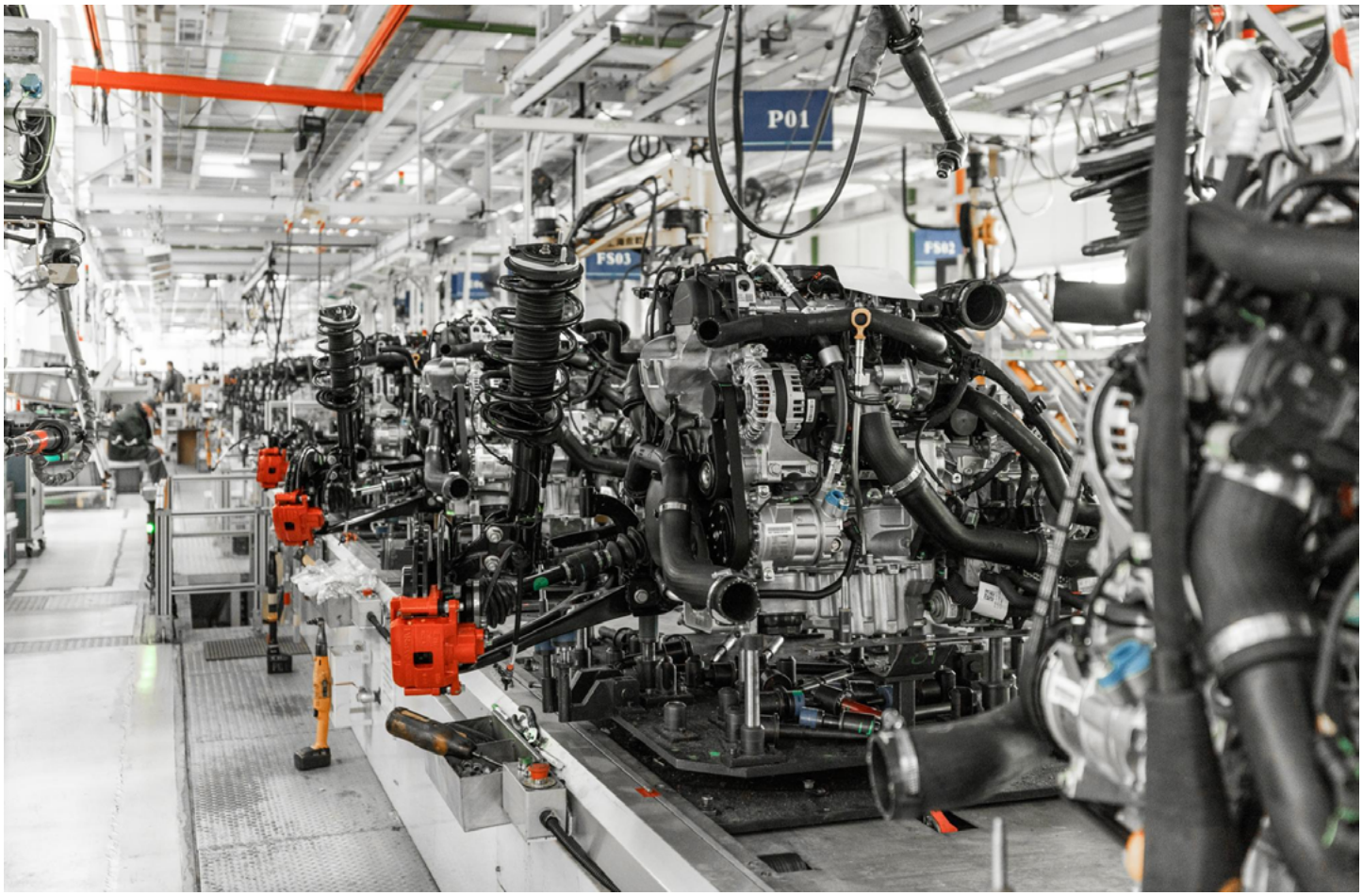
Case Study

How to Improve Power Quality in Automotive Welding Systems



Customer Situation

At a major automotive manufacturing facility in Mexico, welding plays a central role in assembling vehicle bodies. The high-speed welding lines operate using single-phase arc welding machines, each drawing intense, unbalanced currents at temperatures reaching up to 4000°C.

