WeldComputer

The Technology Leader in Resistance Welding

Case Study

Lincoln Industrial Taps WeldComputer to **Discover** and **Reduce Excessive Weld Failure** Rate Issues by More Than 93%

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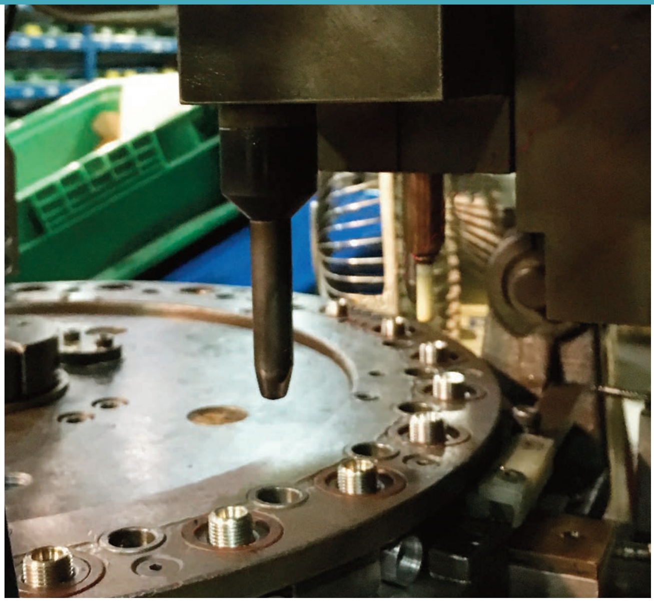
Using WeldComputer's Adaptive Control system, Lincoln Industrial saves more than 250,000 rejected parts annually.



THE COMPANY

Founded in 1910, **Lincoln Industrial Corporation** manufactures automated lubrication systems, manual lubrication equipment, and industrial pumping systems. Since its beginnings, Lincoln Industrial has played a key role in revolutionizing lubrication practices in automotive maintenance. Many of the inventions by the company led to today's modern practices in the industry. In 2010, Lincoln Industrial was acquired by the Swedish company Svenska Kullagerfabriken AB (SKF), where it operates as a subsidiary to this day.

THE CHALLENGE

Lincoln Industrial was experiencing a 50% failure rate on a part that was projection welded on a Federal frequency converter press-type weld machine, equipped with a Unitrol control. The engineers at Lincoln Industrial could not understand the reasons. They did, however, recognize that no amount of destructive testing could predict the quality of the welds that were not destroyed. To determine the root cause for the welding problems and offer a solution to eliminate the issue, Lincoln Industrial requested an on-site visit from WeldComputer Corporation.

THE METHODOLOGY

During a two-day on-site evaluation, WeldComputer was able to determine, using a WeldView Portable Monitor, that the root causes of the welding problems were due to:

- Control inconsistencies caused by deficiencies in the existing control,
- Basic limitations in the control technology being employed, and
- Less than optimum control settings that were programmed to weld the part.

The WeldView Portable Monitor was temporarily set up on the machine to observe the welding process and record welding data during production.

Parameters monitored included secondary current, electrode voltage, conductance (resistance), power, displacement (set-down), and cylinder pressure (force).

The production weld schedule originally observed in this resistance welding operation consisted of 25% preheat for 3 cycles, 70% weld heat for 1 cycle, and 25% postheat for 1 cycle.

The cylinder pressure was set to 45 PSI, which corresponded to approximately 1,400 pounds of electrode force.

THE DATA

The WeldView Portable Monitor visualization (below) shows the typical projection collapse pattern of each weld produced at Lincoln Industrial. This documents that the projection collapsed a distance of 26.73 mils within a period of 9.5 milliseconds (Fig. 1).

