Reduce Product Defects Using Power Quality Correction:

A Case Study from Commercial Manufacturing

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Synopsis

Our customer had an unidentified issue with machine faults producing high levels of scrap.

After installing the power quality filters, an immediate improvement was noticed by the operators. Prior to installing the filter, there were 180-240 pieces of scrap per hour or 16% scrap. With the filter, approximately 10 pieces of product were defective in an hour of operation - a scrap rate of 0.7%. This is a drop in the defect rate by a factor greater than 20.

With the power quality improvements, this manufacturer could sell an additional 170-230 products per hour – a 12-15% improvement in output. An additional benefit is less distraction by the welders watching for defects, allowing them to focus on their jobs on the production line.

This paper will explain the identification, analysis, and solution implemented. The appendix provides more technical, detailed evidence of the power quality before and after the equipment installation for those interested in more detail.

Introduction

In today's competitive manufacturing environment, the amount of scrapped product impacts not only the profitability of the manufacturer but also cost of the product on the market.

Over the last few decades, automation has been introduced into the manufacturing process. Automation was to resolve the inconsistencies in the manufacturing process and produce a consistent product. However, there are instances where the exact opposite has happened.

In the following case you will see how an excellent new process was undermined by poor power quality.

Background

Most automation processes use solid state technology, which is based on static power conversion. This automated equipment utilizes switch mode power supplies, found in equipment such as PLCs, VSDs, VFDs, robotics, LED lighting, CPUs, etc. All these devices distort the AC sinewave, creating harmonics and dirty power.[1] Where this really becomes a problem is when a number of these devices are operated on the same production line or in the same process.

To explain this issue, it is important to understand that these loads are non-linear.

Automated processes use solid state technology and switch mode power supplies. These solid-state devices typically draw electric current in 'spurts or pulses' rather than in linear draw. This distorts the sine-wave and impacts the electrical power system within the whole facility. As more equipment is added in the process, the complexity increases.

Because the solid state devices play such an integral role in automation, their impact on the power system affects the reliable performances of other equipment that depend on good power quality.

Equipment reliability translates to a quality product.

The most common areas for these kinds of problems are in welding operations, but definitely are not limited to welding. It is all too common to hear of mis-indexing[2] problems in robots, especially where resistive welding is part of the process.

[1] Static conversion is the main problem. All devices that switch AC to DC are considered static conversion, and create harmonics. PLCs, drives, arc and resistance welding, arc furnaces.

[2] Mis-indexing is when a robot does not orient itself properly. It could be caused by poor power quality.

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Problem Identification – Robots in the Welding Process

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The welders involved are 2.2 kVA high frequency welders. These welders replaced part of the welding department where the welding was previously done with a gas flame welder and each individual part inserted manually. Each welding station utilized two people to insert the raw parts to be welded by hand. This operation had a product output of about 6-7 pieces a minute.

To improve the efficiency of this process, a new high frequency automated welder was introduced to replace the manual method. The high frequency induction welder was much faster producing about 25-30 pieces per minute and could run virtually unsupervised until the discovery of the rather large scrap rate. Three out of ten pieces, or 33%, were defective and had to be scrapped. It also required a person to check each individual piece manually.

