Environmental Potentials

Power Quality For The Digital Age

CASE STUDY: 800 TON PRESS MACHINE

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Summary: This case study is from Nakanishi Metal Works in Japan. The problems found in the facility are irregular performance of an 800 ton press machine. Some of the irregularities are: incorrect timing of press machine and failure of electric drives controlling the machine. This press machine is a large load and important load in the facility. Downtime and irregular performance of the press machine is very expensive. A Power Sight meter with a frequency analyzer was used to measure power readings at the 800 ton press machine. After analyzing the power readings, experienced EP engineering team suggested installing EP-2500, EP-2000 and EP-2700 units at the location.

After installing the EP units, the power measurements were taken again at the same location. The after readings show a significant reduction in the electrical noise, electrical losses and improved performance of the load. The energy consumption is reduced by 4.2%; the performance increased by 48% and drive failure is eliminated.

Device used for electric measurements: Power sight 4000 (PS 4000) is the power tool used to measure the electrical components. Advantage of viewing all three phases in a single shot with the help of PS4000 device helped engineering team to conclude what was expected as problem.

Readings:

Before EP Installation:

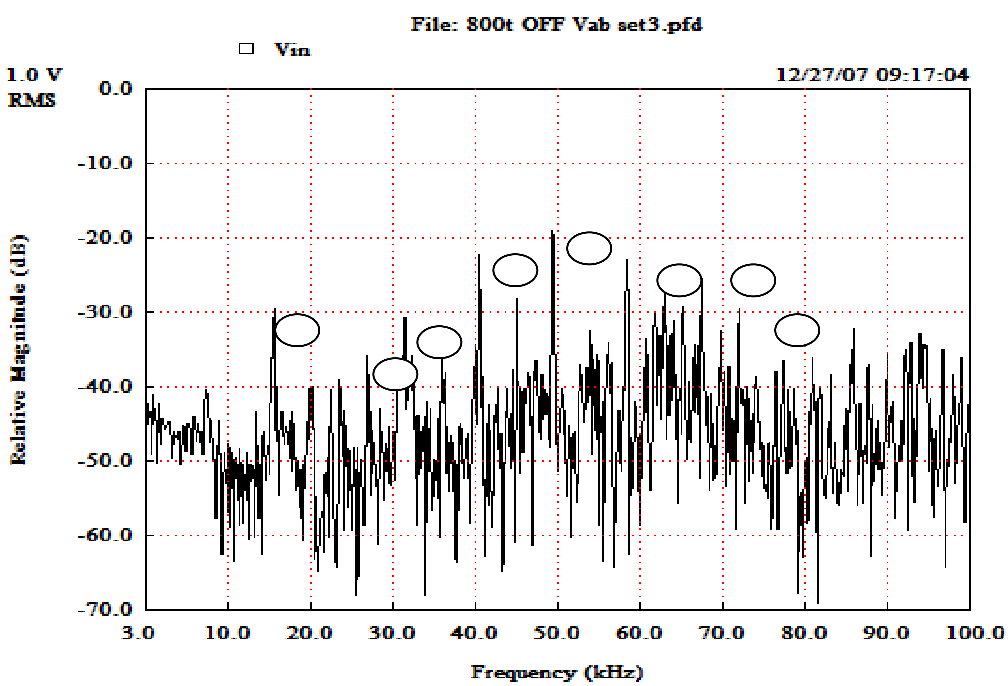

Figure 1

Explanation: Figure 1 shows the voltage HF noise at the load from 3-100kHz. The magnitude of the voltage frequency noise is large and is not typical in electrical system. Transients generated within the facility are the major cause of HF noise. Nonlinear loads constitute major part of any electrical system and also the major cause of polluting the power quality by releasing HF noise to the rest of the electrical system. This facility is equipped with numerous amount of nonlinear loads such as electronic ballasts, electrical speed controlled drives, servers and computers.