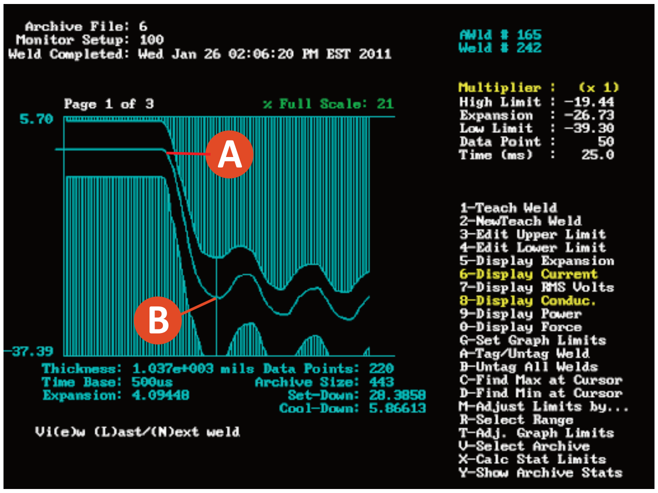


Figure 1. Typical projection collapse pattern at Lincoln Industrial.

1A. Projection begins to collapse here.

1B. Projection completely collapses within 1/60th second after start of welding current.

As with any resistance welding operation, successful welding depends on the ability to produce force and current as a function of time, which is repeatable from weld to weld. Any variation in these parameters will translate into variation in the welded result.

The trace below shows the typical current profile of the new schedule put in place at Lincoln Industrial on January 26, 2011. In a production sequence of 443 welds produced over a period of approximately 38 minutes, the WeldView monitor documented current amplitude variations of 12.9% (Fig. 2).

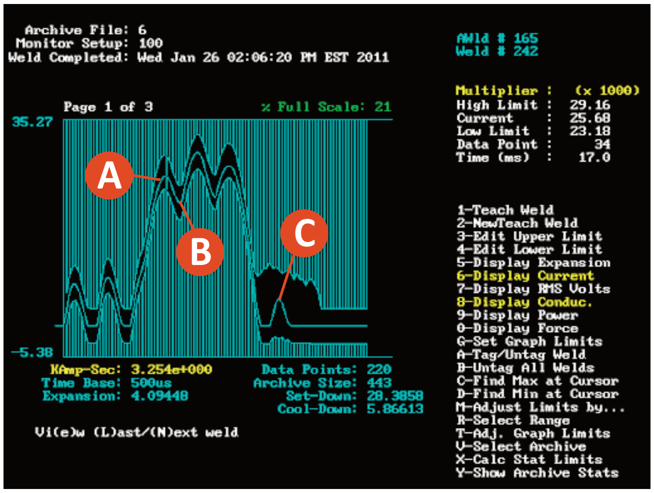


Figure 2. Typical current profile of schedule following the addition of WeldView Portable Monitor.

2A. Over a production sequence of 443 welds, the monitor documented a 12.9% variation in the amplitude of this current pulse, which is the dominant parameter responsible for the projection weld formation.

2B. Conventional SCR control switching technology is impairing this welding process by allowing weld power to drop 41% at a critical time during weld formation 3.5 ms after current peak is reached.

2C. This current pulse should not exist. This monitor trace documents a flaw in the firing of the existing control.

This current variation from weld to weld was identified as the dominant factor responsible for creating an unacceptably small weld window in this production operation. It is common to measure the weld window to assess the stability of a production resistance welding process by using the ratio of the highest to the lowest current that will achieve acceptable welds. In general, if this ratio is more than 1.15 (meaning that the two limits are more than 15% apart), the process tends to be stable with no quality issues; if the ratio is between 1.10 and 1.15, the process can be stabilized through careful control of the incoming parts and good equipment and tool maintenance. If this ratio is less than 1.10 (meaning that the limits are less than 10% apart) frequent quality problems are encountered on the floor.

THE RESULTS

PROBLEM 1: DIFFERENT AMPLITUDE CURRENT IMPULSES WHEN ALTERNATING CURRENT POLARITY

The first problem observed is that a different amplitude current impulse was being produced by the control on every other weld. The frequency converter welding transformer in this welding machine is operated by firing alternate polarity current impulses, to prevent the weld transformer from saturating. This means that if the last weld was produced with a positive polarity current impulse, then the next weld is produced with a negative polarity current impulse; the weld after is produced with a positive polarity impulse, etc. The correlation of the alternating amplitude of the current impulses with the alternating polarity of the current impulses suggests that a phase error in the control's synchronization with the power line is the dominant contributing cause of this variation.

