Harmonics Mitigation of Industrial Motor Drives with Active Power Filters in Cement Plant-A Case Study

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Article Info

Article history:

Received Oct 20th, 2011
Revised Jan 20th, 2012
Accepted Mar 5th, 2012

Keyword:

Adjustable Speed Drives,
Harmonics,
Power Quality,
Power quality analyzer,
minimization of harmonics,
active power filter.

ABSTRACT

With the increasing of use of power electronic controlled variable speed drives in industries, power quality distortion in electric power system has become a serious issue in recent years. In cement plants, because of presence of more number of adjustable speed electric drives, this problem is a greater concern. In this paper, the impacts of harmonic distortions due to Adjustable speed electric drives in Anjani Portland cement Ltd, Jaggayapet, Nolgonda (Dist), A.P, India is investigated. Harmonic measurements at various motor drives with the help of Fluke 434 power quality analyzer have been done to determine where a significant amount of harmonic currents or voltages are presented. From these measurements and subsequent calculations, the impact of harmonics is analyzed and found that the harmonic content of the motor drives to be minimized within the limits of international harmonic standards. In recently, active power filters gained an increased attention due to their effective harmonic reduction. In this paper an active power filter has been developed for minimization of the harmonics, which is implemented in Matlab/simulink based on real time measurement of harmonic data

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1. INTRODUCTION

The In modern power systems, due to increase of non-linear loads, power quality has become a great concern. Non-linear loads, which were only 15% of total loads in 1987, have increased to 50% in 2000. These nonlinear loads introduce harmonics into the supply system and draw non-sinusoidal currents from ac mains and cause reactive power burden, excessive neutral current, Low power factor, low energy efficiency, interference by EMI and distortion of the line voltage, etc.[1,2]. The variable speed drives comes under nonlinear loads and they are one of the major sources of harmonics generation and power quality problems. Harmonics are the main causes of power quality of the electrical power system. Therefore, the standard regulations and recommendations such as IEC 61000-3-2 and IEEE 519 enforce to limit the above problems [3]. Filtering is a common method for suppressing harmonics [4, 5]. The harmonics in supply systems are conventionally suppressed using passive tuned filters, The addition of passive "LC" filters alters, or interferes, with the system impedance, and is known to cause resonance with other network impedances and can result in an excessive amplification of harmonics rather than harmonic reduction [6,7]. In recently, active power filters gained increased attention because of their advantages compared to passive filter and also their effective harmonic reduction [8, 9]. Active power filtering is an alternative approach in which the filter injects suitable compensation currents to cancel the harmonic currents [10].

In this paper, the impacts of harmonic distortions due to electric drives in Anjani Portland cement Ltd, Jaggayapet, Nolgonda (Dist), A.P, India which is major supplier of cement to most of the industries/organizations in Andhra Pradesh in India, is investigated. The harmonic measurement is done with Fluke 431A power quality analyzer. From the measured data, it is found that the harmonic content of motor drives needs to be reduced within the limits international harmonic standards. In recently active power filters gained an increased attention due to their effective harmonic reduction. In this paper an active power filter has been designed for minimization of the harmonics and results are presented in terms of % THD without and with active power filter.

2. ANALYSIS OF HARMONICS IN CEMENT PLANT

Power quality problems especially harmonic distortion associated with nonlinear load such as Variable Frequency Drives (VFDs) are addressed in several papers [7-10] in general, but, papers deal with harmonic distortion in a cement industry is found to be very less. Hence, an attempt has been made in this paper to study harmonic analysis of electric motor drives and effect of harmonic distortion in the cement plant (Figure 1). The cement plant considered in this study produces 2500 tons cement per day. The plant electrical tariff is Rs 1.75 Lakh per Month and motor drives alone consume nearly 45-55% of power according to their operational load. In the cement industry, the motor drives are used in different power ratings for various applications such as Crushers, kiln cooling system, cement mill cooling, raw mill cooling, coal mill cooling, cement mill classifier, coal mill classifier, belt conveyors etc. The drive motor rating varies from few KW to several hundred KW depending on the application. It is identified that these are the prime sources of harmonics in the cement industry. Therefore, a detailed system study has been carried out to study the sources of harmonics.