In this particular case, voltage HF noise is extremely high at 50kHz frequency and is about -20dB. Additional reactance in the electrical system is a cause of frequency noise. Inductance in the wire is not concentrated at one point but is distributed. When the inductive reactance of the wire is equal to the capacitive reactance between the walls of the wire electromagnetic resonance will take place. Generated resonance will cause amplification of the signal and is a function of frequency. This is the reason why peaks are shown at regular intervals on frequency noise graph.

Problems expected: Electrical losses such as ohmic losses, core losses, magnetic losses, imbalance in load distribution and heat in the system.

Solution: Additional reactance in the system must be removed in order to decrease the frequency noise in the system. Electrical filter which is capable of removing frequency noise starting from 3kHz is required.

After EP Installation:

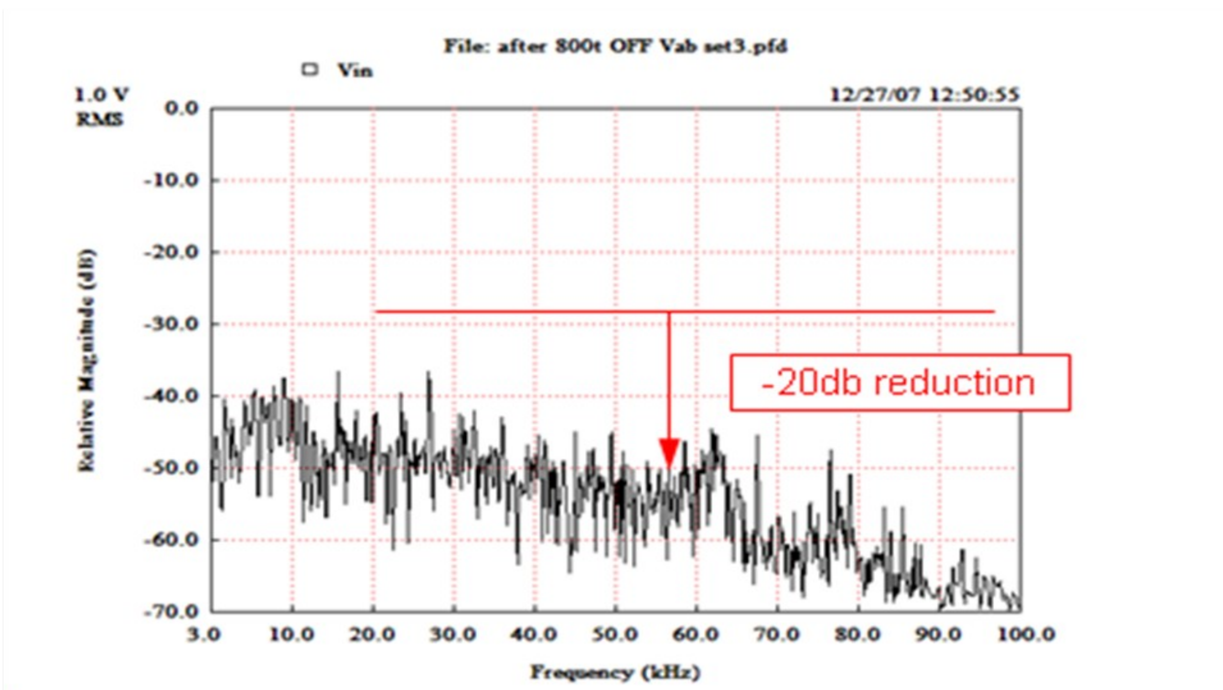

Figure 2

Explanation: Figure 2 shows the levels of frequency noise immediately after EP installation. At 50kHz voltage frequency noise is measured to be -50dB, which is -30dB reduction compared to the before readings. This is significant reduction in the frequency noise.

