Introduction

It is no secret that competition in industrial and manufacturing environments is fierce. Technological advances, modern automated equipment and wide access to information, have in many ways levelled the playing field, which means that only the truly tenacious can now stand out from the crowd. But there's good news! By taking advantage of the opportunities created by Industry 4.0 and the Internet of Things (IoT), almost any manufacturer of electrical systems can boost productivity and profitability – provided that some essential guidelines are observed.

To optimise the performance of a company, one must scrutinise its processes, particularly processes that have been used with very little alteration over a long period of time. By combining value-enhancing process steps in engineering, design, work preparation, production and maintenance, it is possible to create a sound foundation for all efficiency improvements. This is the value chain, a business model that describes the full range of activities needed to create a product or service. The overarching goal of a value chain is to deliver the most value for the least cost in order to create competitive advantage.
Industry 4.0 and the smart value chain

A lot of ink has been expended over the years debating the relevance and importance of Industry 4.0, but the truth is that it is here to stay, and it is already permeating every aspect of business life. In the most basic terms, Industry 4.0 is an initiative promoted by the German government to enhance manufacturing efficiency and flexibility. This definition is accurate as far as it goes, but it does little to reveal the true scope and potential of Industry 4.0, which sets out to do nothing less than to transform factories from being cost centres to becoming profit centres.

The paradigm for the 21st century, encapsulated in Industry 4.0, is to take full advantage of the possibilities opened up by the convergence of the physical and virtual worlds. This means harnessing new ideas and technologies including, for example, the Internet of Things (IoT), horizontal integration through value networks and the emergence of cyber-physical systems.

By adopting Industry 4.0 manufacturers will be able to implement flexibly organised production systems complemented by integrated networking at every stage of the value chain – essential elements if they are to respond effectively to critical challenges that include tougher and tougher competition, mounting cost pressures, increasingly complex products, shorter innovation cycles and depleted resources.
Returning to a consideration of the overall value chain, for most electrical system manufacturers its key links will include: design, selection of components, generation of drawings, production data and bills of material, kitting, preparing the cabinet and mounting plates, cutting the trunking and mounting rails, terminal rail assembly, wiring, testing, incorporating last-minute changes, generation of documentation for the end user, and finally shipping the finished product. It is useful to look at each of these links individually and examine how they are being reshaped by recent developments.
Design

Modern CAE software enables tedious and time-consuming engineering design functions to be performed automatically and instantaneously. With such software, users can benefit from increased productivity, shorter project turnaround times and improvements in product quality. The latest CAE software solutions provide design automation, automatic report generation and data integration tools that can reduce engineering times by 50% when compared with traditional, manually intensive CAD-based drafting packages.

The best packages support design modules for commonly used functions such as motor starters. These modules can be developed and tested once, then reused as needed in any number of designs with the software taking care of changes such as component designations and wire numbers. Not only does this approach reduce engineering time, it also ensures design uniformity, and virtually eliminates the risk of errors. Once a module has been tested, it can be guaranteed to work correctly every time it is used. The software can automatically adapt the imported circuit diagram to conform with standards, regulations and user-defined guidelines.

Support for 3D design is also a feature of the latest CAE software and it makes design much simpler and more accurate. Engineers can readily see whether they have chosen the optimum layouts for components and cable runs, which eliminates the need for shop-floor changes and saves a lot of time during panel manufacture. Some packages go even further and can generate a "digital twin" which allows the panel to be virtually tested – and even virtually demonstrated to the end user – before the design even reaches the shop floor.

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Thermal Design Considerations

Good CAE software makes it easy to take into account thermal considerations when designing switchgear. It provides the functionalities needed to calculate the total power dissipation of the switchgear, which is made up of the power dissipation of the devices plus the power dissipation of the busbar systems. With EPLAN's 3D CAE solution, the results of this calculation can be transferred to the Rittal Therm software package, which allows optimal air-conditioning and thermal management solutions to be readily identified.

Therm takes care of the complex calculation of climate control requirements and guides users to the most suitable, correctly dimensioned climate control component.

