KUKA Reduces Machine Safety Components by 85% While Increasing Machine Safety

A PROFIsafe Case Study

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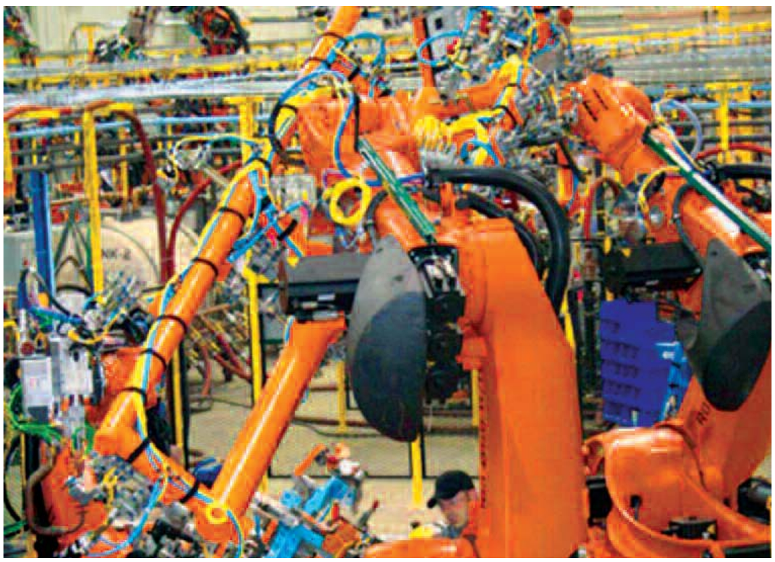
KUKA Flexible Production Systems is one of the most prominent producers of Automated/Robotic production systems for car bodies and chassis.

When KUKA decided to become a Tier I supplier of automobile bodies to DaimlerChrysler, they needed to use their extensive knowledge of body shops and find a partner that was willing to work with them to change the landscape of the North American market. KUKA was faced with designing a body shop utilizing DBOOM (Design, Build, Own, Operate, and Maintain) philosophy with no restrictions on the equipment used. The only criteria, "Utilize only field proven technology." The result: A partnership with Siemens that utilized field proven revolutionary technology realizing substantial cost savings, while significantly improving system safety, manufacturing flexibility and Mean Time To Repair (MTTR). This is all happening at the KUKA Toledo Productions Operation LLC (KTPO) assembly plant, which produces the Body-In-White on the DaimlerChrysler (DCx) Jeep JK vehicles, currently the Wrangler Model.



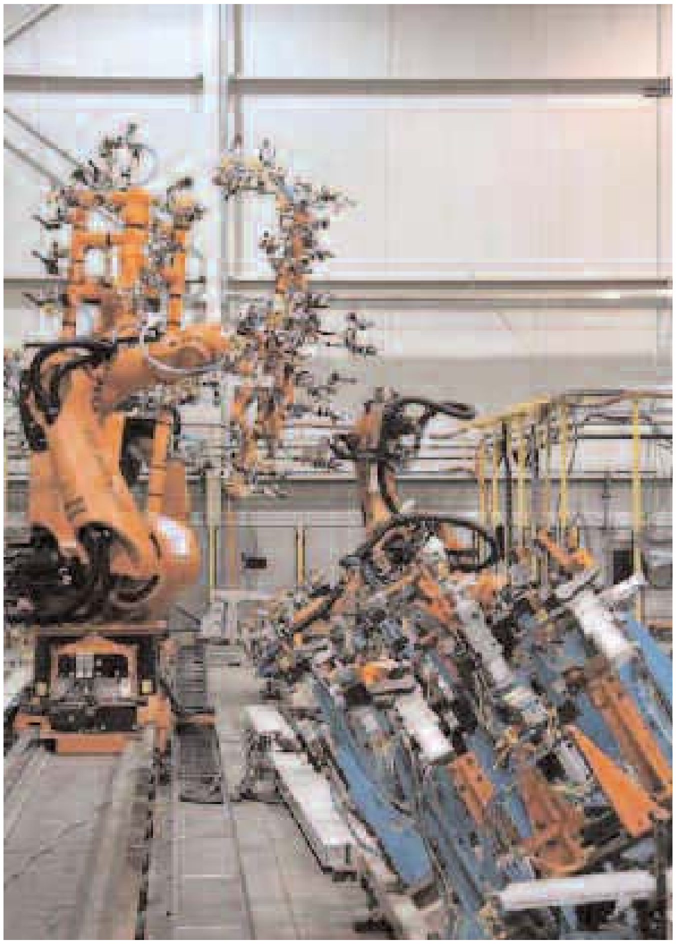
The Body-In-White application involves many systems from underbody to windshield to panel line assembly. Two main problems plagued their current design. First was the hardwired safety required for each cell was expensive to install, troubleshoot and maintain. This hardwiring of these points also made future changes and modifications cost prohibitive. The other was the power distribution to robots and welders.

Traditional machine safety systems in the automotive market are implemented with hard fencing, remote emergency stop pushbuttons, safety gate switches, safety mats, light curtains and large amounts of redundant relays. At the heart of this system is a complicated and extensive system of hard wired circuits, each wired redundantly making the electrical panels very large. This design has inherently hampered flexibility, impeded communications to the control system, increased the cost of troubleshooting and significantly increased the cost of a machine. While hardwired relay logic for control has long since migrated to the Programmable Logic Controller (PLC), little has been done to garner similar improvements in machine safety systems.

