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DIGITAL LEAN WIRING

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DIGITAL SWITCHGEAR AND CONTROL CABINET DESIGN. AN INSIGHT INTO ESTABLISHED PRACTICE.

Engineering2Manufacturing. Company-wide support of interoperability and data usage in design and manufacturing processes multiply productivity, flexibility and competitiveness. Those are also the essentials of forward-thinking service concepts.

Management Summary

There has been a significant increase to recognize the importance of electrical engineering and automation capabilities. It is time to speed-up! Follow-up with digitalization, exactly as it has been successfully practiced in mechanics and manufacturing for years. Integrated processes with electronic data exchange are firmly established in these areas. Design data via intelligent interfaces controls, for example, CNC machining and 3D printing.

According to the study Schaltschrankbau im Wandel von Industrie 4.0 (control cabinet construction in Industry 4.0 transformation) by the University of Stuttgart Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW), it also pays off directly and sustainably to go down this route in the design of switchgear and control panels. ISW recommends making full use of the functionality offered by intelligent ECAD systems in order to create comprehensive, plausibility-checked documentation. If this engineering data is made available company-wide through standard interfaces, it brings numerous benefits.

Engineering2Manufacturing eliminates many tasks previously performed manually using printed documentation. This means acceptance of the initial cost and effort involved in setting up the ECAD component database and the required libraries with all the technical details.

Those who make the change from order-related to functional engineering at the same time are also building the foundation of automated design. That requires a standardization concept with the appropriate design templates. Both will reduce the engineering effort by up to 50%. The ISW study identified the following potential gains offered by digitized, automated processes – from a batch size 1:

- significant reduction of project cycle time and cost, with consistently high quality
- doubled project throughput, and thus reduced opportunity costs for projects not pursued
- digital concepts allow operators to significantly reduce the pressure on specialists
- high planning security and flexibility.

This new flexibility provides a strong competitive advantage, as virtual engineering enables customer requirements to be met even at very short notice. Those are proven facts.

This white paper highlights the engineering and manufacturing sub-processes in switchgear and control panel design projects. Based on largely manual and paper-based operations, it describes how the individual production processes for a typical control cabinet with an average of 200 components and 380 connections can be accelerated by up to 80%



