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Implementation of static VAR compensator in foundry and assessing the performance of metalized film type capacitor

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Abstract
In today's growing world, the use of electrical supplies increase day by day. When compared to generation of electrical supply and demand of electrical supply is not equal In other words, generation is less than demand. In this situation as world is having less sources of generation, this will create electrical crises. So, to meet the demand requirements is only possible way of saving electrical energy or it may also mean that reducing the losses of energy. Concerning about the losses of energy some major aspect is Power Quality, Iron losses, Copper losses, Transmission and Distribution losses etc.. In this paper we consider improving power quality in terms of power factor and harmonics by using static VAR compensator with metalized film capacitor. Also, in this paper, we are assessing the performance of MPP Capacitor in static VAR compensator at foundry.

Key Words: SVC, Power Factor, Harmonics, Metallized film type Capacitor (MPP)

1. INTRODUCTION

The optimum use of existing power with lower loss is possible by reducing reactive power consumption. It means that reducing the reactive power that is use of wastage of power for active load. The simplest way to implement this is to improve power factor of electrical system. When power factor improves the reactive contents of the system is reduced. The second and very important aspect in the current situation is reducing harmonics level to improve quality of voltage and current sinusoidal wave. It will help to save technical as well as commercial losses. Technical losses in terms of quality of voltage and current are near to ideal, satisfactory working of electrical devices. The commercial losses means as voltage and current quality is not appropriate then possibility of damage of electrical devices which leads to wastage of money. So, improving harmonics power quality are both beneficial. Harmonics is multiple of utility, power frequency that is fundamental frequency. Harmonics are generated because of non-linear load e.g. drives, rectifier, electronics devices, converters etc.

These non-linear loads are used in day to day activities to quicken the work or to reduce manpower needed for automation. So, considering the above scenario, improvement of power quality is essential. To improve power quality, a lot of technics are available e.g. STATCOM, fixed capacitor harmonics bank, active filter, static VAR compensator, DVR etc.

In this paper, we have considered static VAR Compensator (SVC) with metalized film type capacitor. The purpose of research is assessing the performance of metalizes film capacitor in static VAR compensator as well as to determine SVC is worth solution to improve power quality.

2. Metalized film type Capacitor

Metalized film type Capacitor means that the capacitor is manufactured using metalized film dielectric that is the polypropylene film is metalized by aluminum or zinc at one side and other side remains dielectric. The thickness of aluminum or zinc is about 0.2µm. While manufacturing of capacitor metalized film is wound on bobbin with specific number of turns to achieve the appropriate capacitance value. [3,5]

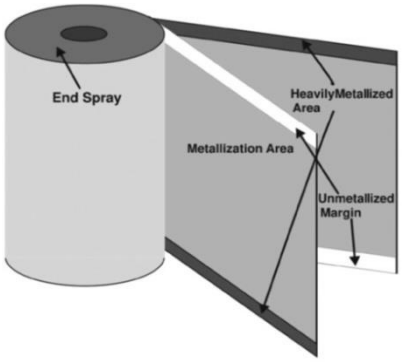

Fig: 1 construction of Metallized film capacitor (MPP)

Above figure 1 shows that same layer of polypropylene on one side is for conducting purpose and the other side is remaining dielectric. The purpose of such construction is to reduce air packets in-between conducting and dielectric material. In this capacitor, silicone gel is used for cooling purpose, as silicone has high resistivity, low thermal conductivity, low toxicity, high gas permeability at 25 ˚C, good electrical insulation etc. The metalized film capacitor has the very important property of self-healing. Self-healing means self-recovery. [4] Any fault occurs in a capacitor the value of capacitance will not drastically change. The change in value is minimum because of self-healing property. Reduction in capacitance depends on how much area of metalized film is defected. If it is small, then small capacitance value is reduced so due to such property of the material even there is a fault on capacitor no major damage or change in capacitance will occur and capacitor remains in system. If such small faults occur rapidly, the capacitance of the capacitor will reduce drastically. The change of capacitance because of fault is 0.1% as shown in below figure 2. [6]