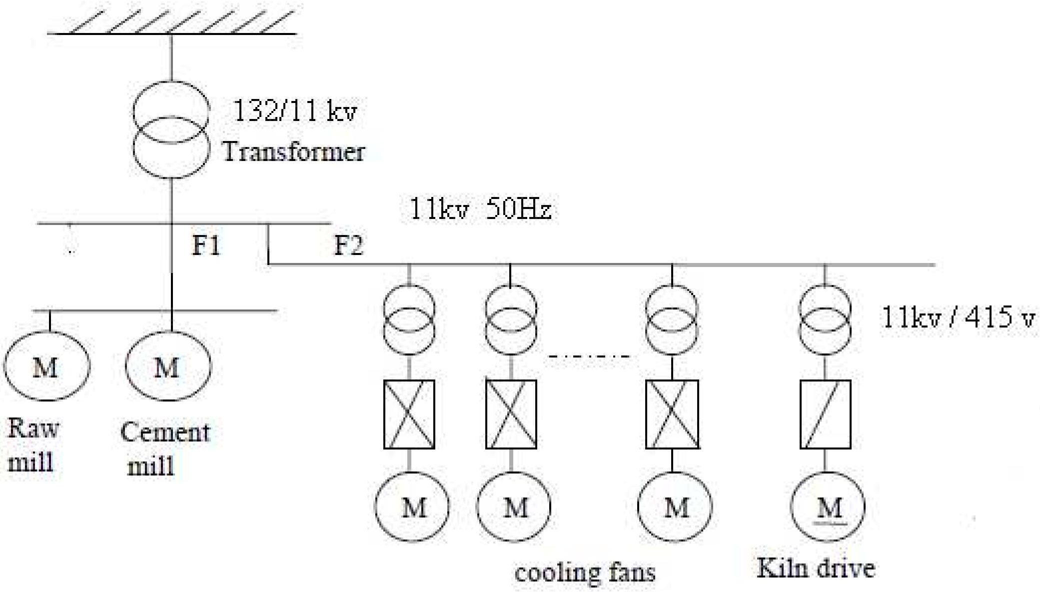

Figure. 1. Electrical layout of the cement plant

Fluke-434 power quality analyzer was used to measure the power quality parameters. This was installed on the 440V (230V phase to ground) motor drive incoming feeder. It sampled three voltages and three currents of the drive system. Using a Fluke-434 three phase power quality analyzer serial data transfer, and with Fluke view software, the recorded data i.e Total Harmonic Distortion (THD), harmonic profile was transferred to a computer. In this paper, harmonic profile of different electrical equipment is mainly considered for investigation. The over voltage threshold was set to 22 KV for the fixed. The over current thresholds were set to 500A for analyzer respectively. Harmonic measurements are an important part of the overall investigation for the number of reasons. The specific objectives of the measurement include:

Determine the harmonic generation characteristics of the motor drives. This is done by performing the current measurements at a variety of locations within the plant. The measurements typically are performed over a period of 1-2 days using power quality analyzer in order to ensure the adequate data is collected to characterize the system operation and for further improvement in the performance of the plant. The harmonic profiles for various motor drives of the cement plat are shown in Figure. 2 to Figure. 10.