Engineering2Manufacturing: Quality in Time and Budget

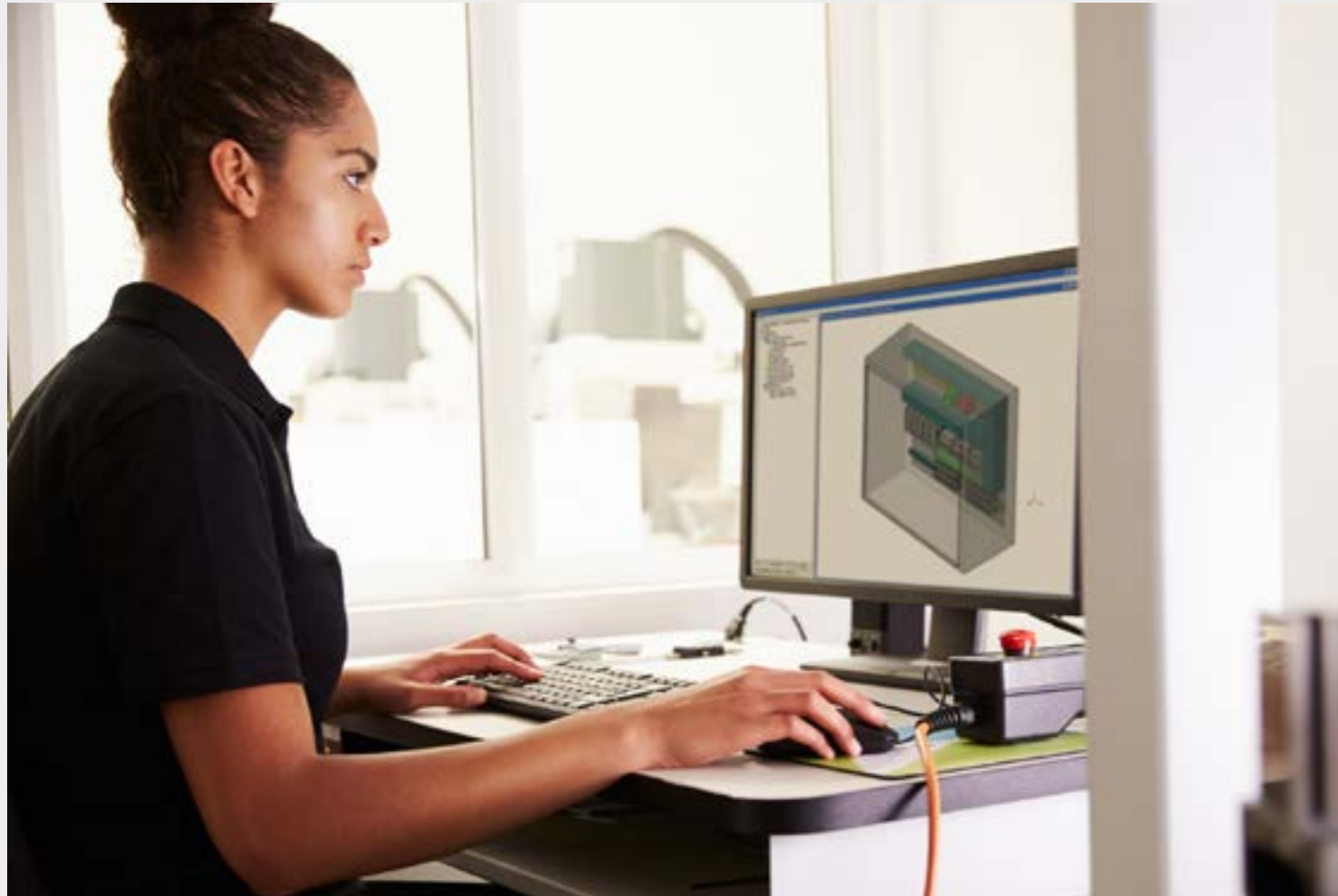
Is it not a contradiction that highly complex, intelligent switchgear and control panels are still mainly produced manually? This is a costly, time-consuming undertaking that ties specialists to many tasks that do not require in-depth expertise.

Helpful lists and overviews can be produced from a detailed circuit diagram with all the required component information and cross-references, such as terminal diagrams, cross-references and connection lists, cabinet structure and assembly data for the cabinet and wires. Systems and machines in downstream processes receive engineering data in a format that they can process directly via standard interfaces.

Each individual manufacturing step benefits as a result, in particular strand production and wiring. Digitized and partially automated processes offer very high potential time savings. On average, approximately:

- 80% by interfacing with a CNC machine, plus a minimal reject rate
- 80% with machine-made strands, with minimal rejects
- 85% for wiring, plus minimal rejects
- 60% for terminal strip configuration
- 30% by automatic labeling of components
- 25% through collision-free assembly using a 3D view of the control cabinet layout
- 20% through improved material flow via digitally integrated and project-related procurement and supply.

Within this, digital concepts for individual operations are being developed that increase efficiency and quality to a particularly high degree. The following applies: the more interconnected the processes, the greater the chance to tap the full potential.



65% quicker due to flexible production planning

Instead of giving the numerous tasks on the shop floor to a single, highly qualified technician, it is worth sharing the workload among several operators. The jobs are thus performed in parallel rather than sequentially.

Production planning is particularly suitable for this, where teams work at specially equipped stations; for example, for sheet metal processing, or for the manufacture and pre-assembly of mechanical components.

Machines and robots also shorten the process as they are able to work significantly more quickly and precisely than humans. If operators are not working on an automated machine, then appropriate instructions are provided electronically at the work station to ensure that they work quickly and accurately.

Virtual wiring for measurement of wires

If the ECAD documentation does not provide wire lengths because component dimensions and routing data are missing, then these must be determined by another means. Digital Lean Wiring (DLW) is a tool that enables the missing data to be determined quickly, easily and independently of the ECAD system.

All it takes for DLW, is an error-free, correctly scaled 2D drawing of the control cabinet layout; DLW accepts exchange formats such as DXF, DWG and PDF. If this data is not available, then DLW is able to determine the lengths using a high-resolution photo of the control cabinet with the mechanical components already fitted (as built). The connections can then be mapped quite easily via the GUI and mouse input in the virtual representation of the control cabinet. DLW uses this as a basis to determine the lengths of the individual strands.