PROBLEM 2: EXCESSIVE CURRENT IN THE PREHEAT CYCLE

The second problem observed was that too much preheat current was being applied, which caused the projection to start melting and begin to collapse before the application of the welding current. The amount of projection collapse during the preheat cycle was correlated with the amount of preheat current delivered by the control. Coupled with the control's inconsistent heat delivery, the preheat current programmed into this weld schedule increased the variability of the welds produced.

Based on this observation a recommendation was made to reduce the preheat current and time to a level that would keep the projection from starting to collapse during the preheat stage. Other recommendations included slightly increasing the cylinder pressure setting and weld heat setting. The result reduced the failure rate from 1 out of every 2 parts to approximately 1 out of every 30 parts. However, this still left the operation with an unacceptably narrow weld window of operation.

PROBLEM 3: FAULTY CONTROL FIRING CAUSES UNEXPECTED CURRENT PULSE

The third problem observed was that a fault in the control firing created a current pulse that was not programmed in the weld schedule. The weld schedule was programmed for zero cycles of postheat. Yet the control still produced one of the three pulses that made up each cycle of heat programmed by the control. This is due to a timing fault in the hardware/software implementation of the existing control.

PROBLEM 4: SCR CONTROL DROPPING POWER DELIVERY WHEN POWERLINE FLUCTUATIONS OCCUR

The fourth problem observed can be traced to limitations inherent to the SCR switching technology employed. Typically, thousands of line fluctuations occur in a factory daily. In this application, the entire weld formation takes place within a period of one programmed cycle of the control (1/60th second). This makes it impossible for the existing type of control to compensate fast enough to counteract the effect of these powerline fluctuations on the welded product.

Another limitation, inherent to the SCR switching technology currently employed, is that the wave shape of the current pulse is dictated by the power line characteristic. This characteristic causes the power delivered to the part to drop by typically 41% at a point in time only 3.5 milliseconds after the current peak is reached. The critical time in the formation of the weld that this power drop occurs is limiting the size of the weld that can be produced.

THE SOLUTION

Tests performed demonstrated that the WeldView Portable Monitor reliably identified these failed parts as they were produced. Based on these tests, changes in the control settings were rendered, reducing the failure rate from 1 out of every 2 parts to approximately 1 out of every 30 parts. While that's a 93% reduction in failed parts, this is still costly for Lincoln Industrial. At their reported production of over 500,000 units per year in this welding operation, monitoring alone would only identify the poor welds, not address their needs for quality improvement. As a result, without fixing the variability leading to these issues, Lincoln Industrial would continue to have a costly quality issue – an estimated upwards of 17,000 parts would still be rejected annually!

The ultimate solution we implemented was to configure a **WeldComputer Wave Synthesis Adaptive Control** to effectively address all three of the fundamental issues identified with the present welding setup, while also providing an incredible ROI for Lincoln Industrial.

The Adaptive Control solves many of Lincoln Industrial's current problems by implementing a weld schedule that:

- Checks the initial weld force/pressure and combination part thickness before welding and alerts the operator if a problem exists,
- Delivers heat as a function of time that is best matched for the part being welded,
- Compensates for part variation by raising or lowering the programmed current as each weld is taking place, to control set-down consistency,
- Evaluates the set-down response of every weld in real time as the welds are being produced and actuates an output that can be used to reject the part when an undersized weld is produced, and
- Stops the machine when a specified number of sequential parts are rejected and alerts the operator of a problem that needs to be corrected.

Overall, the WeldComputer Adaptive Control solution continues to provide ongoing cost savings by decreasing the number of parts that have to be rejected and increasing the quality and consistency of all welds produced. The Adaptive system has allowed Lincoln Industrial to:

- Increase the operating weld window to acceptable levels,
- Make the process virtually immune to power line fluctuations,
- Improve the strength and consistency of all welds produced,
- Reduce the number of welds that need to be rejected, saving costs from reduced scrap,
- Automatically reject the part when a welding problem is detected,
- Reduce the overall maintenance costs of the machine, and
- Dramatically improve the productivity of the overall operation.