3. RESULTS AND ANALYSIS

3.1 Harmonic Profile without filter

3.1.1. 132kw cooler id fan

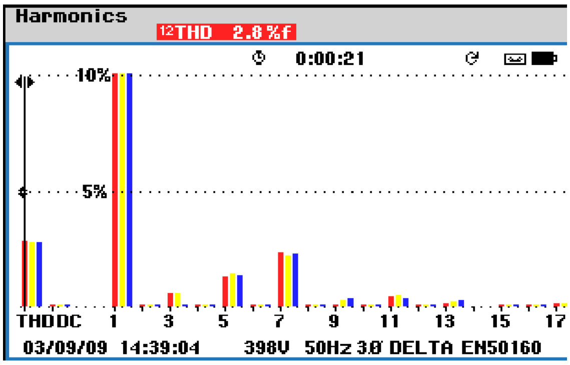

Figure. 2(a).voltage of cooler ID fan

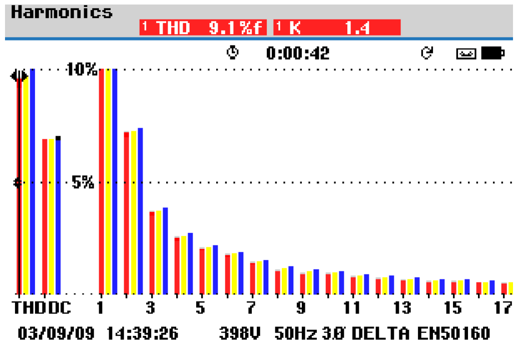

Figure. 2(b). Current of cooler ID fan

3.1.2. 650kw ph fan

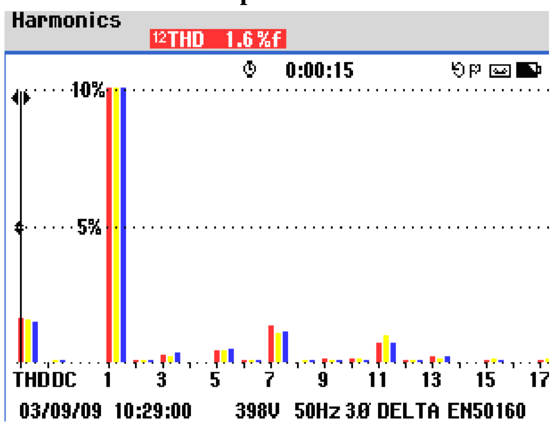

Figure. 3(a). Voltage harmonic profile

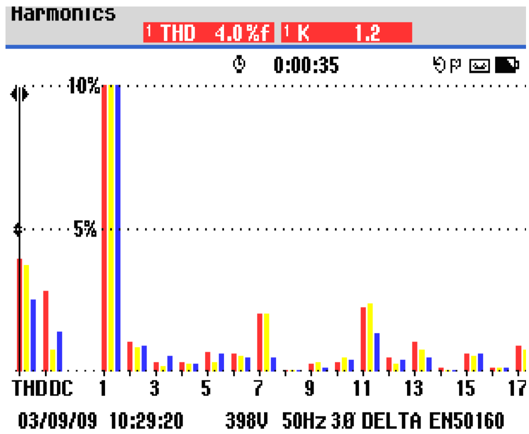

Figure. 3(b). Current harmonic profile

3.1.3 750kw cement mill 1

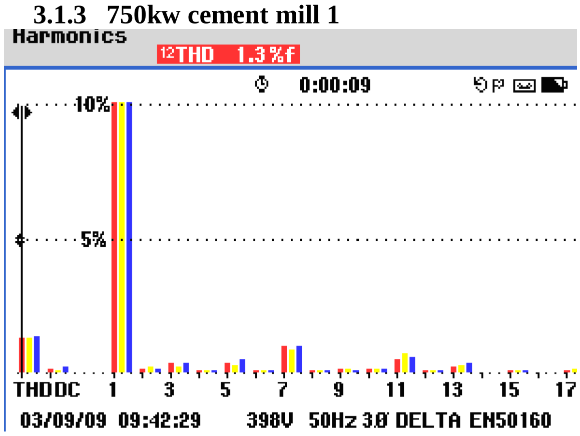

Figure. 4. Voltage of cement mill 1

750kw raw mill

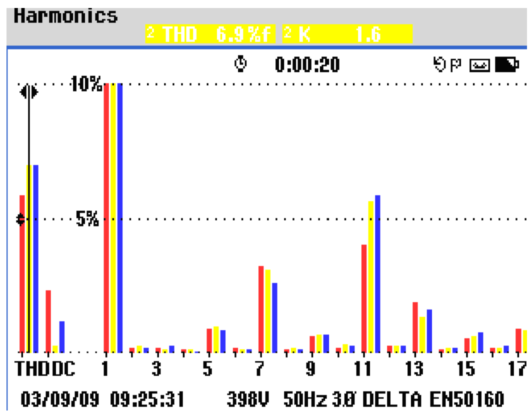

Figure.5. Current of raw mill

3.1.4 850kw cement mill2 fan

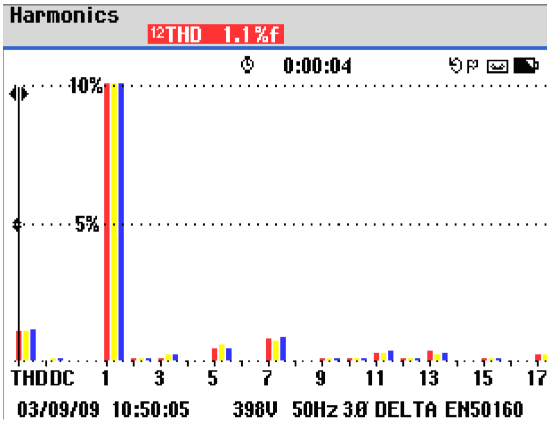

Figure. 6(a).Voltage of cement mill2 fan l

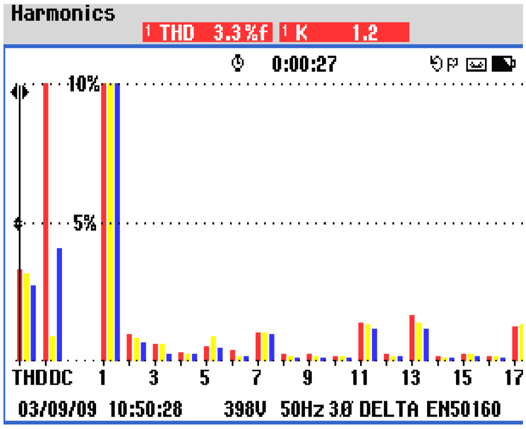

Figure. 6(b). Current of cement mill2 fan

3.1.5. Clinker breaker

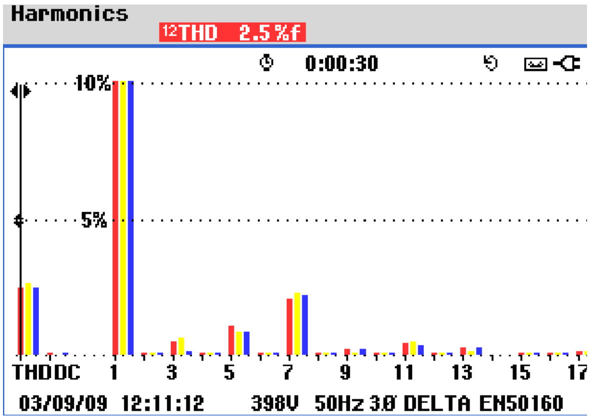

Figure. 7(a). Voltage of Clinker breaker

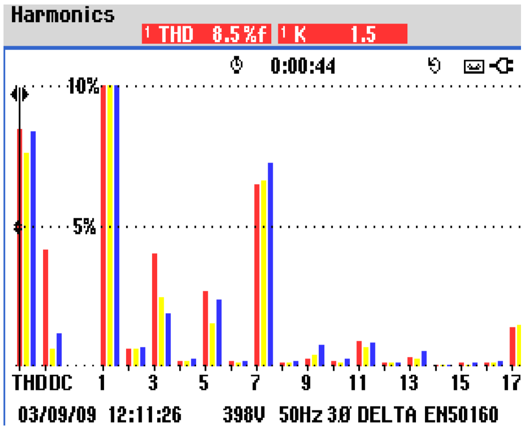