Along with other characteristics, such as color, cross-section, wire end preparation, etc., the system location identification is transferred from the controls design data in DLW via standard interfaces. If this information is not available, it can be prepared by DLW so that all the relevant wiring information needed for production is stored in one file.

This file formats the base for the entire wire processing. Highly efficient wire processing machines for (partially) automated strand production process this data directly, without any other intermediate steps.



50% faster wire production – including QA

Manual production of ready-to-connect single inner conductors, wires and in particular of entire wire harnesses, including assembly of the connector housings, is very time-consuming. The technician then analyses each individual assembly on site and obtains the relevant production information from the diagrams, usually available as print-outs.

There is no doubt that routine and a high level of attention are required to avoid damage during processing and to select the right connection points so that components are connected correctly. That applies even more when last-minute changes need to be made without affecting the delivery date or lowering the quality or safety standards.

If the assembly information is known in advance, then the wires can be pre-assembled automatically. All the process steps can be carried out automatically, from cutting to length, dismantling and stripping to crimping, tinning, resistance and ultrasonic welding to the pushing on of marked seals or heat-shrink tubing, through to the taping and detailed labeling of the wire ends. The type of wire used for the transfer of power, signals or data plays no role in this.

The production and process data is transferred in WPCS (Wire Processing Communication Standard) format directly to the cable processing machine via an interface. CSV data is converted.

Nowadays – thanks to software- and sensor-controlled tools – modern wire processing machines work precisely and almost without any material wastage. They produce single wires, wire bundles and wire harnesses in consistently high quality and many times more quickly than would be remotely possible manually. Depending on the level of automation, the machines work between 30% and 80% more quickly.

Using the highest levels of technology, machines produce even complex wire harnesses in a single process. Just in time. They leave the machine fully prepared in accordance

with the relevant documentation. These machines have a modular design, so they can be changed over quickly and easily setup for the next production order without any great effort.

Built-in cameras in these high-tech machines use individual sampling to monitor the quality during the process. The images verify

that each contact is processed correctly. If the machines are part of the manufacturing control system, the images can be stored with the production order, which means that the result remains traceable. This feature is becoming increasingly significant in light of highly automated and transparent manufac-

turing towards data analytics and machine learning.