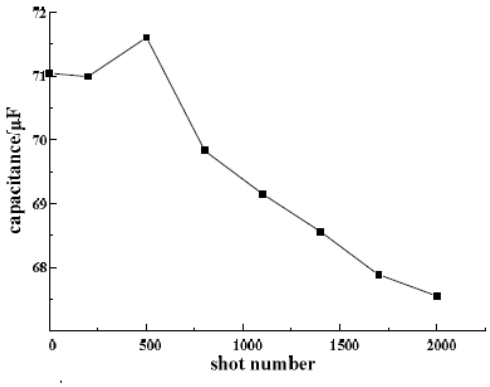

Fig: 2 Effects of no. of faults on Metallized film capacitor

3. Static VAR Compensator

The Static VAR compensator is one of the FACTS devices for power quality improvement. This device provides the rapid flexible reactive power. SVC gives flexible shunt impedance to the system by mutually or synchronously switches ON/OFF the Capacitor or inductor. As per requirements of system. That is, if reactive power is lagging then SVC will operate the Capacitor which give capacitive impedance to improve the power quality or if reactive power is leading SVC will give lagging impedance by applying inductive impedance. SVC having a dynamic response of switching that is fast action taking against change in quality. This property of SVC leads to improve transient stability, Harmonics, Power factor etc. SVC consists of major component, thyristor for switching, Capacitor for capacitive impedance and inductor is for inductive impedance. The type of SVC is as shown in figure 3. To achieve the power quality at least two type of SVC has to make a combination. [1]

1. Mechanical Switched Reactor
2. Thyristor switched reactor (TSR)
3. Thyristor switched capacitor (TSC)
4. Harmonics Filter
5. Mechanical Switched Capacitor

Mechanical switched reactor (MSR) control by MCB / Isolator or any other switching devices but which operates manually. As the inductive impedance requires this type of branch of SVC will be operated by the operator. TCR is a thyristor control reactor this is intelligently operates based on firing angle to thyristor as per the requirements of inductive impedance. Thyristor switched capacitor (TSC) is also operated as the same manner as per TCR operation. The reactor or capacitor is fully control by thyristor firing angle which will trigger by any brained system like microprocessor or fuzzy logic.[9]

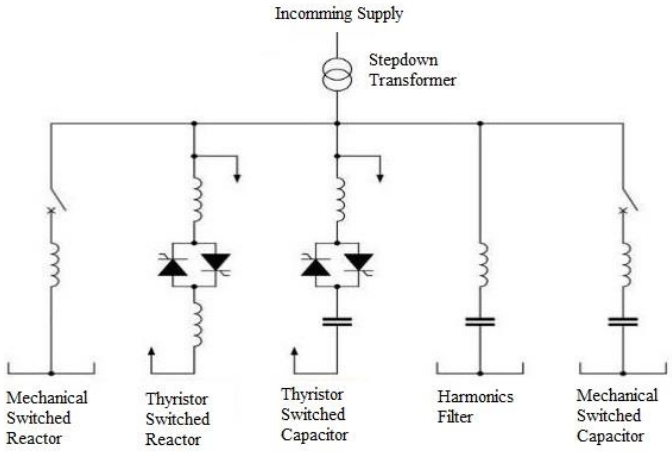

Fig: 3 Static VAR Compensator (SVC)

4. Practical Analysis of SVC by using Metallized Film capacitor:

Foundry load is considered for implementation of SVC with metallized film type capacitor. Foundry having an electrical load details are 2 induction furnace controls by AC drives having a capacity of 550 kW each. The other load is approximately 400 kW for auxiliary load like grinders, compressor, cranes etc. The auxiliary load contains the induction motors, pumps etc. The furnace load in foundry is used to melt the metal to form final products. [7]

From the above load it clears that the furnace load damages power quality in both the way that is the power factor is very low which is also due to drives are for control will generate the harmonics. So, for this analysis Induction furnace load is considered. For the analysis fluke 434 – II Power / energy quality analyzer is used to measure the electrical parameters like Power factor, Harmonics, active power, reactive power in addition to this voltage, current frequency is also measured. The reading of the analyzer is as shown in figure 4 and 5. [2]