Current Waveforms:

Before EP Installation:

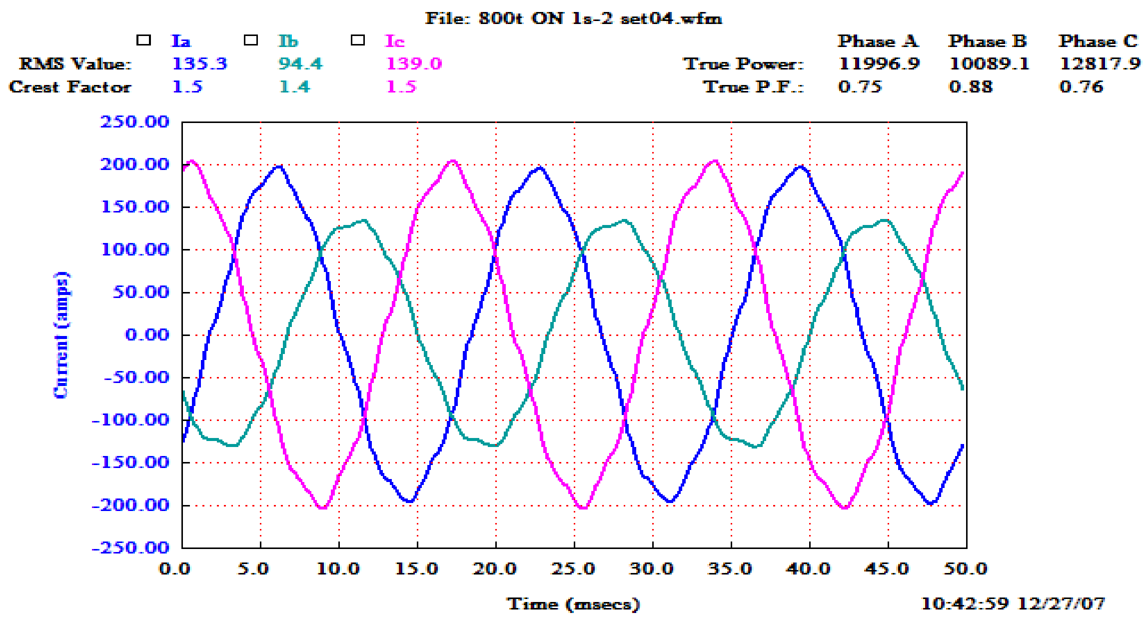

Figure 3

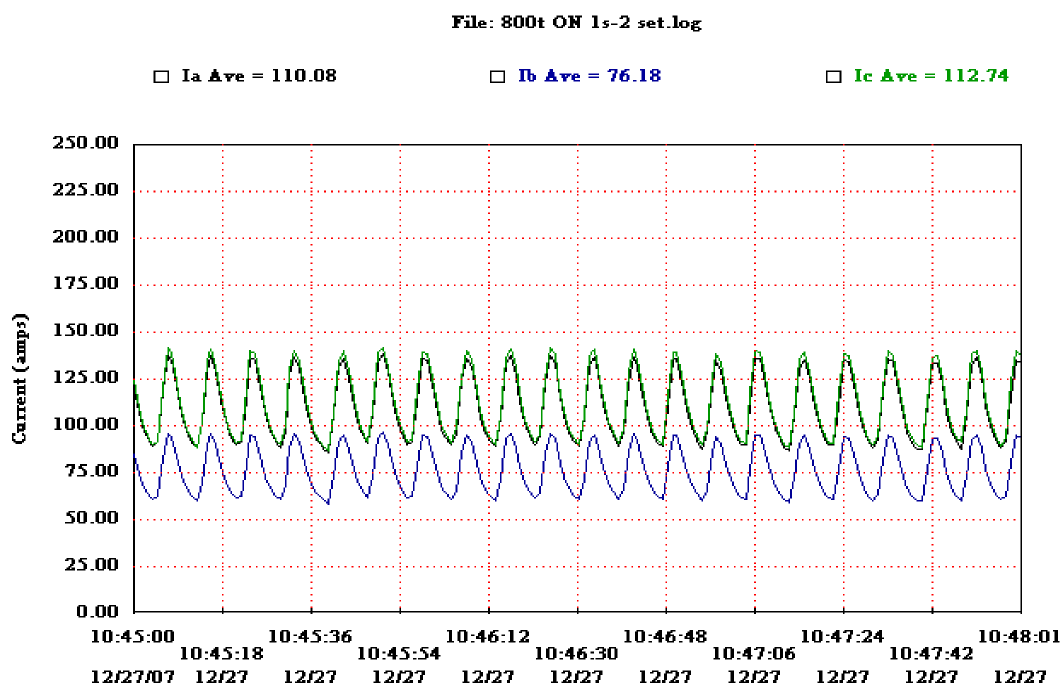

Figure 4

Explanation: Current magnitudes on the three phases are not balanced. Phase B is low in magnitude when compared to phase A or Phase C. The crest factor is 1.5 for two phases, it should be 1.4 for an ideal sinusoidal waveform. Increase in the crest factor is due to the high peak currents (which are due to frequency noise generated by nonlinear loads). Kirchoff's law states the phases should be equal in magnitude in a three phase system. Due to increase of inductive reactance on the wire, skin effect and proximity effect prevails. Proximity effect causes sharing of electrical and magnetic fields between the phases of a system. Sharing of fields is against electrical rules and can cause improper load distribution. For any electrical load to be operated at maximum performance and efficient, all of its phases have to be equally balanced. Proximity effect is directly proportional to reactance of the system with the frequency.

When the phases are not balanced, magnetic field on the stator windings of the 800 ton machine are improperly distributed both on phase and magnitude. Stator winding associated with phase B turns the rotor at slow speed compared to stator windings associated with phase A and C. This will lead to ineffective field coupling between stator and rotor causing less slip efficiency. Bearing currents are also generated due to the common mode noise generated due to improper filed distribution.

Imbalance in the load distribution will cause motor to behave erratically, causing core losses and slip losses. Performance and efficiency of the motor is significantly affected by imbalance in the load distribution.

Small notches on the current are visible and are a consequence of frequency noise and transients. Notch width is directly proportional to the reactance in the electrical system. There is a proportional relationship between reactance and the width of the notch; an increase of reactance in the system equals an increase in the width of the notch. For a perfect sinusoidal wave, the notch width should be zero and this can only be achieved by removing additional reactance in the system.

Solution: Load has to be balanced on all the three phases by removing additional reactance which is the primary cause of proximity effect.