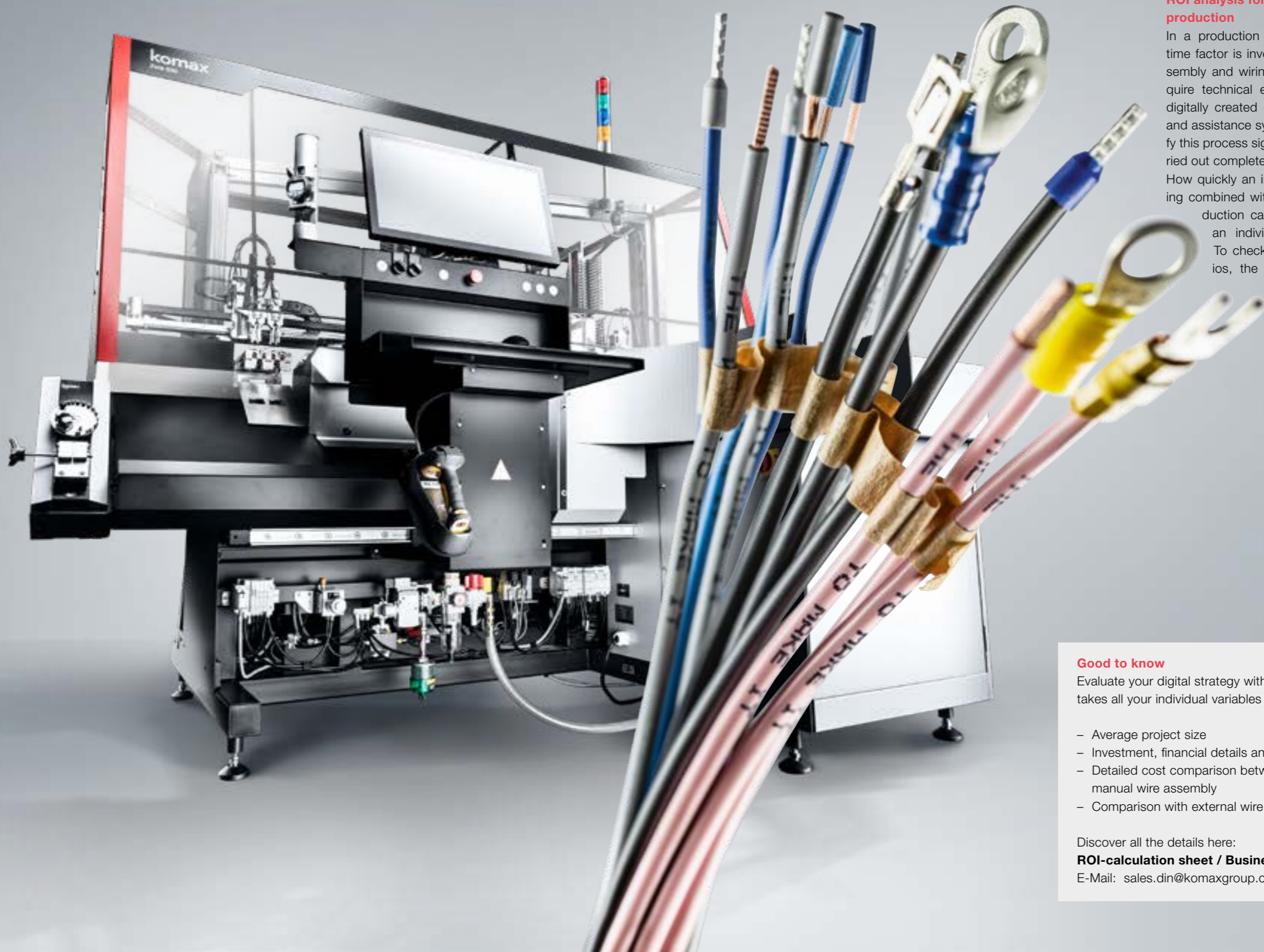
Moreover, networked machines are also able to transfer process data results to analyze parameter and output data; for example, for condition monitoring and predictive maintenance.

ROI analysis for fully automatic strand production

In a production environment a significant time factor is involved regarding strand assembly and wiring, and both inherently require technical expertise. Comprehensive, digitally created equipment documentation and assistance systems shorten and simplify this process significantly, so it can be carried out completely by machine operators.

How quickly an investment in digitized wiring combined with machineaided wire production can be amortized considers an individualized ROI calculation.

To check through different scenarios, the user defines the relevant application as well as the target values and records the actual effort required.



Good to know

Evaluate your digital strategy with an ROI analysis that takes all your individual variables into account, such as:

- Average project size
- Investment, financial details and analysis
- Detailed cost comparison between Data2Wire and manual wire assembly
- Comparison with external wire processing

Discover all the details here:

ROI-calculation sheet / Business-Case evaluation

E-Mail: sales.din@komaxgroup.com

60% quicker due to digitally guided wiring

According to the ISW study, wiring that uses printed documentation accounts for almost half of the total cabinet production time. A typical control cabinet with about 380 connections was evaluated. The study determined that approx. four minutes were required for each connection, resulting in a total of almost 30 hours per cabinet, or well over three working days.

If, however, switchgear and control panel building companies use digitally assisted wiring, a single operator can complete the job within one working day. Assistance software guides him through the process step by step. Additional information is provided via interactive documentation on a CAD viewer. Each work step has to be confirmed. At a gross hourly rate of EUR 30.00, this method reduces production costs per cabinet by approx. EUR 600.00, meaning that the acquisition costs of assistance software are amortized quickly.

Best practice examples

Besides the leading global switchgear and control panel building companies for low-, medium- and high-voltage applications, many medium-sized hidden champions have proved for some time that projects in their industries can be digitized and automated to a significant extent. The success of the companies below shows that the technological working methods described in this paper are no longer just a dream, but are established practice.