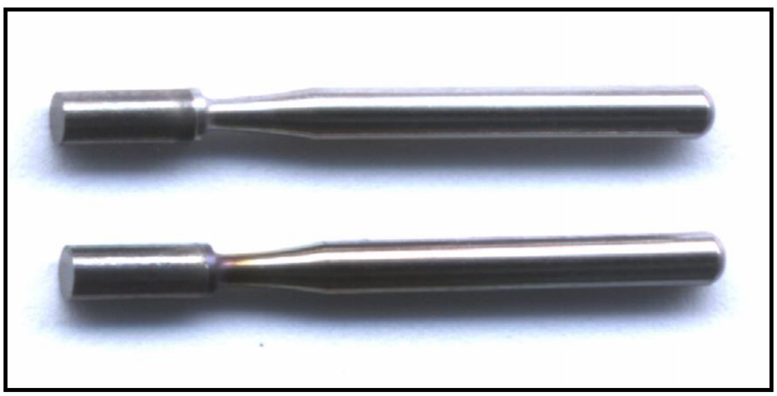

Figure 1: Bad Welds

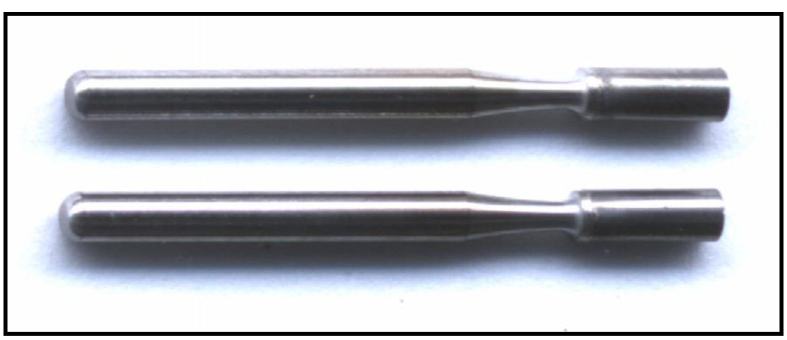

Figure 2: Good Welds

Numerous modifications were done on the new welders including changing the configuration of the welders from single phase to three phase. The changes had little or no impact at all. More welders were added to the same point of common coupling and the situation deteriorated even more.

This scrap rate was the problem the manufacturer struggled with for about four years. So, in essence the manufacturer had reduced labour costs with the automation, but had done so at a cost of higher scrap rates.

Cos Phi Solution

Cos Phi was consulted to provide an analysis of the power quality on the production line. Our analysis found that major problems were occurring when welding cycles coincided as when two or more welders fired coincidentally at the same time. The more welders were connected to the distribution panel, the more frequent were the coincidences.

This problem could not be resolved by interlocking the welder without significant loss of production.

Every time the welder fired the inrush current was causing a voltage drop on the source which in turn would deplete the power to the next welder at random.

Adjusting the heat bias was no answer because the next weld would be overheated (See Figure 3 and compare to Figure 4). Since the welding area distribution panel was dedicated only to the welders it gave us the possibility of mitigating the problem for all the welders from one central location with one filter. The sine-waves were studied for their characteristics and duration in order to choose the appropriate mitigation device.

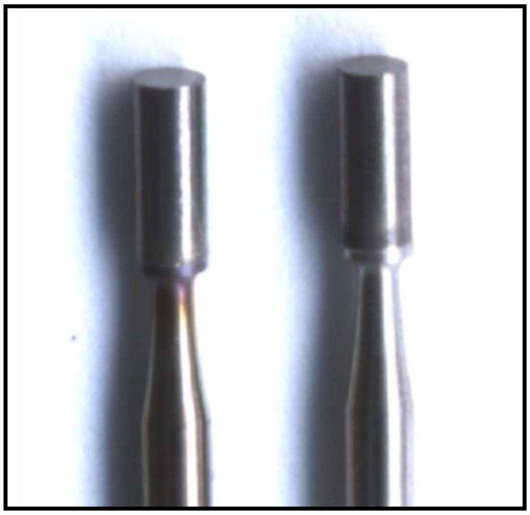

Figure 3: Left component is over heated; Right component is under heated

The decision was to install a 50 Amp Aim Active Filter that would accommodate 50 Amp of distorted current. Even though a 25 Amp unit would have sufficed, the cost difference was not enough to go with the smaller unit and if the mitigation was successful more welders could be added.

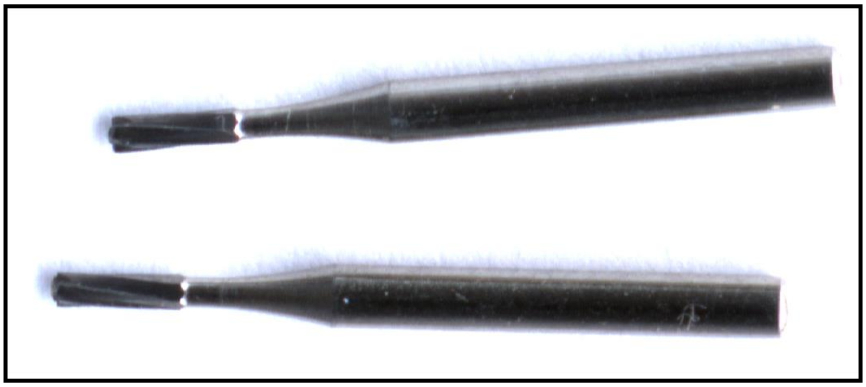

Figure 4: Finished Products

Upon firing up the Aim filter, an immediate improvement was noticed by the operators. Prior to installing the filter, there were 180-240 pieces of scrap per hour or 16% scrap. With the filter, approximately 10 pieces of product were defective in an hour of operation - a scrap rate of 0.7%. These failures were attributed to other causes such as improper positioning of the product.

