Case Study:
Automated Metal Stamping

In this document:

Overview

A large automotive metal stamping plant in the United Kingdom (UK) processes thousands of tons of sheet metal each year to supply door and side panels, hoods, and chassis parts to its manufacturing and assembly plants throughout Europe. The stamping plant consists of 8 automated transfer press lines and associated machinery such as conveyers, handling machines and scrap process. Each press line stamps components for a different vehicle model and has its own dedicated supply transformer operating at 415v 50Hz.

Typical Automotive Stamping Line

Stamping machines generate high levels of active (kW) and reactive power (kVAr) consumption during their normal sequence of operation. The power consumption is dictated by three main variables; the downward pressure that needs to be applied to the sheet metal being processed, the grade (thickness) of the steel, and the upward pressure required to release the stamping die from the block. When there are multiple press lines operating in the same locale, serious disturbances on the electrical network can be caused that affect other manufacturing processes within the plant. Further, these disturbances may impact other consumers that are sharing the same local electrical distribution infrastructure.

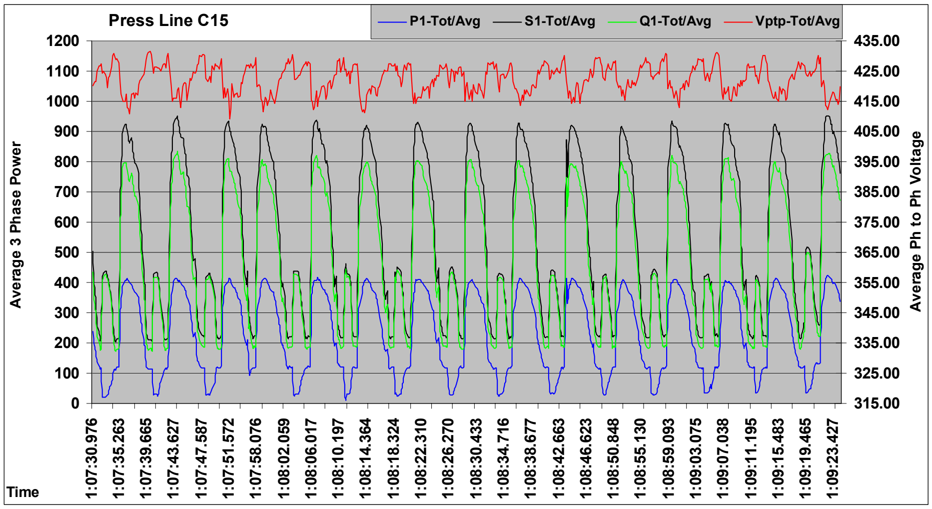
In this particular installation, the supply transformers were under stress, as continuous and simultaneous operation of all press lines was resulting in high reactive power (kVAr) and apparent power (kVA) consumption. This continuous large power consumption was leading to transformer overloads and over-heating. The presence of harmonic distortion contributed to further heating, and meant that some transformers were operating above 100 degrees centigrade (212° F). This case study presents before and after measurements of one press line from this installation which has an Elspec EQUALIZER dynamic power compensation system rated at 785kVAr. This EQUALIZER system is tuned to filter 5^{th} order harmonics, and is connected directly to the press line's supply transformer, operating at 3-phase 415V, 50Hz.

Transfer Press Line Load Profile

The Press line idles at a very low load level, <10kW per phase, however when the stamping process begins the power levels fluctuate dramatically. Typically the load increases from less than 10kW per phase to 400kW to 420kW per phase within 3 to 4 cycles, *(60 - 80ms @ 50Hz, 50 - 67ms @ 60Hz)*, and that peak consumption is then maintained for 4 to 5 seconds. The dynamic load fluctuations re-occur continuously every 7 to 8 seconds during a normal stamping run.

Figure 1 on the following page is a 2-minute sample that graphically depicts a typical power profile of a normal batch process on the press line. The graph demonstrates that power consumption fluctuates dynamically, with reactive power (kVAr) varying by as much as 650kVAr each stamping cycle. Ultimately, these reactive power fluctuations result in unacceptable degrees of voltage modulation (sag) and high energy consumption. Eliminating or reducing these reactive power demand peaks is essential if voltage stability is to be attained.