W. Althaus, Uwe E. Zoller Elektrotechnik, Schubs Steuerungstechnik, Multivac and Design Ready Controls (DRC) are just a few examples of companies that have data-driven projects. They have defined and standardized their processes in a similar

way, even though they serve different target groups. In the production planning systems, activities are triggered simultaneously and processed at the dedicated stations:

- Sheet metal working
- Side panels, doors and mounting panels are machined. Excavation, drilling, milling and tapping are carried out in one step, in accordance with the design data.
- Wire processing station
- The strand assembly is also carried out automatically. Integrated wire changers supply the machine with wires, even with different cross-sections. They assemble, sort, bundle and label up to 36 strand types in a single step. The printed reference identifiers not only facilitate the wiring, but also the commissioning and maintenance.
- Cutting station
- This is where mounting rails and terminal channels are cut to length by machine.
- Pre-assembly of terminal strips
- The mounting rails for terminals are cut to length, assembled and labeled according to data provided in a fully automated process.
- The mechanical assembly is carried out according to the 2D/3D cabinet layout plan.

Industry 4.0: Mangelberger Elektrotechnik manufactures in a smart factory

At Mangelberger Elektrotechnik, up to 20 control cabinets stand on the loading ramp every day. The Bavarian company has a fully digitized smart factory, supported by machines and robots. The machines and systems are networked internally and the systems that feed in the parts are also networked with the suppliers.

Robots assemble the switchgears and control panels fully automatically from batch size 1. Mangelberger has developed the following processes:

mangelberger
Corporate Technology

- The developing team transmit their data directly to the defined automation environment.
- The engineering is continuously and automatically checked for plausibility. The planning data is systematically cross-checked with the process data and with real data from previous switchgears. The Bavarian company has handled energy and lighting management for some of the most successful chain stores in the world for more than 30 years. Various systems supply big data to the internal business intelligence system.
- Use of an intelligent supervisory control center through which the production of control panels can be controlled automatically, manually or by a mix of both.
- Up to 860 components are supplied to the robots automatically, including DIN-Rails, metal parts, control, protection and switch devices, along with input and output terminals.
- During assembly, the component batch information is recorded automatically, documented and transferred to the project specific wiring plans.
- "Pay per click": component feeding systems are networked with the suppliers. They supply components, tailored precisely to the Mangelberger systems, on a consignment basis. When parts are removed, a signal is sent to the supplier, which then books and invoices them as purchased.
- A patented multi-gripper mounts up to 12 input and output terminals on a DIN-Rail in one step. After labeling by laser, it then passes it on to the automated frame assembly.

DRC automates its entire Engineering-to-Order (ETO) process

Design Ready Controls (DRC), with its patented configurator Automated Panel Expert (APE®), has succeeded in organizing all processes from system configuration to aftermarket needs in a completely digital and automated manner. To this end, customers of the American supplier of control systems and cable harnesses specify and commission their projects in the DRC web portal.

Required documentation is automatically generated and released to manufacturing. The strategic use of robotics and software helps augment human skill. A single point manufacturing flow reduces or eliminates handoffs. Every project is inspected and documented at critical stages, and every control panel receives 100% full function testing.



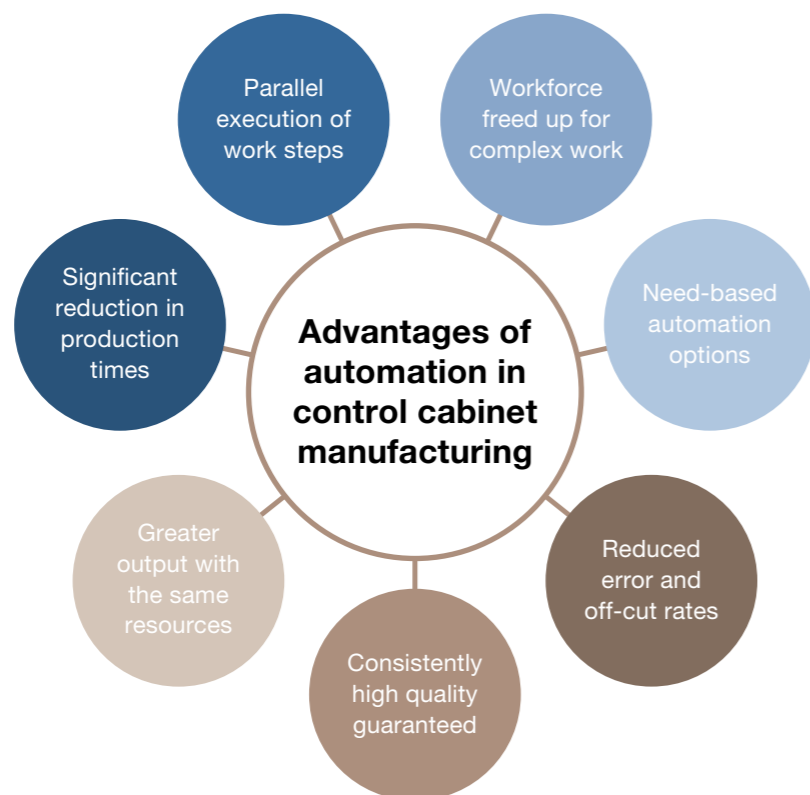
Automated supply chain optimization supports the manufacturing of hundreds of panels with varying complexity every week:

- Advanced algorithms generate panel layouts with optimal enclosure sizes, create bills of material, and send instructions to CNC machines for enclosure modification.
- A single wire file is automatically sent to multiple wire processing machines; this helps maximize machine utilization and minimize change outs.
- Manufacturing is 100% paperless, with instant access to work instructions, visual aids, and all production documents.
- A master production system electronically captures personnel and work center information to provide real-time status of jobs in production.
- Industry leading practices, such as augmented reality for guided assembly of control panel assemblies, improve product quality and workforce productivity.
- Automated torque data collection provides detailed information on each panel build, and establishes standard reference points for torque tool settings.

These companies prove that digitalization has definitely arrived in switchgear and control panel manufacturing. It allows companies to be more flexible and efficient, which helps them to be more customer-oriented, to react immediately to customer inquiries and to meet customer requirements more quickly.

These best practice methods also show that there is significant potential for improvement along the entire value chain – even with a batch size of one. The above mentioned companies have significantly reduced their production time. At the same time, they control their labor resources in a much more dynamic and demand-oriented manner. This enables them to compensate for a lack of skilled labor, even during peak periods, without having to cancel a project.

Each company has developed an individual roadmap for their goal of digitalized and automated working.



« For Mangelberger, the move to automated wiring using an agile robot is one of the next key milestones; starting from the intelligent supply of wires to the automated processing, through to identification and wiring.»

Jürgen Mangelberger, Managing Director, Mangelberger Elektrotechnik GmbH



« We have partially automated our production planning. This enables Zoller GmbH to assemble, label and tape in sequence quickly and efficiently. The labeling allows us to produce switchgear and control panels for our customers efficiently and with a high level of quality.»

Johannes Zoller, Operating Manager, Uwe E. Zoller GmbH Elektrotechnik



« Through the continual use of automation in conjunction with equipment such as the Komax Zeta machines, we are able to elevate our level of quality to new levels. In addition, we can drive down costs, reduce time to market and augment our workforce to utilize workers skills on higher level tasks.»

Jacob Willson, Director of Manufacturing and Quality Engineering, Design Ready Controls



« Thanks to the targeted optimization and networking of our work processes, we have completely automated our production. With wire assembly, sheet metal processing, terminal block production and fully automated wiring, we can offer a complete range of services.»

Marco Schneider, Managing Director, W. Althaus AG

Komax – leading the field now and in the future

As a pioneer and market leader in the field of automated wire processing, Komax provides its customers with innovative and sustainable solutions for any situation that calls for precise contact connections. Komax manufactures series and customer-specific machinery for various industries, catering for every degree of automation and customization. Its range of quality tools, test systems, and intelligent networking solutions complete the portfolio, and ensure safe and efficient production. Komax is a globally active Swiss company with development and production facilities on several continents. Komax uses its extensive distribution and service network, which includes local companies and their employees, to support customers across the world on site, thus ensuring the availability and value of their investments after equipment commissioning through standardized service processes.



Market segments

Komax offers outstanding competence and solutions for various areas of application and draws on them to generate the desired value-added for the entire process and optimize economic efficiency in line with customer requirements. The main markets of Komax are as follows: automotive, aerospace, industrial and telecom & datacom. With this breadth of experience, customers obtain expert knowledge for process optimization and access to the latest technologies.

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