At the end of the calculation, you’ll receive detailed documentation, providing peace of mind when calculating climate control components.

All evaluations are based on the requirements of IEC/TR3 60890 890 AMD 1 and DIN 3168 for enclosure cooling units. A calculation of the overtemperature to IEC 61439 can be generated in Therm with a single click.
Choosing the best components to use in a control panel is always a headache for design engineers, especially in today’s world where new and improved devices appear almost daily. Possible solutions are to “use the same as we did last time” or to trawl through component manufacturers’ websites looking for the latest developments. Neither of these is particularly satisfactory: the former stifles progress while the latter is tedious and time consuming. There is, however, an attractive alternative that addresses all of these issues: an online component database.

Containing data on hundreds of thousands of components from hundreds of manufacturers, the EPLAN Data Portal is free to use and, as the data it contains is provided by the manufacturers themselves, it is accurate, complete and up to date. It is an invaluable resource for designers, providing all of the information they need to select the best components for their applications in a single easy-to-access location. And the data is formatted so that it can be imported directly into leading CAE packages which saves time and eliminates errors.

What’s more, the new EPLAN Data Portal is now available in the cloud as part of the EPLAN ePULSE cloud environment. The latest highlights, with benefits for users and manufacturers alike, are enhanced facilities that include smart search functionality and a newly developed user interface that is exceptionally intuitive in operation.
Manufacturing drawings and documentation

As would be expected, CAE systems invariably produce detailed mechanical and electrical drawings for control panels, but they can also do much more by, for example, automatically generating terminal schedules, bills of material (BOMs), PLC I/O allocation tables and other essential items of documentation. The best systems even feature a convenient bi-directional interface with the Siemens TIA portal, which is a big time-saver for those working with Siemens products. Not only do these features relieve design engineers of much tedious work, they also ensure accuracy and completeness.

Furthermore, when a CAE system is used for panel design, drawings and documentation no longer need to be synonymous with paper. Instead, drawings and documents can be formatted for direct display on the screen of a computer or a tablet. This brings big benefits. Layout drawings generated in 3D can, for example, be rotated to provide views from any angle and all of the items are easy to keep up to date because they are accessed as and when needed from a central repository. No more problems on the shop floor or onsite because outdated paper drawings have accidentally been used!
Kitting & QR Codes

Kitting may seem like a very small element in the manufacture of control panels, but it is in fact an area where big improvements in efficiency can be easily made. Good CAE software will, as we have seen, automatically generate BOMs that are complete, free from error and structured so that all of the necessary panel components can be ordered and arranged for installation from EPLAN. E.g. transformer and protection devices (+EN1) are sorted for Enclosure 1 and PLC items go into (+EN2) enclosure 2. The BOMs will also include all of the small and easily overlooked items like terminal end cheeks and coding plugs for connectors, which if they’re not available, can play havoc with the kitting process.

Research carried out by EPLAN has shown that a typical panel builder can cut the time spent on kitting and fetching parts from the stores by as much as 50% if they switch from manual to automatic methods. This is a useful contribution to any company’s competitive advantage and profitability.

A useful feature which is now supported by EPLAN CAE software is the ability to create QR codes that can be embedded in drawings and other documentation. Access to additional information is then possible at every stage of the end product’s lifecycle simply by scanning the appropriate QR code. This aids manufacture, testing, commissioning and fault finding. Further, Rittal, are now marking their products with QR codes which provide a direct link between the product and the documentation, virtually eliminating the risk of errors and also greatly enhancing traceability.
Preparing the cabinet and mounting plates

Metalworking operations in the panel building sector, such as drilling mounting plates and making cut-outs in cabinets, have traditionally been carried out manually, using hand tools. For low-volume production, this approach can still be effective, but even then, the use of a CAE design system offers substantial benefits as full-size drilling templates can be produced with ease. Temporarily attached to the mounting plate or cabinet face that is being drilled or cut, they make accuracy easy to achieve and greatly reduce the opportunity for mistakes.