The Challenge

Despite having a 6MVAR medium-voltage capacitor bank installed at 13.2kV, the plant struggled to maintain the required power factor of 0.95, as stipulated by Mexico's national grid code. Instead, the compensation system was triggering resonance with harmonics from non-linear loads, resulting in power quality violations across the facility.

Measurements showed voltage drops down to 435V during welding cycles, reactive power demand spiking to 1.2MVAr, and current harmonic distortion (THDi) reaching as high as 80%. Voltage harmonic distortion (THDv) also surpassed the 5% threshold defined by IEEE-519.

In addition, flicker levels (Pst and Plt) exceeded code limits, and real-time monitoring revealed peak currents reaching 2,500 A, along with a drastically low power factor of 0.2 at times.

Power Quality Analysis

To thoroughly analyze the disturbances, Elspec's local agent, Kotkoff, used the PureBB, Elspec's Class A power quality analyzer (IEC 61000-4-30 compliant) with continuous waveform recording. This allowed for high resolution of waveform visualization in real-time which was crucial due to the high-speed nature of the welding process. The extra ability of this analyzer to record and store all this data was also crucial for data analysis to be able to recommend the right power quality solution.

Key Findings

- Voltage sags down to 435V during active welding.
- Reactive power demand reached 1.2MVAr (three-phase).
- High harmonic content: THDi up to 80%, THDv above 5%.
- Unbalanced phase loads and high flicker values (Pst and Plt).
- Peak instantaneous currents: 2,500A.
- Third harmonic (Ah3): ~500A; Fifth harmonic (Ah5): ~180A.

Solution

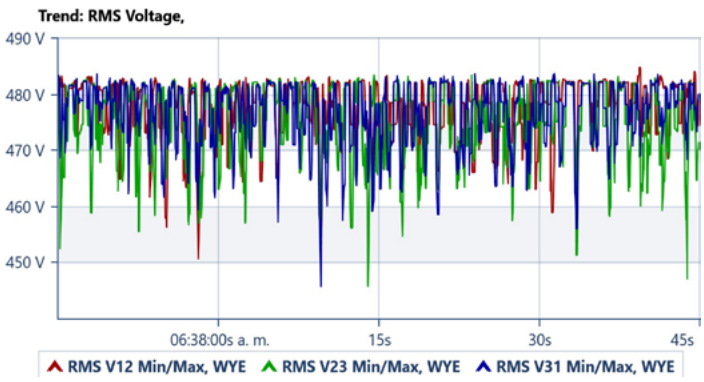
Elspec's Equalizer Unbalanced system was installed to address the site's dynamic and highly unbalanced load conditions. The Equalizer Unbalanced is a real-time, high-performance power quality solution specifically designed for non-typical loads where each phase may differ by 30% or more. This all-in-one system compensates each phase individually with high accuracy, managing reactive power, mitigating voltage drops, filtering harmonics, and reducing flicker and voltage fluctuations. The installed system delivered 1,140kVAr at 480V, utilized 14% detuned reactors, and was directly connected to the main switchboard supplying the welding process. Its ultra-fast response time of just half a cycle ensures seamless and dynamic power quality correction in real time, enhancing machine reliability and improving production quality.

The system was integrated directly into the main switchboard of the welding line substation, ensuring localized correction where disturbances originated.

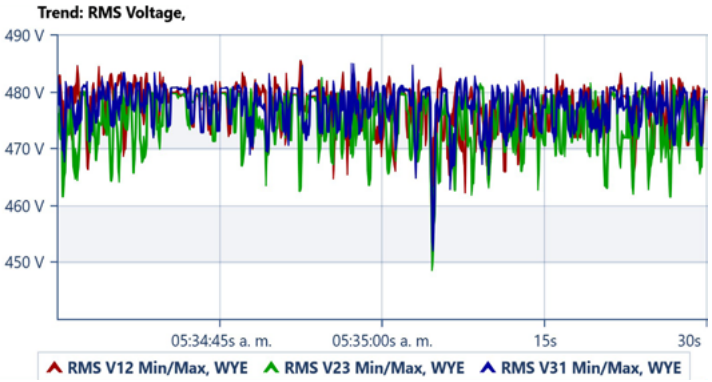
Results

After implementation, a comparative analysis showed remarkable improvements:
Voltage Vrms remained stable, reducing deep sags amount significantly.