Figure 1 – Press Power Profile (2 min)

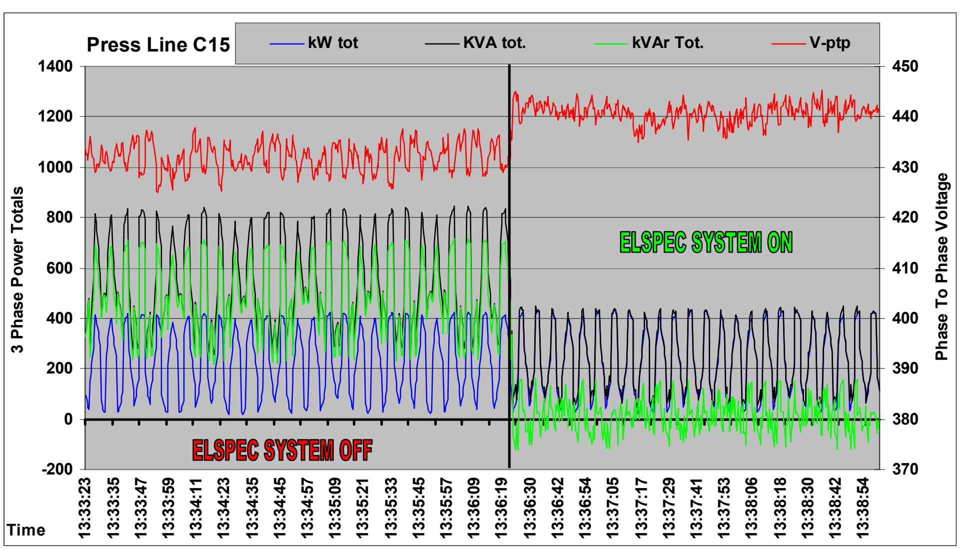


The EQUALIZER Dynamic Compensation System

The Elspec EQUALIZER system is specifically designed to compensate for this type of dynamic load with high reactive power consumption. Using electronic switches (SCR/SCR) and sophisticated control algorithms that consider True Power Factor (PF) while taking into consideration all harmonics up to and including the 63rd harmonic order, it calculates and responds to reactive energy demand (kVAr) within less than 1 network cycle *(<20ms @ 50Hz, <16.7ms @ 60Hz)*. In this instance, a system rated at 785 kVAr was installed directly at the press line transformer. The system consists of 6 x 131kVAr capacitor groups tuned to the 4.7th harmonic to reduce the impact of the 5th harmonic during the peak demand.

As Figure 2 demonstrates, the introduction of the Elspec system has a dramatic effect on the power consumption recorded at the press line supply transformer. Apparent power (kVA) consumption is reduced by nearly 50%, indicating the effectiveness of Elspec's EQUALIZER system in reducing the peak reactive power demand. The average 3 phase voltage (ptp) also shows an improvement of +2.5%.

Figure 2 – Before & After Results



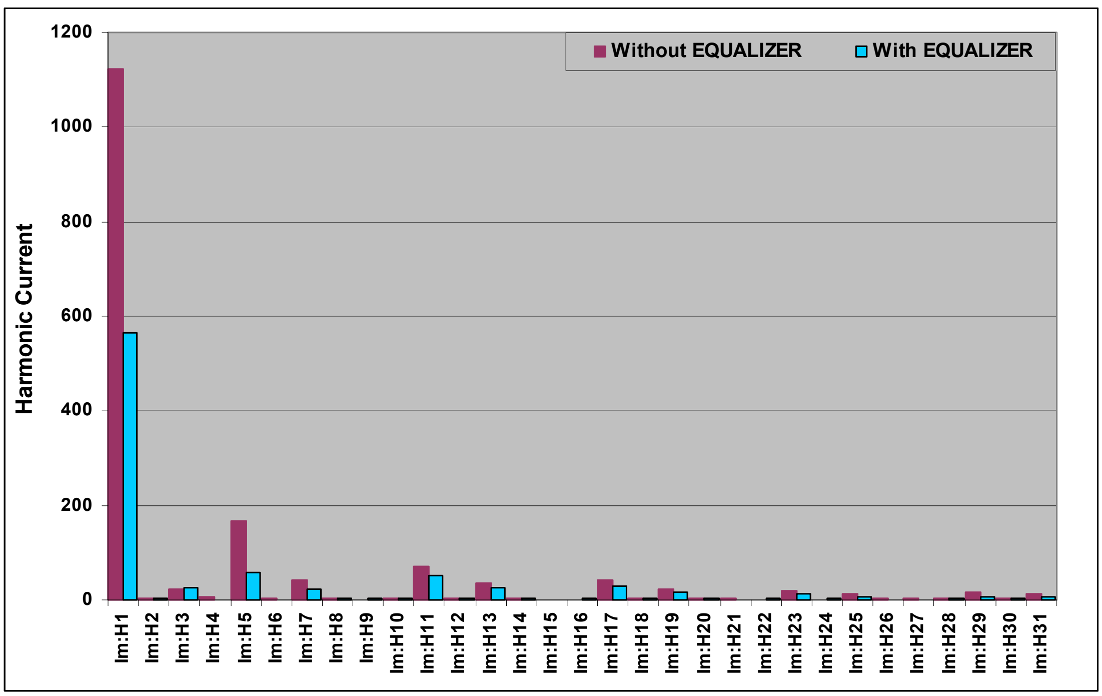
Harmonic Mitigation

The press line's speed and process controls generate relatively high levels of harmonic current distortion. This harmonic distortion is a major contributory factor to the supply transformer's high operating temperatures. Although the main contributing harmonic is the 5^{th} (H5), the overload of the supply transformer results in the amplification of all harmonics recorded, up to and including the 31^{st} order.