Figure. 7(b). Current of Clinker breaker

3.1.6 Cooler fan 1

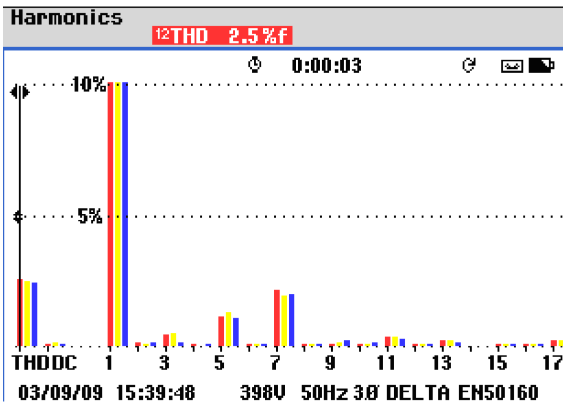

Figure. 8. Voltage of cooler fan1

Cooler fan-2

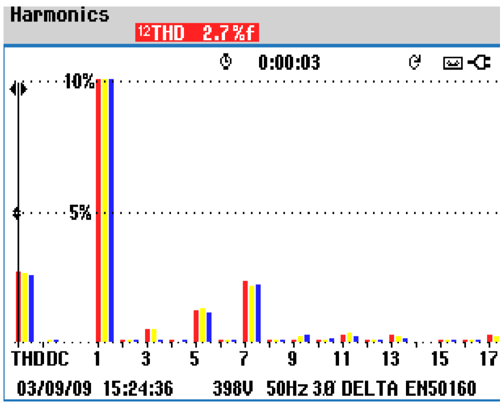

Figure. 9(a). Voltage of cooler fan2

3.1.7 Cooler fan-4

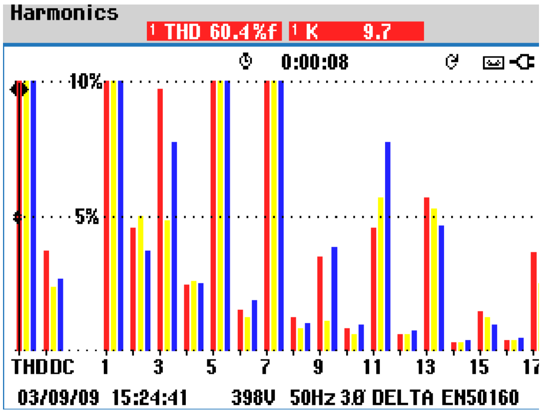

Figure.9(b). Current of cooler fan2

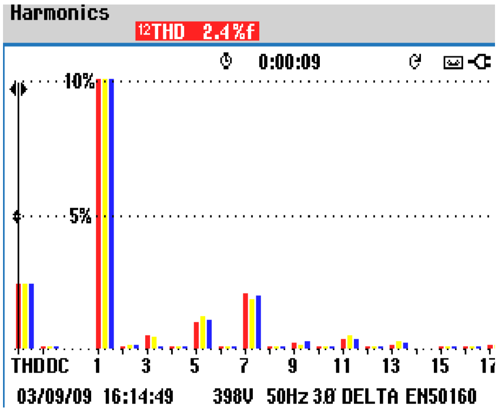

Figure.10(a). Voltage of cooler fan4

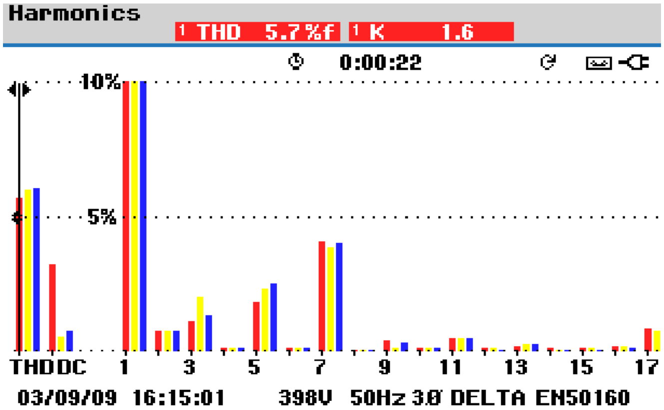

Figure.10(b). Current of cooler fan4

Table 1. Summary of harmonic distortion of various motor drives

Name of drive	Voltage %THD	Current %THD	Remarks
132 KW Cooler id fan	2.8%	9.1%	Normal level
650kw ph fan	1.6%	4.0%	Normal level
750kw cement mill 1	1.3%	--	Normal level
750kw raw mill	--	6.9%	Normal level
850kw cement mill2 fan	1.1%	3.3%	Normal level
Clinker breaker	2.5%	8.5%	Normal level
Cooler fan-1	2.5%	--	Normal level
Cooler fan-2	2.7%	60.4%	Above normal level
Cooler fan-4	2.4%	5.7%	Normal level
Cooler fan-4h	2.4%	2.6%	Normal level
750kw raw mill	--	6.9%	Normal level