Without EQ Unbalanced:

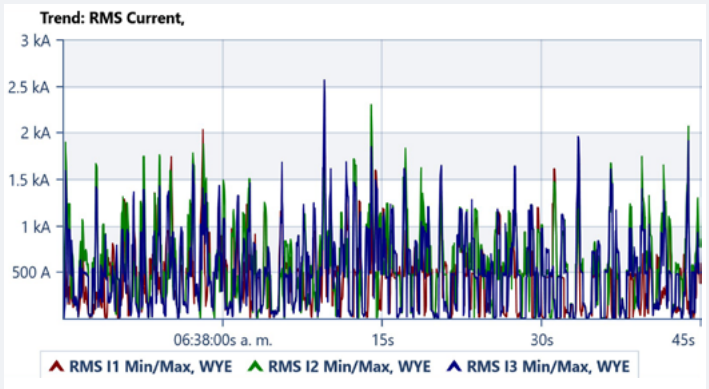


With EQ Unbalanced:

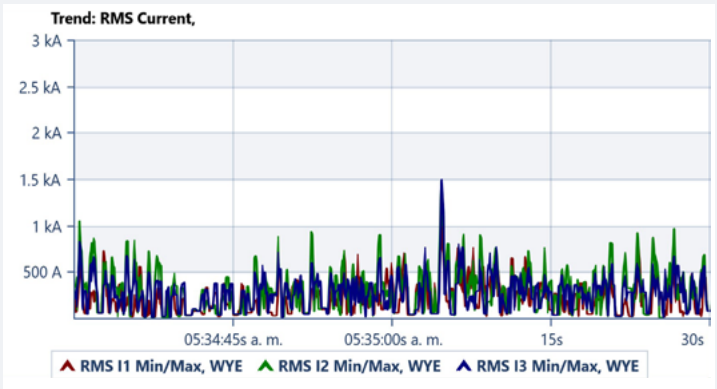


Current levels decreased significantly to around 500A.

Without EQ Unbalanced:

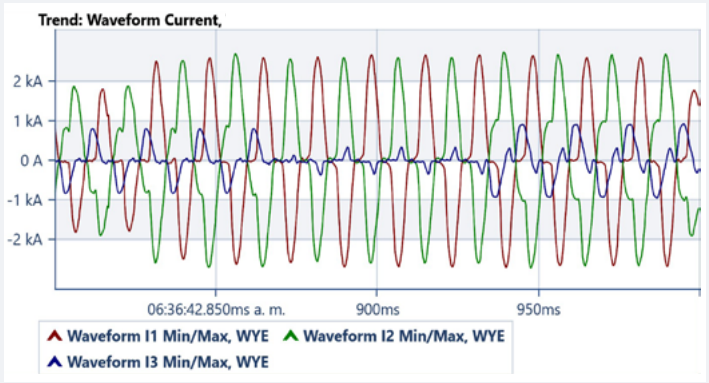


With EQ Unbalanced:

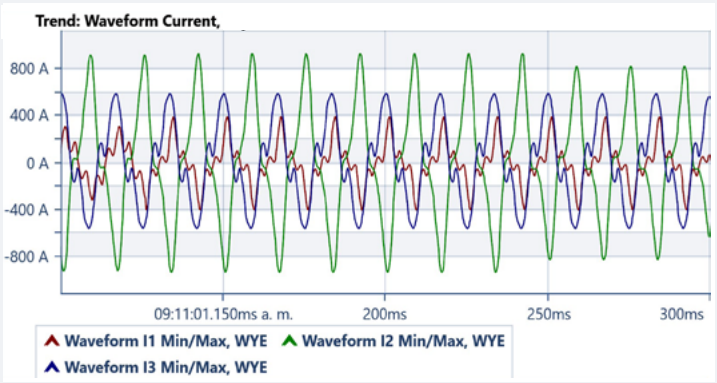


The waveform shows significantly lower peak currents compared to before the implementation; additionally, the current appears more balanced.

