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ENDIS 4.0 as replay on requirements of Industry 4.0 in field of power supply and automation for mining

This article presents a new product line for energy distribution and control ENDIS 4.0 from the perspective of the Industry 4.0 require-ments implemented by Europe. The paper presents various variants of the technical solution and possibilities of configuration and quick reconfiguration. The authors also included their remarks and observations of the current level of implementation of the Industry 4.0 guide-lines in the Polish as well as world mining industries.

Key words: *ENDIS, Industry 4.0, Compact station, Energy distribution, transformation station, IoT*

1. INTRODUCTION

The idea of Industry 4.0 is well-established in Europe. In Poland, the mining industry is increasingly being discussed and visible in the activities of many companies. The concept itself brings to mind the associations like an intelligent mine, plant, factory, digitalization, full integration of products with the infrastructure, and their communication with the manufacture or analysis of data in real time.

So, what is Industry 4.0? This is the fourth phase of the industrial (r)evolution. The first revolution took place in the 18th century and was based on the mechanization of production by using a steam engine. The second one started at the beginning of the 20th century after the introduction of mass production and use of electrification. The third one started after the popularization of automation in the 1970s, which was made possible by the dynamic development of electronics and IT solutions. The fourth revolution is happening now; this is a revolution based on cyber-physical systems and dynamic data processing (Fig. 1).

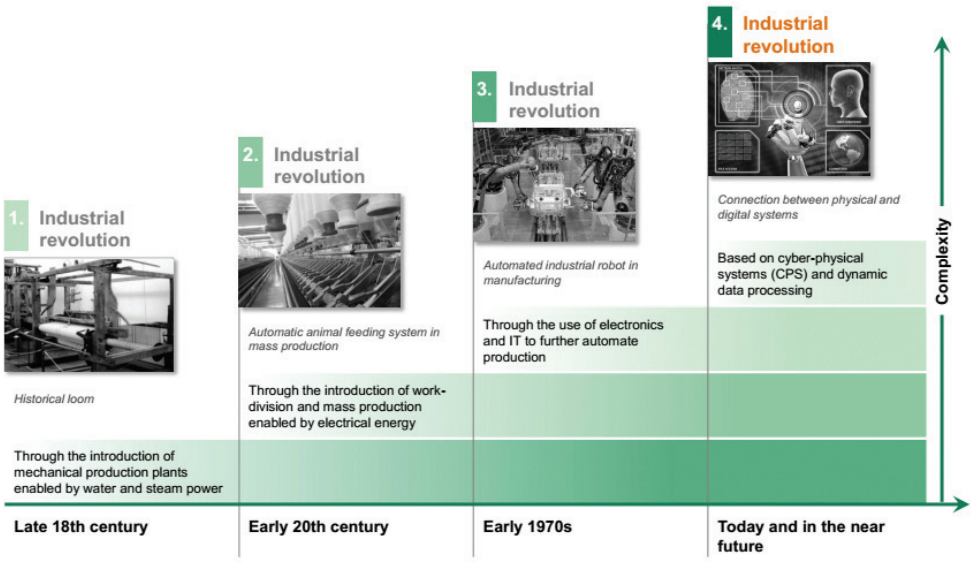

Fig. 1. Industrial revolution stages [1]

As a world leader in the production of highly advanced electrical solutions for the mining industry, the Becker Group also meets the requirements of the Industry 4.0 as well as those of customers from all continents within its new ENDIS 4.0 product line. Below, we present the various technical and technological solutions in this area.

2. ENDIS 4.0 – INTRODUCTION OF PRODUCT LINE REFFERRING TO INDUSTRY 4.0 REQUIREMENTS

ENDIS 4.0 is a family of universal compact stations for different voltage levels depending on demand. Thanks to its modular construction, it provides the possibility for 4, 8, 12, 16, or 24 contactor panels (including circuit breakers). The compact station design enables use for voltages from 500 V to 4.16 kV, resistance to voltages up to 25 kV, a nominal current of 1250 A, and a connecting short-circuit current of 25 kA. This feature makes it easy and quick to reconfigure stations due to customer requirements needs or configuration change of powered machines and equipment.