This case study demonstrates the significant bottomline impact in reducing defect rates. With the power quality improvements, this manufacturer could sell an additional 170-230 products per hour – a 12-15% output improvement.

Appendix

Detailed Analysis of the Power Quality Correction

Looking at the problem from the point of view of power quality and examining the sine-waves with the filter ON and OFF, it is obvious that the power quality had a significant impact on the quality of the product.

If you observe Phase A (Figure 1) and Phase B (Figure 3) and Phase C (Figure 5), all when the filter was OFF, it is evident that the voltage distortion occurred only if two or more welders were firing at the same time. Then observe Phases A, B, and C (Figures 2,4, and 6) with the filter ON and the sine-waves are virtually undistorted.

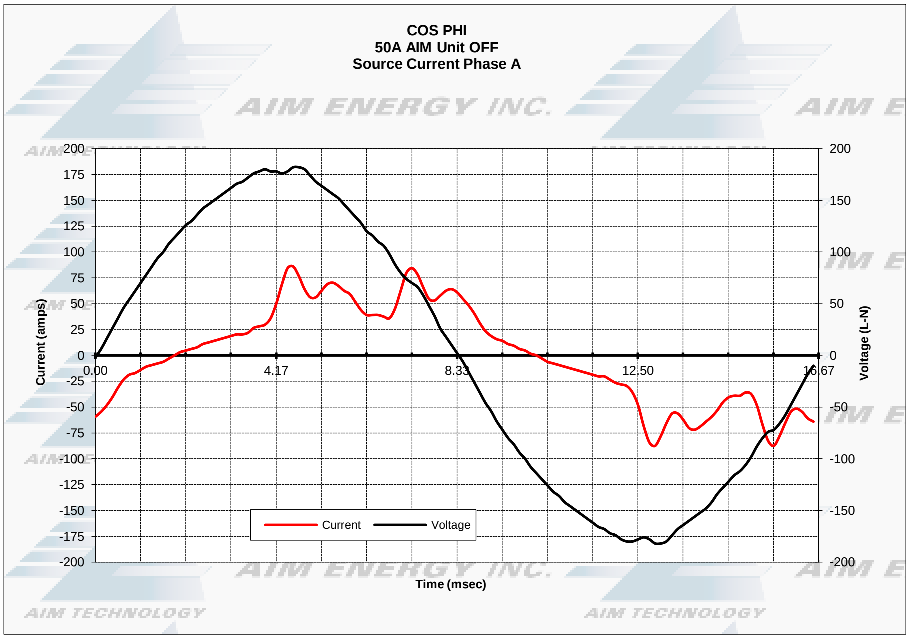

Figure 1: Filter OFF

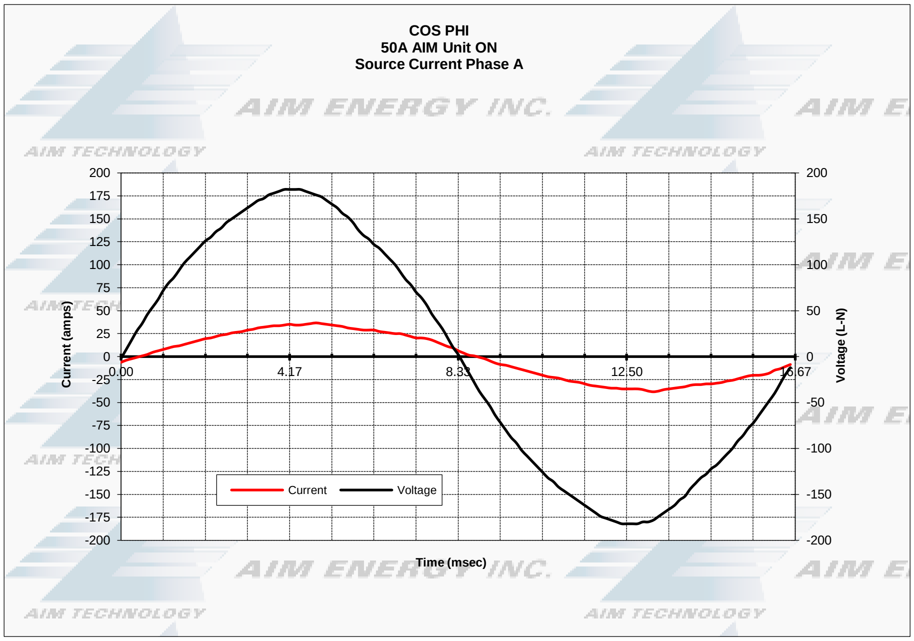

Figure 2: Filter ON

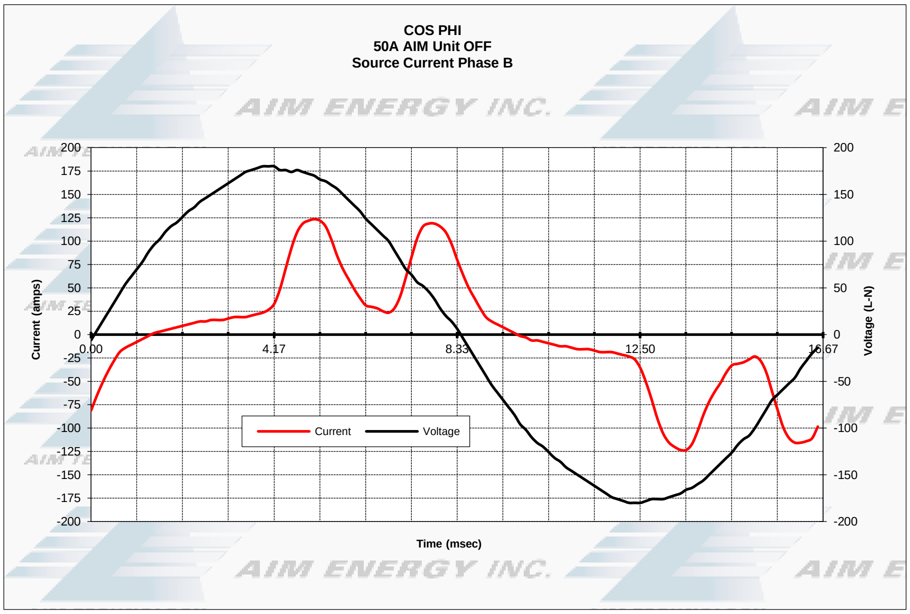

Figure 3: Filter OFF

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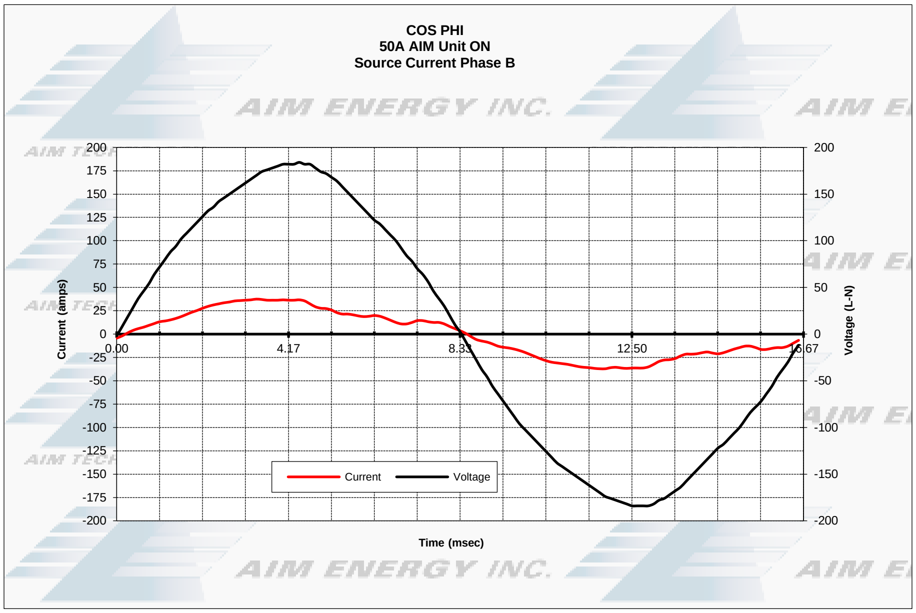