Without EQ Unbalanced:

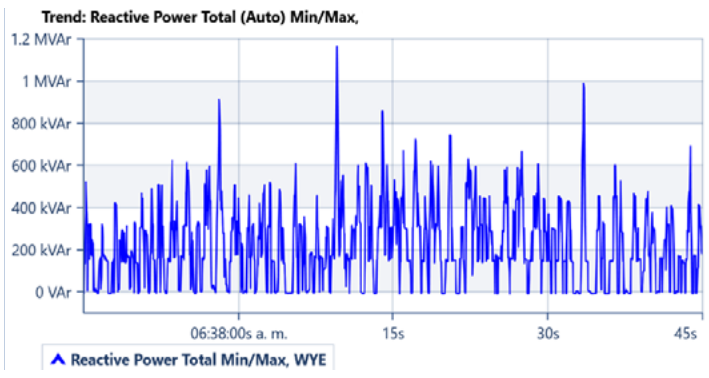


With EQ Unbalanced:

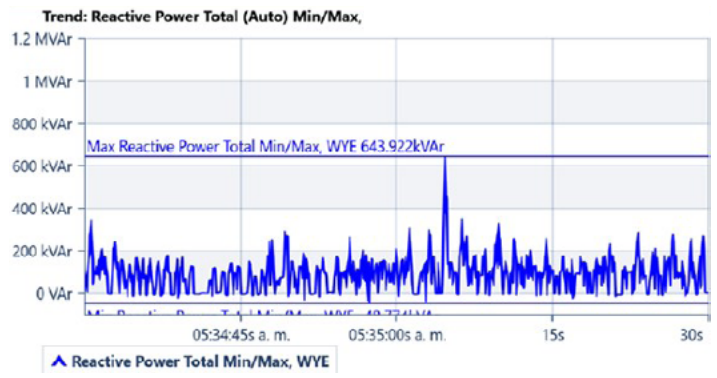


Reactive Power demand was reduced with the implementation of the system, lowering the average peak demand from 800kVAr to 150kVAr.

Without EQ Unbalanced:

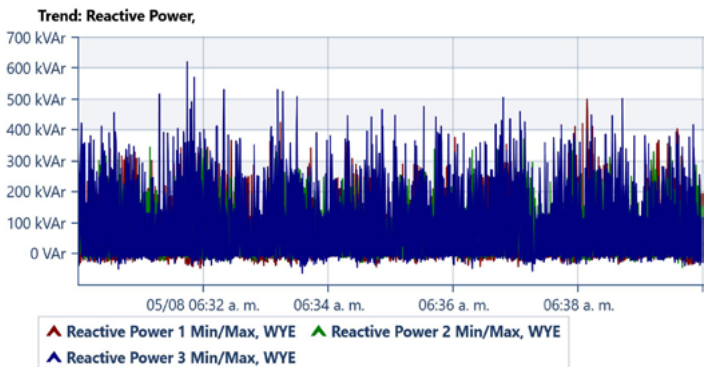


With EQ Unbalanced:

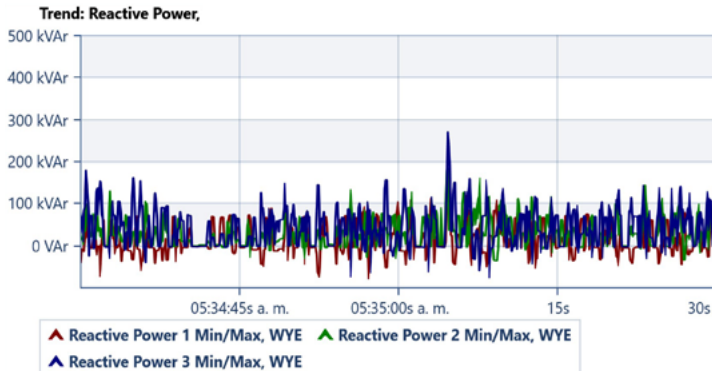


In the single-phase reactive power graph below, it can be seen that the filter is capable of dynamically compensating reactive power per phase, reducing all three phases simultaneously.