Even bigger benefits accrue from embracing automation, however. Machines are now available that will take data directly from the CAE system and use it to drill or make cut-outs in any type of sheet metalwork such as an enclosure door or mounting plate. Accuracy is guaranteed, and the time savings are substantial. Machines in the Rittal Perforex range for example, interface directly with EPLAN software boosting productivity and efficiency.
Preparing the cabinet and mounting plates

These include the Rittal Perforex LC 3015 3D laser machining centre, a revolutionary system for the drilling and cutting of stainless steel, sheet steel panels and powder coated metals. Using the facilities provided by EPLAN Pro Panel software, which has integrated 3D modelling, the Perforex LC 3015 can be programmed to perform measuring and machining to an extremely high degree of accuracy while processing panels in a fraction of the time previously required for these operations.

Also available are milling machines in the Perforex BC series which can be used with almost any kind of material, including spray-finished sheet as well as stainless steel, aluminium, copper and plastic. These machines are efficient even with a batch size of one and eliminate many hours of tedious manual work with hand tools.

It is true that this kind of equipment requires a significant investment, but even in medium-volume applications the efficiency gains they make possible mean that they will pay for themselves surprisingly quickly.
Trunking and mounting rails

Inefficient and inaccurate cutting of trunking and mounting rails not only leads to needless production delays but also wastes materials. Automation can, however, readily address these problems. The first part of the solution is a modern CAE package that will calculate the exact length of every piece of trunking and mounting rail used in the panels you’re making. The second part of the solution is to use an automated cutting centre. This will take cutting data directly from your CAE package and automatically setting the stop for each piece of trunking or mounting rail that needs to be cut. All the operator has to do is to push the trunking or rail up to the stop and press a button to initiate the cutting operation. It takes only a second or two, so it’s much quicker than manual cutting. In addition, the machine makes a clean, accurately aligned cut every time and the piece is always cut to exactly the right length, therefore minimising waste, lowering costs and accelerating the entire process.
Terminal rail assembly

Few tasks in panel building are as tedious as assembling terminal rails. For panel builders involved in large-scale production, machines are available that will automate this operation, but for those for whom investment in such specialised machinery is not yet an attractive option, there is an excellent alternative: let the terminal supplier build your terminal rails for you. Once again, the key is a modern CAE system, which will prepare terminal rail information, including details of spacers, barriers and marker legends, in a format that can be transmitted directly to the terminal supplier. The best of these will then take that data and build the terminal rail assemblies at very competitive prices and on very short delivery times. The assemblies are supplied ready to use, complete with all labels and markers. The time savings are substantial, and the finished assemblies are guaranteed to be exactly as specified.

For those ready to invest in large-scale production, machinery is available which will accept terminal data from a CAE system and can process up to 800 terminals per hour.

- Automatic assembly and laser marking of terminals
- Automatic cutting to size and labelling of support rails
- Engraving support rails with user defined info such as project or picking numbers
- Consistent quality thanks to the fully automated process and process optimisation from a quantity of one
- Measurement errors avoided thanks to controlled axes
One of the most complicated and time-consuming jobs in control panel manufacture is wiring, but data from a good CAE system can help in many ways. First of all, a 3D design package will make it easy for the design engineers to preview all of the wiring runs within the panel and to decide on the best routes that will provide optimum segregation between, for example, power and signal cables. The package will also calculate the exact length of each wire, and generate the information needed to produce cable markers. If required, it will also produce a point-to-point wiring diagram that includes the size, insulation type, colour and type of every cable in the panel. This greatly speeds the wiring process and reduces the risk of mistakes.

Automation can also lend a hand. Affordable wire processing centres are now available, including the likes of Rittal’s Wire Terminal, that will take data from the CAE system and cut to length all of the wires needed for a control panel, then strip the ends. If cable-end ferrules are needed, the same machine can crimp these in place quickly, efficiently and reliably. It will also print the cable markers, again using information directly from the CAE design package. Working this way saves a lot of time – no tedious manual calculation of wire lengths, no searching for the right cable markers – and will help to minimise cable wastage as exactly the right length is cut, every time. It also helps to ensure that the correct cable is used for every connection.
Testing

Keeping the time spent on testing to a minimum is a high priority for all panel builders. To achieve this, the first requirement is a good design, perhaps one that borrows elements from earlier designs that have been shown to work correctly and efficiently. The next step is accurate documentation for the shop floor, so that the errors are minimised during the building and wiring stages. Good wiring information is particularly important, as a typical control panel will have tens or even hundreds of wires and connections – and one wire incorrectly connected or missing can take a long time to find on test.