Figure 4: Filter ON

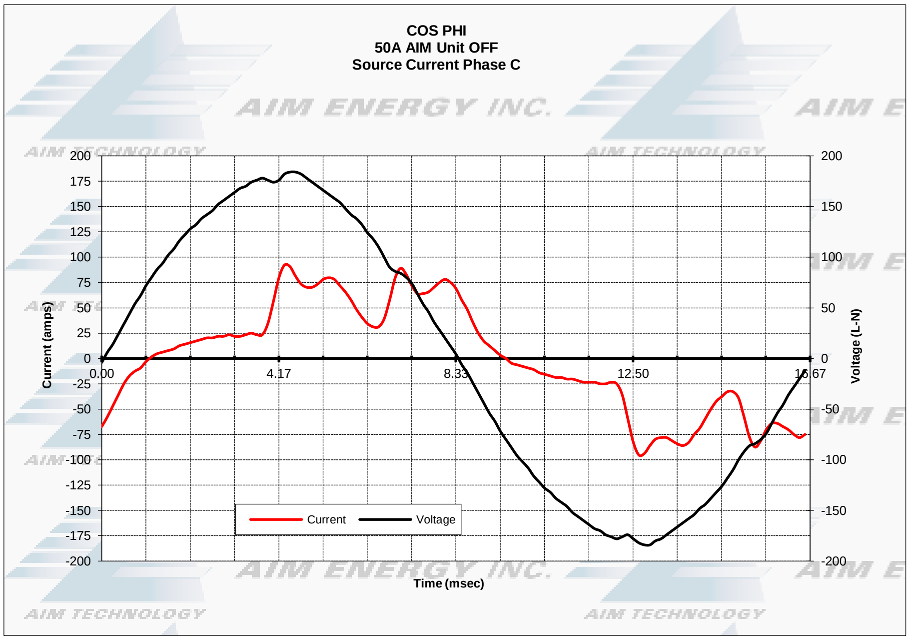

Figure 5: Filter OFF

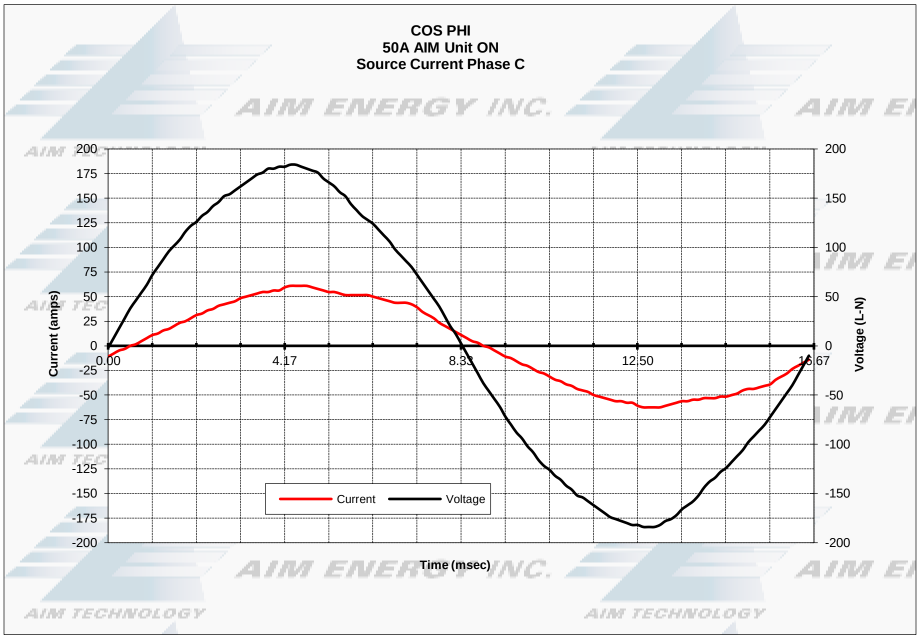

Figure 6: Filter ON