The following table, Figure 3, illustrates the measured harmonic spectrum recorded during peak load conditions both before and after the Elspec EQUALIZER was installed. It is clearly evident that harmonic currents are present at nearly every harmonic frequency up to and including the 31^{st} order, although the intensity at higher orders is lower in comparison.

When all harmonic currents are taken into account in conjunction with the fundamental current, these press lines have a low power factor. This means there is significantly more current flowing in the stamping plant's power system than is required to 'get the job done.' This increased current can also lead to higher cabling losses per kilowatt of connected load.

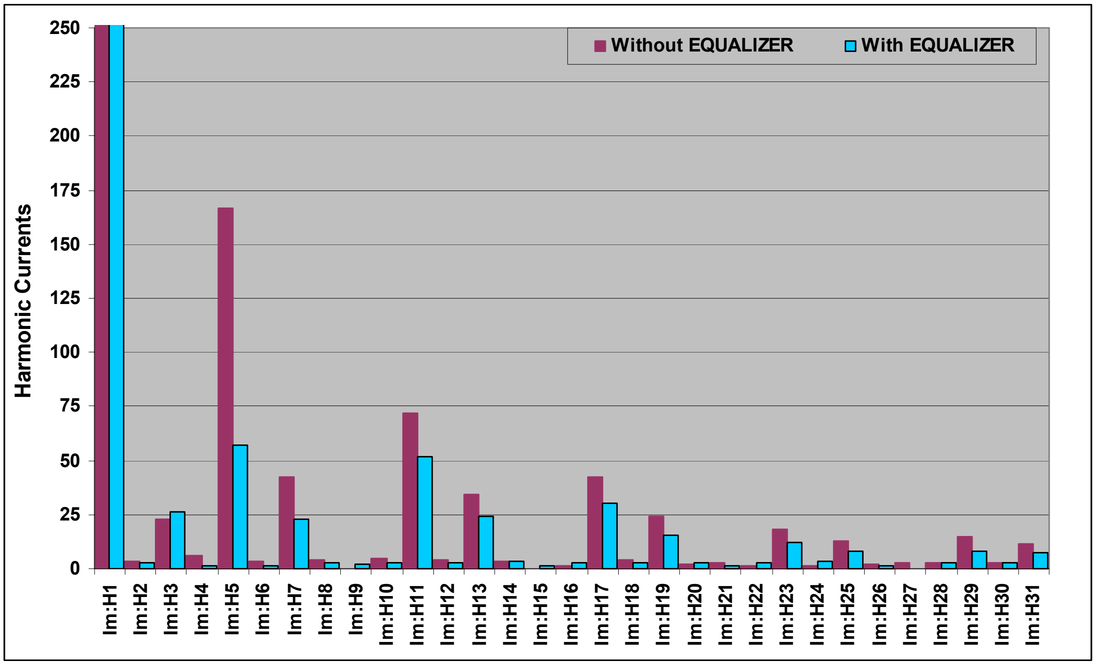
Figure 3 – Harmonic Current Reduction



It is evident that the Elspec EQUALIZER has been successful at reducing the harmonic impact of not only the targeted 5^{th} harmonic current, but also has effectively lowered the harmonic current on each harmonic order. Figure 4 on the following page features a zoomed view of Figure 3. It offers a much clearer picture of the degree of harmonic mitigation achieved during the press line's peak operating conditions.

As Figure 4 shows, all significant positive and negative sequence harmonic currents have been mitigated when the Elspec EQUALIZER system is operating. The fifth harmonic (H5), potentially the most damaging, has been reduced from 167A to only 55A *(nearly 70% reduction)*.

Figure 4 – Harmonic Current Reduction (ZOOM-IN)



Performance of the EQUALIZER / Overall Installation Results:

Metal stamping plants throughout the world are realizing the benefits of real-time reactive power compensation. By installing Elspec's EQUALIZER system, these facilities have improved voltage stability, lowered maintenance costs, increased service utilization of their transformers, achieved harmonic current reductions, decreased power system losses and reduced or eliminated power factor penalties.

This installation of an Elspec EQUALIZER system yielded the following specific performance results:

- *Load current on each press line is **reduced nearly 50%** (from 1150A to < 570A)*
- *Average voltage on each transformer was **raised by approximately 2.5%** (10V)*
- *Reactive power **(kVAr) consumption significantly reduced** from 245kVAr per phase to < 50kVAr, improving power factor to an average of >0.95*
- *Maximum Apparent power (kVA) **demand lowered by over 45%** (from 840kVA to < 450kVA)*
- *Due to increased voltage, taps were reduced yielding a billed **kWh consumption savings***
- ***Increased transformer utilization** (more load could be added)*
- *Reduced operating temperature of transformers and plant electrical system **(lower losses)***
- ***Lower total energy costs***
- *Electrical-related **downtime was reduced***

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