Without EQ Unbalanced:

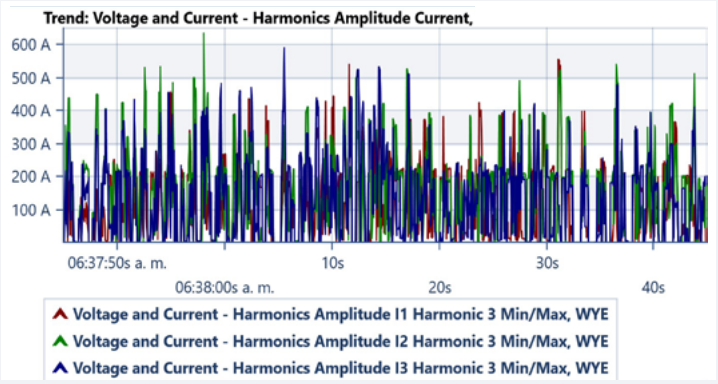


With EQ Unbalanced:

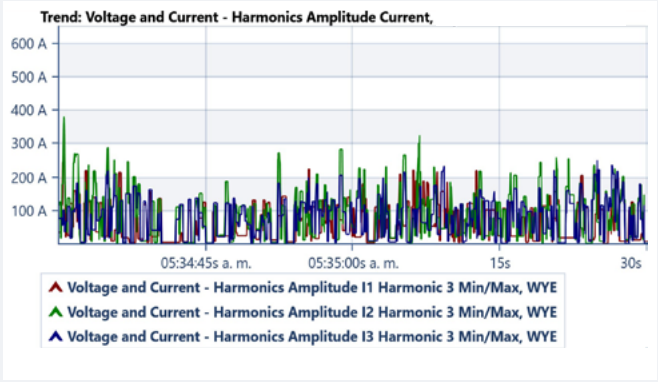


Third harmonic (Ah3) dropped from 400 A to 200 A.

Without EQ Unbalanced:

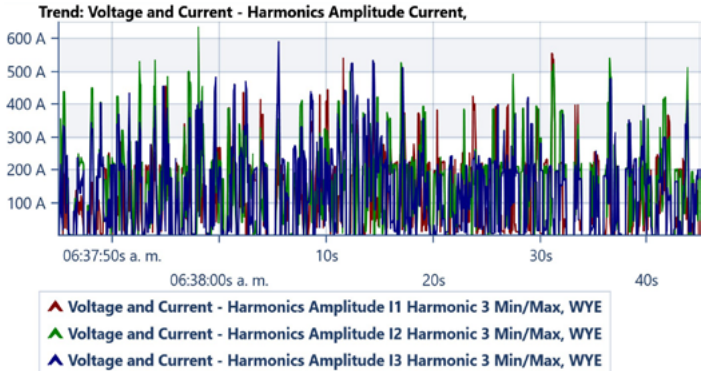


With EQ Unbalanced:

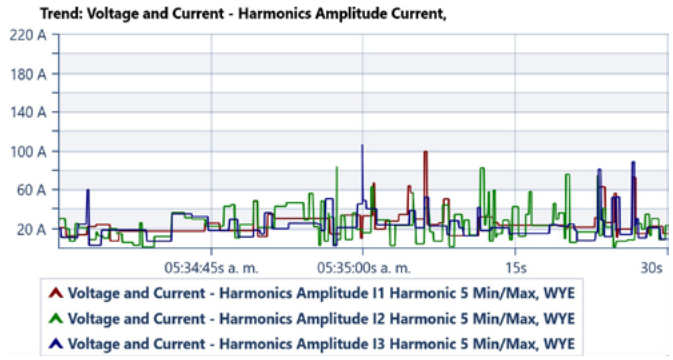


Fifth harmonic (Ah5) dropped from 180 A to 60 A.