850kw cement mill2 fan	1.1%	3.3%	Normal level
Clinker breaker	2.5%	8.5%	Normal level
Cooler fan-1	2.5%	--	Normal level
Cooler fan-2	2.7%	60.4%	Above normal level
Cooler fan-4	2.4%	5.7%	Normal level
Cooler fan-4h	2.4%	2.6%	Normal level

3.2 Harmonic reduction with Active power filter

The main intention of carrying out this case study in the cement plant is to determine the extent of harmonics produced by different types of non linear loads exist in the plant and to apprise whether any of the locations that had a significant level of harmonic distortion that could lead to an electrical problem in the near future. This paper analyses the level and the effect of harmonics within the plant distribution system and harmonics injected in to the grid. Total harmonic distortion should be less than 5% throughout a plant's distribution system as per the standard. Table 1 show the harmonic profile of the electric drives in Anjani Portland cement Ltd. From the Table 1, it is observed that %THD of certain electric drives is very high and beyond the International standards. Values above 5% are investigated thoroughly. Some cases, the harmonics produced by low voltage VFD used in the cooling fans are higher than 5%. Particularly, Thyristor controlled drives used in cooling fan-2 give up to 60.4% THD in current and it has to be minimized to avoid current harmonics related problems as mentioned in the previous sections. Hence, harmonics need to be reduced, for which different solutions are available such as adding line reactors, passive harmonic filters but active power filter is most preferred for effective harmonic reduction, i.e, even in non-ideal supply voltage (e.g. unbalance, voltage pre-distortion) these types of harmonic filters ensure effective minimization of Total Harmonic Distortion (THD). Therefore, many applications currently in use can replace the common line reactors with an advanced active power filters if the cost performance balance leans to a positive investment.