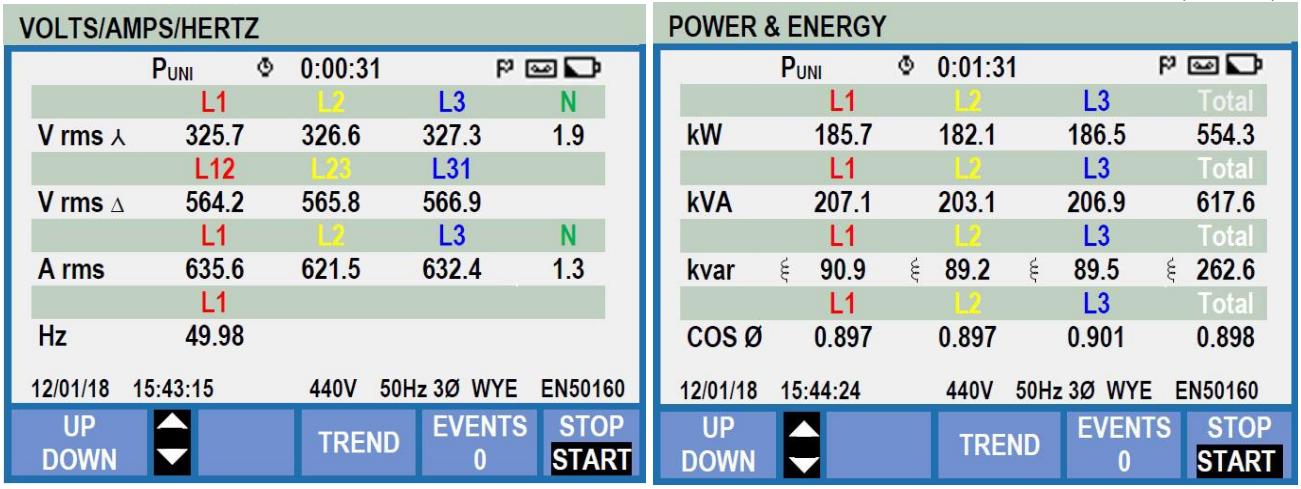

Fig: 4 Power Factor, Active Power, reactive power reading without SVC installed.

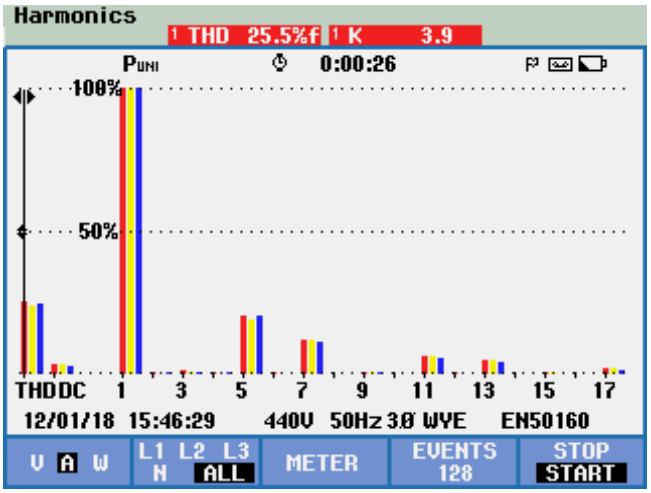

Fig: 5 Harmonics reading without SVC installed

The above readings show that when SVC is not connected in a system the power factor of induction furnace is 0.898 lagging. Due to low lagging power factor reactive power components increases due to this kVA demand is increased so that transformer is over loaded, however load having a less requirements. This will also lead to increase in the transformer losses.

From figure number 5 it is observed that the level of harmonics in induction furnace is very high even though load is totally inductive, but this load is controlled by electrical drives. Due to the drive, operation harmonics are generated, and it will pollute the electrical system. The total current harmonics distortion is 25.5%, the dominating harmonics are 5^{th} and 7^{th} level of harmonics.

To improve the power quality issues shown in figure numbers 4 and 5, a static VAR compensator with metalized film type capacitor is designed and installed at PCC. The SVC is a combination of TSC, TCR. The rating of SVC is 536 kVAR, 800 V, 3 Ph. The SVC contains MPP type capacitor, iron core inductor with thyristor. An SVC is connected in a shunt manner at PCC to get shunt capacitive and inductive impedance for improvement of power quality. After the installation of SVC again measurement has been taken at the same point with fluke 434-II power quality analyzer. The readings are shown in figures 6 & 7.