1 Month After Installation:

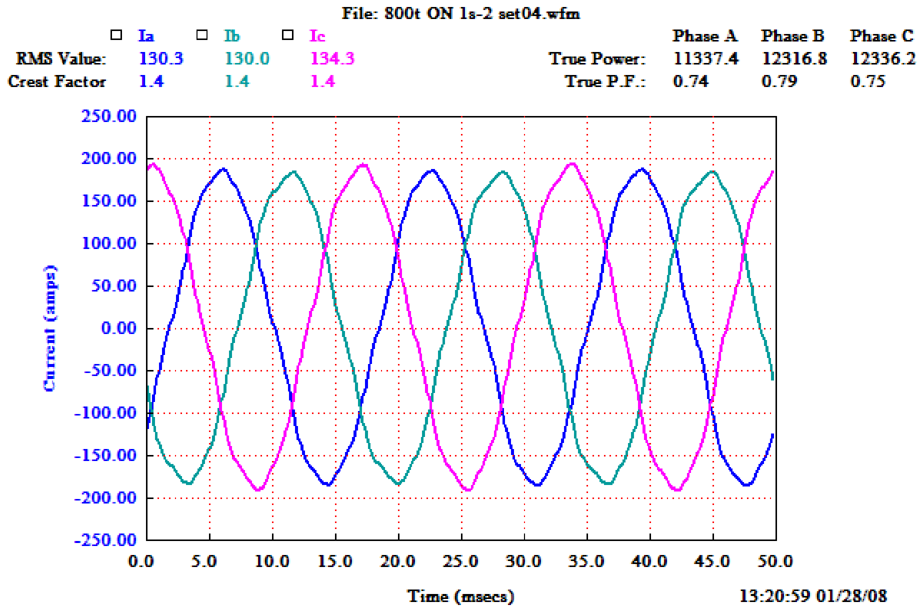

Figure 5

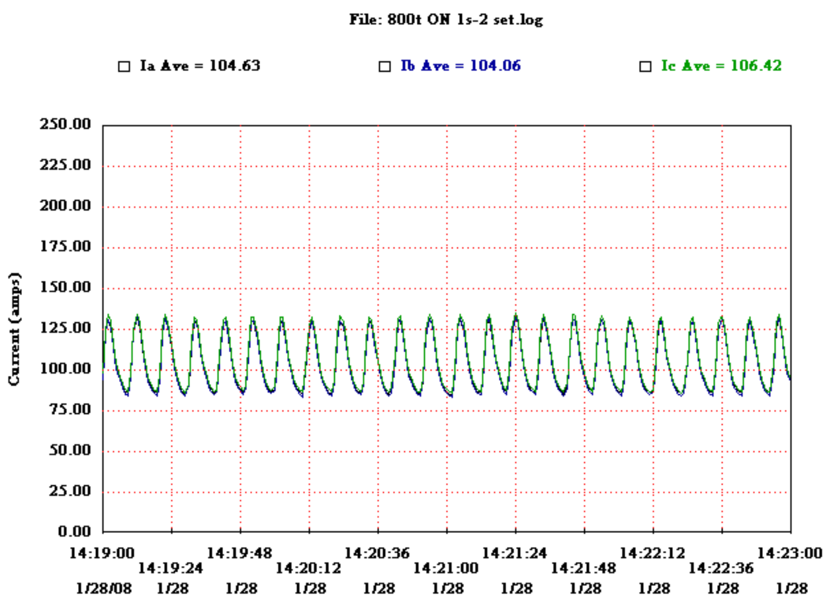

Figure 6

Explanation: After EP installation the magnitudes of currents are balanced. EP removed the additional reactance in the electrical system and corrected the crest factor to 1.4. Correction of crest factor is explained by the removal of frequency noise from the system. This reduces proximity effect and balances currents.

Current Log Scale Close-up:

Before EP Installation:

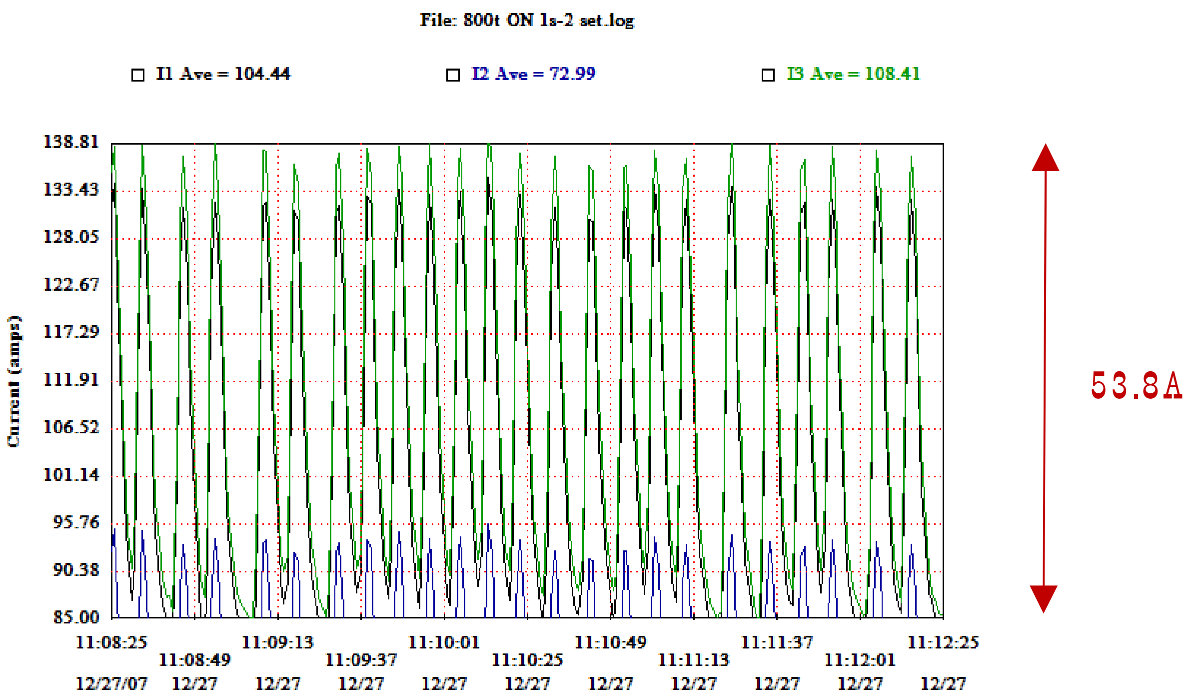

Figure 7

Explanation: Imbalance in the current distribution is observed due to proximity effect.