The compact station can be installed in the so-called high (*H*) and low (*L*) housing (Fig. 2). In the high version, 2 levels are available with up to 24 slots for contactor panels. The individual compartments are closed by a quick-action door. The construction enables its installation on the flange of the transformer station. The applied constructions are as standardized as possible and well-thought-out in terms of quick reconfiguration and servicing.

Additionally, housings can be equipped with many types of fast connectors and grooves on both sides (which is presented in Figure 3).

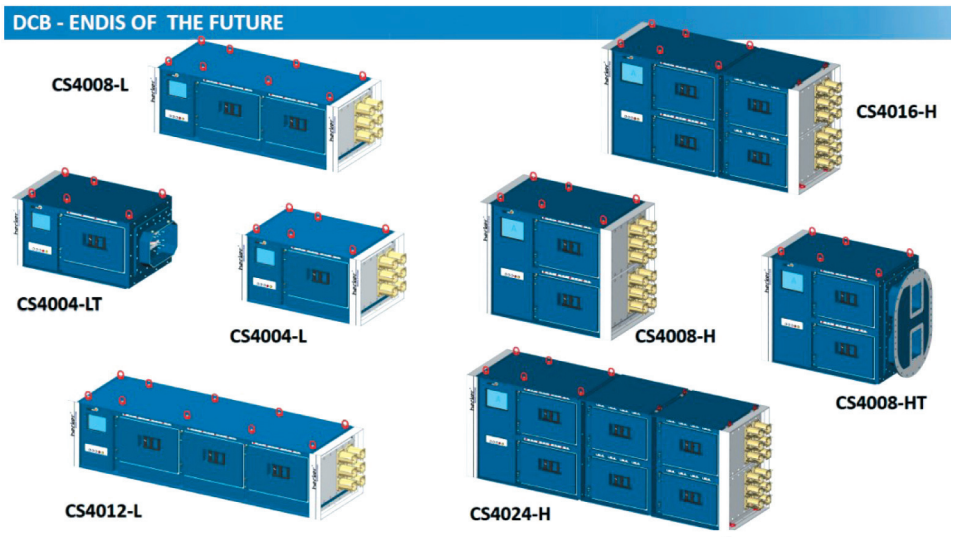

Fig. 2. Configuration possibilities of compact stations

Fig. 3. Different types of connectors and grooves can be used

The construction frame for the insertion of contactor panels (Fig. 4) is mounted completely outside the flameproof housing. The frame design eliminates the need to connect main and auxiliary bushes in a flameproof housing. Thanks to this, it is also possible to use a construction frame for inserting contactor panels in a non-explosive zone after installation in a suitable industrial enclosure. In addition, when there is a need to replace the interior of the casing in underground conditions, the entire structure can be prepared in a suitable place (workshop), and the whole structure can be changed at the station workplace.

Particular characteristics of the frame are as follows:

- contactor panels are electrically inserted and pulled out with the possibility of manual manipulation,
- automatic disconnection of faulty contactor panels from the main circuit with constant diagnostic connection to the panel,
- automatic recognition of inserted panel (no panel encoding);
- load capacity of main contacts up to 1000 A,
- possibility of using a power switch up to 1000 A,
- optionally integrated arc protection (optional),
- free-access at the back of the compact station for cable connections,
- universal sliding position for single and double- and double-outlet contactor panels and transformer panels.

Compact stations of the ENDIS 4.0 family are equipped with the optimized new generation of contactor panels. The design of all of the contactor panels is identical for all voltage levels. The TCU 2-output contactor panels are made for rated voltages of up to 1140 V and load currents of 2 × 250 A, and they have a switching capacity of 4 kA. Contactor panel type HPC 500 has been designed for rated voltages of up to 4.16 kV, a 500 A load current, and a rated switching current of 6 kA. The power current contacts can be replaced independently. The CB 1000-type power switch has been designed for a rated voltage of 4.16 kV, rated current of 1000 A, and holding capacity of 25 kA (Fig. 5). The light output is integrated into the compact station without having to use the space for the contactor panel.