Accurate documentation for testing is also needed. This is not necessarily the same as the documentation used to build the control panel, as modifications may have been necessary during the build process and it’s essential that these are reflected in the drawings and documents used for testing. Advanced features of modern CAE packages help in all of these respects, supporting right-first-time designs and producing impeccable documentation that’s easy to keep up to date when changes and revisions are made. The best CAE tools make use of cloud platform technologies to ensure that a single source of dependable and up-to-date information is readily available for all project participants regardless of location or job function. This is an enormous benefit at the testing stage and has the potential to significantly reduce the overall time to market.
Last minute modifications

Last-minute modifications are a panel builder’s nightmare. Often the result of late changes in customer requirements, they delay deliveries and they increase costs. Once again, a good CAE system is the key to addressing these problems. If it has 3D functionality, it will allow the design engineer to work out exactly where the new parts can be placed and will provide warnings of any possible collisions with other components. Better yet, the CAE package will generate accurate drawings and create documentation that properly records the modifications, for now and for posterity.

Not all last-minute changes come from the customer, of course. Ad-hoc changes sometimes need to be made on the factory floor, in the test department or even onsite during commissioning. In the past, a big problem with such changes was making sure that they were properly reported to the design team so that drawings and documentation could be updated. All too often marked-up drawings showing the changes got lost or were simply filed away and forgotten.

If the paperless approach to drawings and documentation is adopted, all of these issues disappear because the computer or tablet that’s being used to view the drawings also provides a communication route back to the design team. Changes can be recorded directly on the device and are instantly available to the designers who can review them and ensure that they are properly recorded. This saves endless trouble throughout the life of the panel, as those who need to maintain it, modify it or fault-find on it, can be sure that they’re working with accurate information.
There are very few design engineers who enjoy the tedious work of producing detailed end-user documentation for a control system, but fortunately a good CAE system will automate almost all of this work. Drawings can be generated at the click of a mouse, along with parts list, recommended schedules of spares, tables of terminal assignments, PLC I/O schedules and much else besides. The documentation is guaranteed to be accurate as it is produced directly from the design data and, as already discussed, it can be delivered electronically as well as, or even instead of, on paper.

Electronic documentation has much to recommend it for both the panel builder and the end customer. It opens up possibilities, such as rotatable 3D views, which have no paper equivalent. It can be configured so that users can quickly “drill down” for further information – clicking on a component on a schematic diagram could, for instance, instantly pull up detailed information about that component and how it is configured.

Additionally, electronic documentation is much more convenient for end users to work with – when they’re fault-finding on a system for example, they no longer need to carry around a sheaf of cumbersome drawings because all the information they need is accessible via their tablet or laptop. This is facilitated by EPLAN ePULSE technologies which connect data, projects, disciplines and engineers worldwide in an open and cloud-based way.
Shipping the Panel

The panel is built and tested, your customer is waiting, so all that’s left to do is ship it as quickly as you can, but there are a few more tasks before that panel is quite ready to leave you, especially when it comes to the progress of your logistical operations. It is possible that your panel needs a carton or even a crate to protect it in transit, and it will almost certainly need to be despatched with comprehensive documentation detailing how it should be installed, commissioned and maintained.