1 Month After EP Installation:

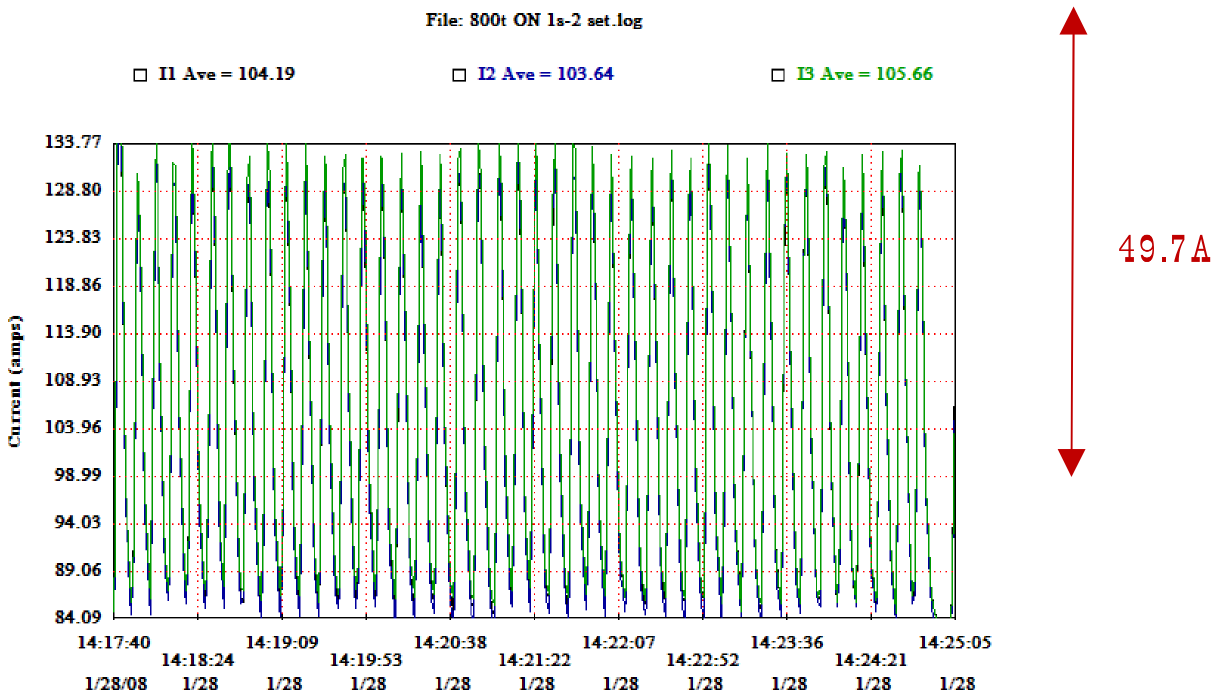

Figure 8

3 Months After EP installation:

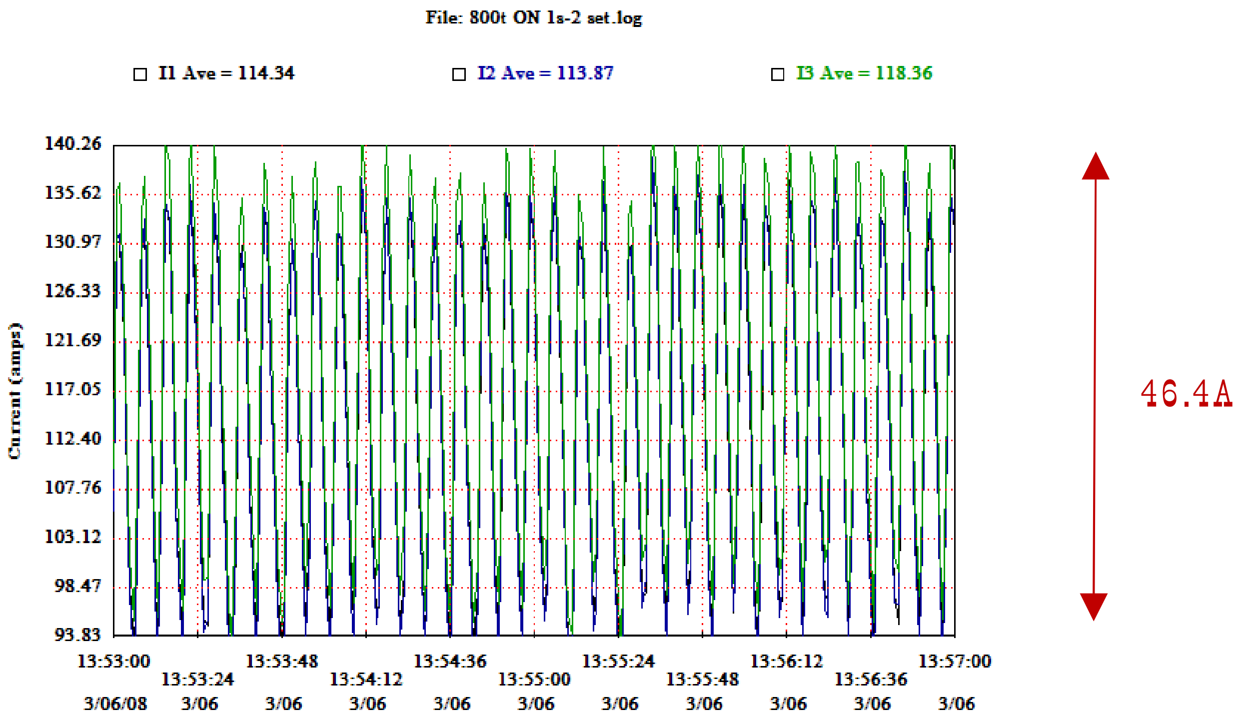

Figure 9

Explanation: A significant reduction in the maximum value of the current is observed after installing the EP units. This is the direct measure of crest factor. A 13.75% reduction in current magnitude is seen, this means that the heat losses are reduced by more than 28%.

Productivity: This 800 ton press load operates in a 4 min cycle. Prior to installing EP units there were 23.5 presses measured in 4 min cycle or approximately 5.88 presses per minute. After installing EP units the number of presses per 4 minute cycle increased to 35, or approximately 8.75 presses per a minute, this is more than a 48 % increase in presses. This significant increase in the production is due to increase of the motor efficiency when the imbalance in it is improved.

Conclusion: This study focuses on an 800 ton press at NKC. Power readings were taken before EP installation, after 1 and 2 months of installation. Significant reduction in frequency noise ranging from 3-100kHz is observed. Voltage and current waveforms are well balanced after installing the EP units. Crest factor of the waveforms are corrected to 1.4. Peak magnitude of currents reduced by 13.75% and this translates into a 28% reduction in heat losses. Good power quality is maintained by EP system after removing the proximity effect in the system. Productivity is increased by 48.8%.