type of load. As we saw in chiller plant threre was not any large change in load after power restoration because chiller takes atleast 5 minutes to restart. Meanwhile pumps are started to circulate water.

VII. Acknowledgment

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