CAE software will instantly and accurately tell you the panel’s overall dimensions, so you can be sure that your shipping carton or crate will be a good fit and, as we have seen, it will also generate all of the necessary documentation. That means no more delays in the despatch department and helps to ensure that your panels, well protected by exactly the right shipping crates or packaging, reach the end user in pristine condition, just as they left your factory.
Optimising your operations

EPLAN’s CAE software provides all of the benefits discussed in the previous sections of this white paper, saving engineering time, reducing errors and simplifying every aspect of the design process. Meanwhile, Rittal production equipment (which includes laser cutters, wire stripping machines, wiring machines and machines for cutting trunking and mounting rails to length) is the key to optimising the later links in the value chain. Thanks to the synergies between EPLAN systems and Rittal products, almost all aspects of control panel manufacture can be automated, which saves time, minimises the risk of errors and optimises the use of materials.
Optimising your operations

If investment into automation machinery isn’t right for you at this time, other options are available. Tools and services included in the Rittal Configuration System (RICS) which integrates directly with EPLAN Pro Panel software, makes it possible for engineers to configure control cabinets easily and quickly, then have them manufactured to order and delivered by Rittal.

RICS users simply select their preferred enclosure system and start configuring. Progress can be tracked at any time with 3D visualisation and, once the online configuration has been completed, the specification and order are sent directly to Rittal. The service is fast, efficient and competitively priced, and RICS draws on Rittal’s extensive experience to ensure that configurations are always optimised.
The winning formula

A recent study evaluating the use of CAE software revealed that almost all engineering companies could make big time savings and efficiency improvements by partially automating engineering processes. In other words, with a relatively modest investment, companies can reap large benefits.

The European 4.0 Transformation Centre (E4TC) at the RWTH Aachen University Campus investigates the strategic digitalisation of the design and control of machines and factories. A recent eight-month field study carried out by E4TC examined a total of ten process steps for engineering in machine manufacturing and created a workflow model that contains typical work steps of the production cycle: engineering, design, bills of materials, reports, control cabinet layout, devices and templates.

The path to higher efficiencies in the value chain was mapped out using established methods, going from standardisation through to automation. To evaluate the efficiency of each work step, the study examined the workflow methodology at five different “eLevels”. One important conclusion was that standardisation of devices and design templates (equivalent to moving to eLevel3) can save 50% of the time required to create schematic diagrams. What’s more, by going further and moving to partial automation (eLevel4), an additional 25% of the time can be saved.

Using the data they collected, the researchers found that engineering companies can become 20% more efficient by moving from one eLevel to the next eLevel, and that device-oriented working methods bring a 25% time saving for schematic creation. These time savings, which result from the use of CAE systems, translate into cost reductions that can significantly enhance profitability. The study further showed that the key to higher efficiency in engineering lies in the division of labour into order processing and data generation for standardisation.

Comprehensive digital engineering documents that include schematics and 3D control cabinet designs – known as digital twins – enable considerable optimisation in manufacturing. This potential is very well illustrated in the document “Control Cabinet Manufacturing 4.0” from the Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW) at the University of Stuttgart.

TIME SAVINGS FOR CREATING SCHEMATICS

-25%

-50%

-75%
What the future holds

Only truly comprehensive solutions for optimising processes in electrical system design will help users make real progress. This means that there is a greater need for combined hardware and software solutions, product-related data and holistic services for process integration throughout the customer’s operations. When all the solutions really come together, the end result is enormous gains in productivity and profitability.

This is why EPLAN believes that in the future CAE software will play an even greater role in planning, designing and organising engineering projects. The software will enable better and faster communication between customers and manufacturers, as well as providing greater integration with manufacturing technologies available on the shop floor. All of these things are being made possible by the emergence and growth of Industry 4.0 and Internet of Things (IoT).

IoT is set to offer real time design and manufacturing capabilities and as a result, engineers using CAE software will be able to work more efficiently and respond more rapidly and effectively to customer requirements, however complex these may be. In the future, CAE software is expected to become more responsive and to allow direct communication between plants and machines, integrating all areas of manufacturing seamlessly. Although not quite artificial intelligence, next generation CAE software will be somewhat akin to a guiding mentor, wisely advising design engineers in their work and helping them make the most of its in-built knowledgebase.

In the future EPLAN and Rittal expects to see even greater integration of resources. This means that using multiple solutions from a number of suppliers that somehow have to be matched up together by the user will become a thing of the past. In its place, a strong, integrated value chain solution that works seamlessly and delivers optimal results with minimum errors will become the gold standard.