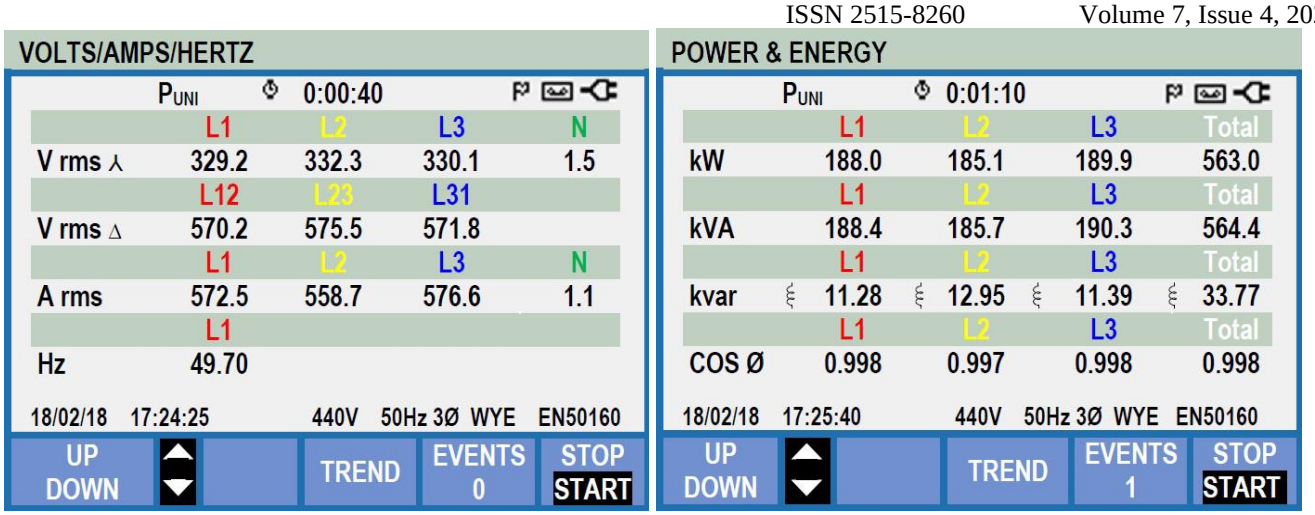

Fig: 6 Power Factor, Active Power, reactive power reading with SVC on Dt. 18.2.2018

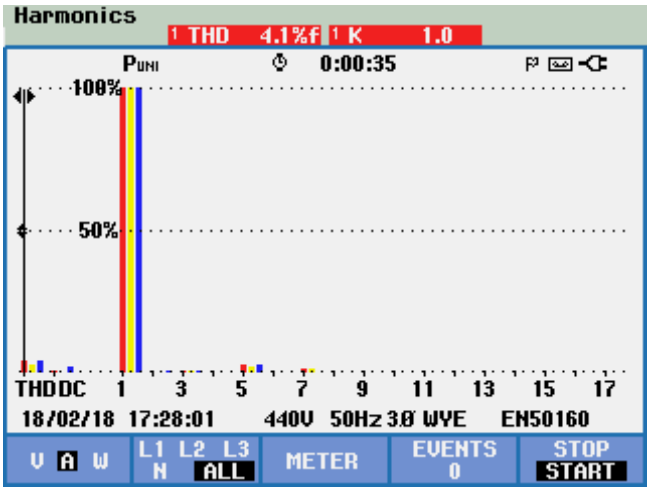

Fig. 7 Harmonics reading with SVC on Dt. 18.2.2018

From the above reading, the power factor of the induction furnace is improved up to 0.998 as shown in figure number 6. When power factor is improved the active and apparent power are approximately the same, so it means that how much power required to the induction furnace only that much power is taken from the transformer. Excess power of transformer required to the load that is reactive component required to the load is reduced by power factor improvement.

The total current harmonics distortion is also reduced up to 4.1% shown in figure number 6. The reduced harmonics level is below the limit as per IEEE 519. [10,11] The total voltage harmonics distortion also reduced below 3%.

To assess the performance of metalized film capacitor in harmonics polluted industry, the above SVC is continuously working for approximately two years with same load condition. After two years again power quality study conducts at same point with same instrument the readings are as shown in figure 8 and 9.