Knowing this was a major source of costs and complexity, KUKA looked to simplify the safety system with a new, more cost effective method for safety management and controls using a fail-safe controller with high diagnostic capability. While this alone would have saved thousands in wiring and troubleshooting, Kuka saw moving from hard wired safety relays to a stand alone Safety PLC-based method was not enough. Combining both machine safety and standard machine control on one field bus was key to nearly eliminating all relays and "out to the field" wiring, creating significant reductions in control panel space requirements, hardware requirements, engineering design, troubleshooting and overall wiring costs.

KUKA chose a PROFIBUS-based processor that communicates to all field components, including safety devices, via an inexpensive two wire cable capable of speeds up to 12 MBaud. The previous standard solution included communication via a simple field bus for control and hardwired circuits for safety which all acted independently. The architecture in that legacy design required a large five door main control panel with auxiliary panels on the robots, roller tables and assorted field device locations. Power was supplied by expensive multi-conductor cable drops.

The Siemens processor chosen acts as both the control processor for normal machine functions and safety processor to monitor and control all safety devices. Working from one common programming environment, and utilizing ladder logic for both process control and safety, has substantially reduced the engineering efforts and increased flexibility. Previously, all relays and PLC inputs required monitoring via independent logic to detect faults. Diagnostics were hampered by the complex and isolated designs. With the new Siemens solution, KUKA has implemented point level diagnostics for all critical I/O (both standard and safety I/O) and bus



Body side panels are selected and held for assembly by KUKA Robot with extensive fixturing.

level faults. These events are automatically generated and displayed on the single machine HMI, significantly reducing troubleshooting time and expense. Furthermore, by adding an inexpensive device called a "Diagnostic Repeater" all information on the field bus is reported on the HMI including pinpointing any breaks in the communication cable within a foot of the break. By combining safety and standard I/O along with a common programming method, KUKA engineers reported an impressive 85 percent reduction in relays, local I/O, terminal blocks and cable connections which has substantially reduced labor costs. The entire design was reduced to six standard panel configurations that could handle all varieties of system design requirements.

The base design criterion was to only design and build what was needed on the smallest of systems to reduce capital costs. As the system expands for other body types, or requires the addition of other equipment including robots, expansion to the design is easily achieved. Furthermore, KUKA engineers reported that the modular design/build accounted for a substantial savings on engineering hours since the overall design was reduced to six standard panels utilizing common wiring and addressing. The ability to have electrical equipment ready during commissioning with no last minute engineering greatly reduced the time to market. This was largely due to the common field wiring, labeling and extensive diagnostics available in the safety system. The ability to have common safety code from one system to another also greatly reduced the commissioning time. Since the code is now software based rather than hardware based, adaptability to engineering changes and flexibility is greatly enhanced.

The second major obstacle for cost reduction was the extensive power wiring to the field for robots, welders and general control. The traditional method used fused branch circuits with motor starters, circuit breakers for robots and tip dressers. Proper fuse sizing was required as was the testing of each circuit prior to power up. This resulted in significant time required for startup and commissioning. Additionally, a common issue in the plant is power load balancing by having various types of voltages tied to the grid. All of this was housed in multi-door main power enclosures that occupied a significant amount of real estate.

Siemens introduced KUKA to FastBus®, a 3-phase bus bar system for power distribution. The modular design provides the flexibility needed to fit any application. Circuit breakers and starters, which are typically pre-wired at the factory, are easily snapped on or removed from the bus bar in seconds. With complete domestic and international approvals, this system makes it ideal for a global panel design. Overall, the FastBus system helps save panel space by allowing one to wire and mount circuit protection and motor starters in a tight line, and therefore, reducing installation costs with faster mounting and significantly fewer power connections. The KUKA design was based on bringing in 480VAC into the machine and distributing the power out to the 24VDC devices via power distribution panels which were also completely free of fuses. Balancing plant power loading became significantly easier since all incoming voltage to

KUKA engineer, Rod Brown, at one of only two control enclosures for the entire system. Smaller remote panels are used with combination standard and safe I/O devices.

the devices was now 480VAC 3 phase with total elimination of single phase devices and transformers.

KUKA was able to see substantial reductions in components, labor and space while increasing the flexibility of the system. With an adjustable main circuit breaker, the main panel was capable of handling any combination of up to eight safe (Category 4) motor power networks and/or fourteen 25A robot power drops with one design. KUKA engineers reported a significant start-up savings with this design. Schedules would typically dictate 2-3 days of commissioning/ debug time per system. With the Siemens FastBus system, that time was reduced to less than one hour. Future expansion costs are also reduced as the system is scalable without re-engineering. All of this is accomplished without air-conditioning. The traditional system required a five door main enclosure which was now reduced to two doors with shorter overall height gaining back expensive real estate. KUKA reported the overall footprint of the cell was reduced over twenty percent utilizing this design philosophy.

Utilizing robots, adhesives are applied and body panel components are welded inline.

For KUKA USA, prior experience with Siemens software and solutions was virtually non-existent. KUKA engineering and floor personnel learned and implemented the Siemens system very quickly. Ease-of-use and Siemens "train the trainer" approach enabled Kuka to reduce implementation risks and meet tight deadlines. "We built the system in no time and commissioning was surprisingly easy. This approach has saved us $10's of thousands on the first installation alone," says Rod Brown, KUKA Engineer.

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