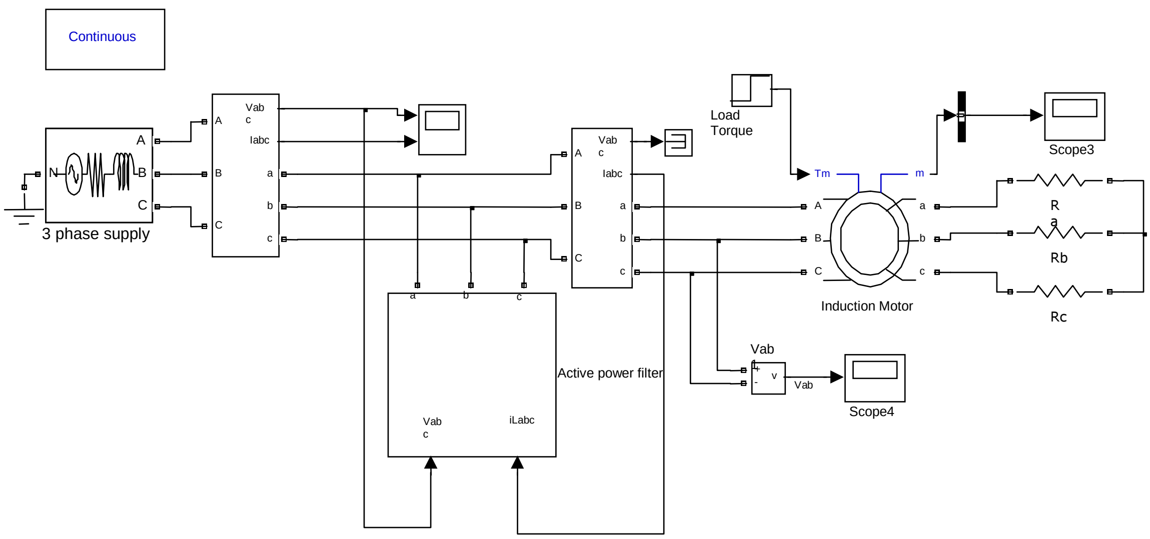

Figure 11. Simulink diagram of a 1st group dryer drive with filter

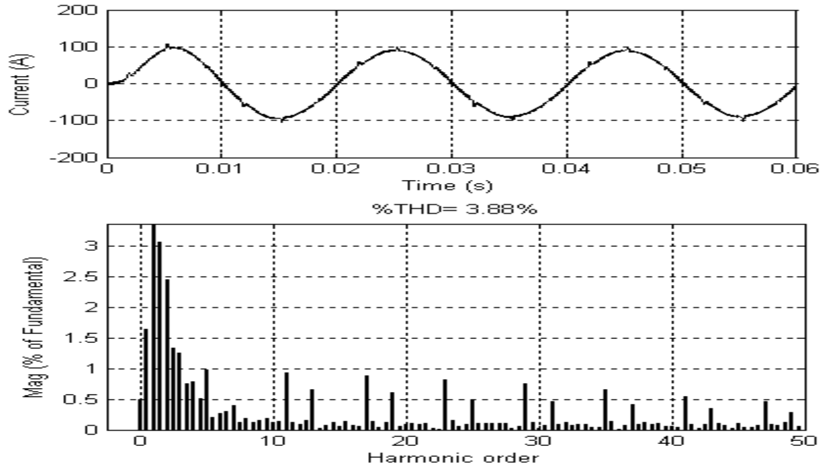

Figure12. Current waveform with active filter

The drive system with active filter is implemented in Matlab/Simulink and is shown in Figure. 11. The results with the insertion of shunt active filter show a substantial reduction in the current harmonic content. This will be a very useful scheme especially in industries where multiple induction motors of large capacity are frequently started from a 3-phase supply. Figure 12. Shows the current waveform of cooler fan-2 with active filter, from the waveform it is clear that the %THD is reduced to a great extent and it is also given in Table 2.

Table 2.comparison of %THD in current

	$\%THD_I$ Without filter	$\%THD_I$ With filter
Cooler fan-2	60.4%	3.38%

4. CONCLUSION

A case study has been carried out for harmonic analysis of electric drives in M/S Anajni Portland cement Ltd. Both voltage and current harmonics at supply side have been measured practically using fluke 434 power harmonic analyzer and results are presented. These investigations reveal that the harmonic content is more, particularly in cooler fan-2, %THD of current is very high i.e 60.4% because it is only the motor controlled by the variable frequency drive out of four cooler fans. In order to reduce the harmonic content, an active filter has been designed and simulated the cooler fan drive in Matlab/Simulink and result is tabulated in terms of %THD with and without filter. From the Table. 2, it is observed that the %THD of the current has been reduced significantly from 60.4% to 3.83%.

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