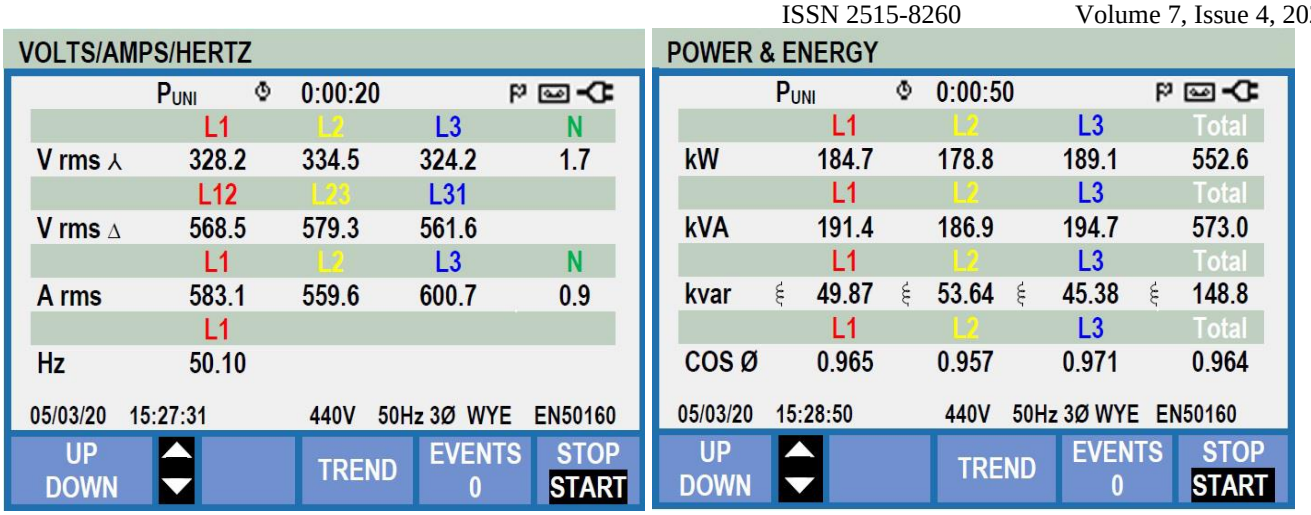

Fig: 8 Power Factor, Active Power, reactive power reading with SVC on Dt. 05.03.2020

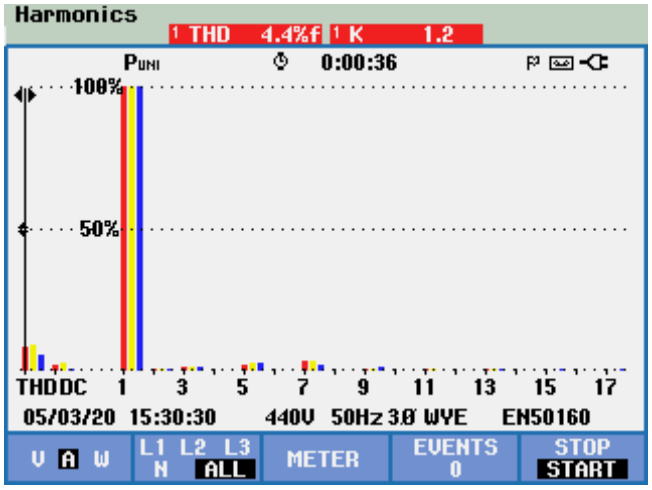

Fig: 9 Harmonics reading with SVC on Dt. 05.03.2020

Capacitance on dt. 18.02.2018 (microfarad)			**Capacitance on dt. 05.03.2020 microfarad**		
R-Y	**Y-B**	**B-R**	**R-Y**	**Y-B**	**B-R**
1162.04	1161.90	1162.15	458.65	454.60	455.87

Table: 1 Capacitance value before &after two year

Comparing the result of the reading before two years and after two years as shown in figures 6, 7, 8, 9 After two years, the value of power factor reduces to 0.964, which earlier was 0.998. This change happens because of capacitors output is reduced. The level of harmonics remains approximately same. The change in capacitance also recorded as shown in table number 1 which shows that difference between capacitance values that is output of capacitor is differentiated between before and after readings.

5. Conclusion

A way to improve the power quality of Induction furnace Static VAR Compensator is proposed in this paper. Another significance of this paper is to assess the performance of metallized film capacitor in SVC connected at harmonics polluted industry. As demand is not equal to supply so saving energy improvement

of power quality is a very important task. To achieve a good power quality, in this paper SVC is proposed and implemented in a foundry type industry at induction furnace load. The induction furnace load is having a poor power quality in terms of low power factor, high harmonics level etc. After implementation of the SVC the power quality is improved to the desired standard values. To assess the performance of MPP capacitor SVC kept in a same system for two years after this is seems that the value of capacitor is reduced due to this the improved power quality is slightly damaged. So, as per the results it is recommended that use SVC in a high harmonics polluted industry with MPP capacitor is not perfect solution. Therefore, it is recommended assessing the performance with other type of capacitor like all polypropylene film type capacitor or Electrolytic capacitor.

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