Without EQ Unbalanced:

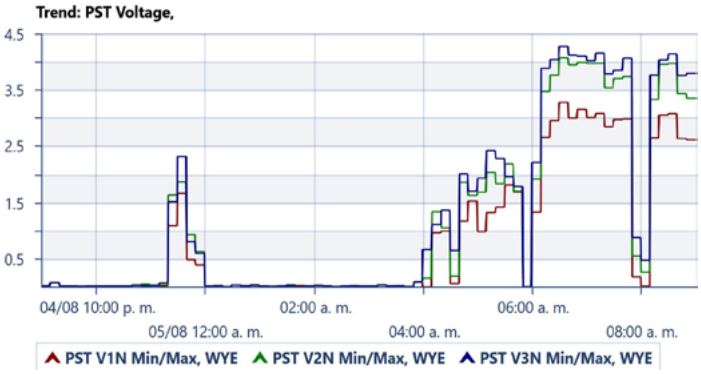


With EQ Unbalanced:

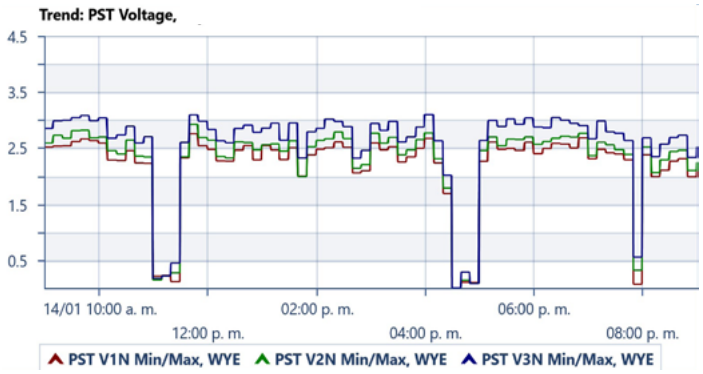


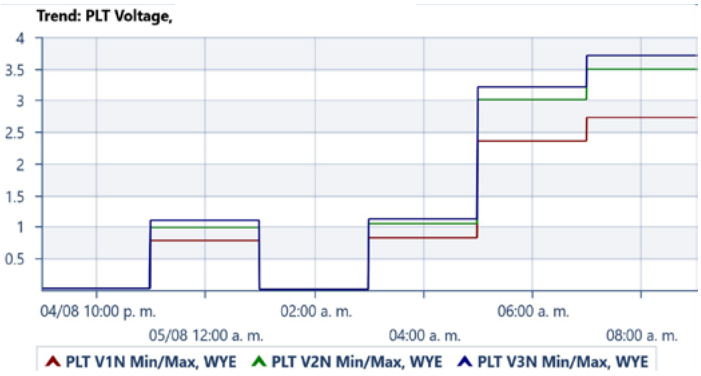
Flicker levels (Pst and Plt) significantly reduced.

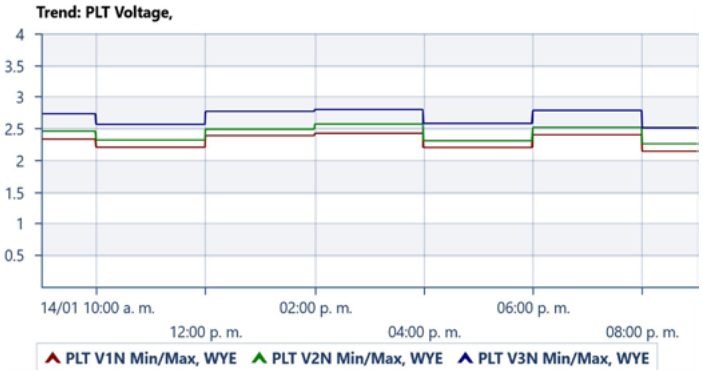
Without EQ Unbalanced:



With EQ Unbalanced:







Power factor stabilized around 0.88, reducing drops of 0.2 significantly.

Conclusions

This case highlights the effectiveness of Elspec's Equalizer Unbalanced system in addressing severe power quality challenges in the automotive welding industry. With its real-time, per-phase compensation capabilities, the system ensured significant improvements in voltage stability, current balance, harmonic mitigation, and flicker reduction. These enhancements helped the plant optimize energy usage, extend equipment life, and improve overall production quality.