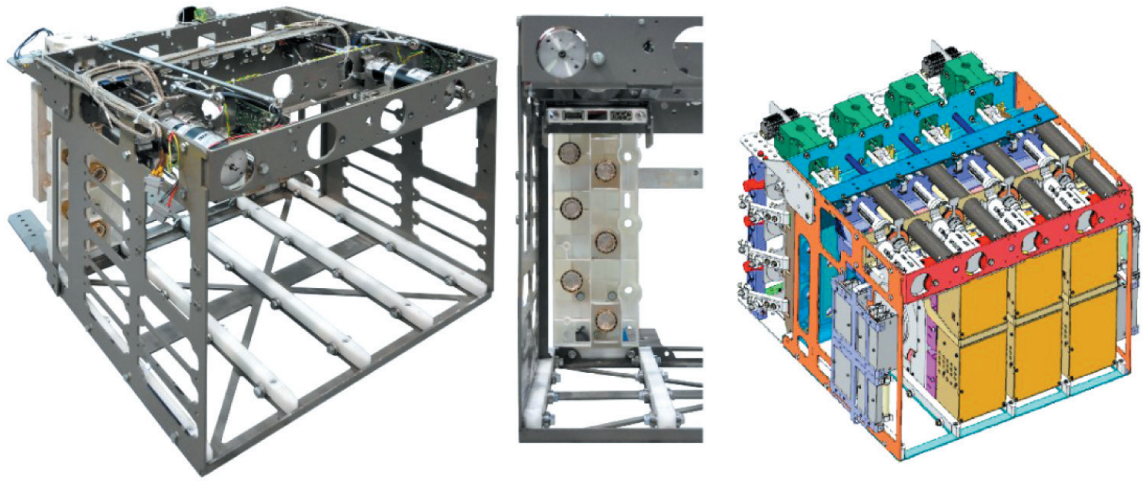

Fig. 4. Construction frame for insertion of contactor panels

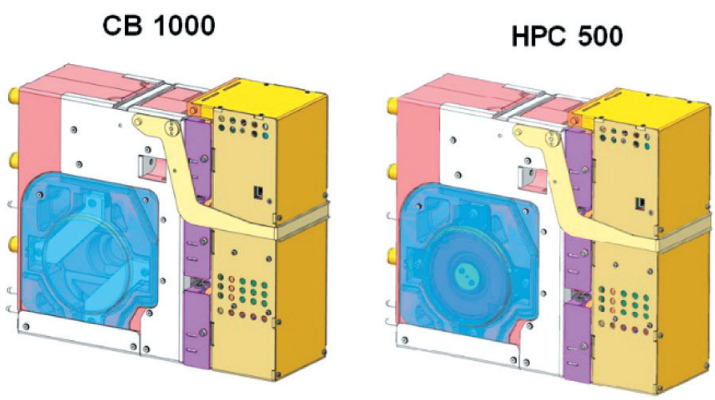

Fig. 5. Contactor panel

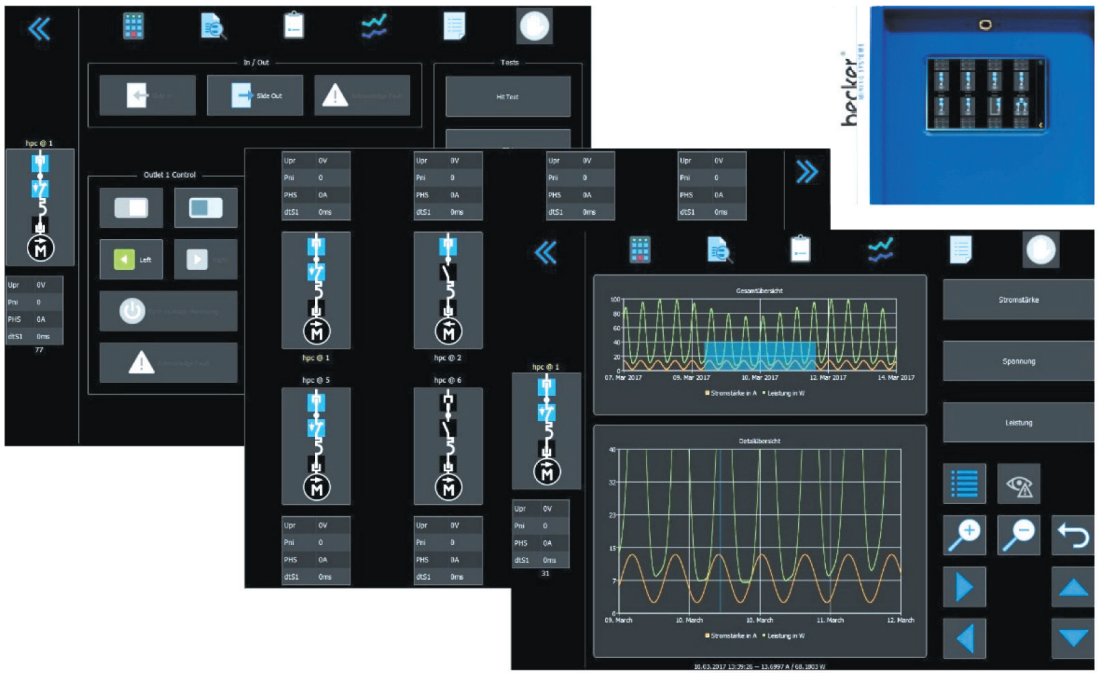

Fig. 6. Touch-screen display of compact station visualization panel – examples

The standard equipment is a control module with a transmission speed of 500 kBit/s for network interfaces and communication with contactor panels. The station has a 15-inch touch screen with full visualization of the diagnosis of individual panels, their configuration, and their history (Fig. 6). Even when the panel is disconnected from the main power supply, full diagnostic transmission and power supply of the control circuits is maintained.

At present, only a part of the equipment and sensors are connected together in industrial plants. Sensors combined with automation systems are mainly used to read parameters and control the production process. The Industrial Internet of Things means that more and more devices are equipped with built-in sensors and processors, which allows for efficient communication and interaction. It also influences the increasingly centralized control, and the decentralized analysts enable decisions to be made in the real world [1].

Within the compact station, all important components are diagnosable, "connected" and intelligent, and able to communicate with the outside world. Thanks to this feature, Becker's service team can even remotely determine which component has failed and how it happened. Additionally, thanks to such extensive diagnostics, it is possible in some cases to perform predictive service activities. The Becker Group places a particular emphasis on this functionality because of the fact that it has customers on every continent (where the possibility of remote service and prediction of failures amounts to significant savings in maintenance costs).

Optionally, the compact station can be integrated with the PLC via the Mincos AST, BTS, or other system bus interfaces (or others from customer requirements for applications without additional external controllers).

With widespread connectivity and the use of standard communication protocols from Industry 4.0, there is a growing need for cyber-attack protection or interference with the proper operation. As a consequence, the core of its cyber-security is the reliable communication and advanced user-identification systems providing access to the devices. ENDIS 4.0 fully meets these standards by protecting the communication interfaces as well as providing access to parameter changes or important settings.

For easy operation, commissioning, and servicing of the station via the 15-inch screen, there are numerous easy-to-understand instructions available in both the text and graphic forms (schemes, animations) in the language of the user's country and other required languages. Additionally, the station can act as a transmission hub and converter between different transmission technologies (Fig. 7).

Additionally, Becker makes it possible to remotely connect to the compact station and remote support of customer service while allowing for such a connection.

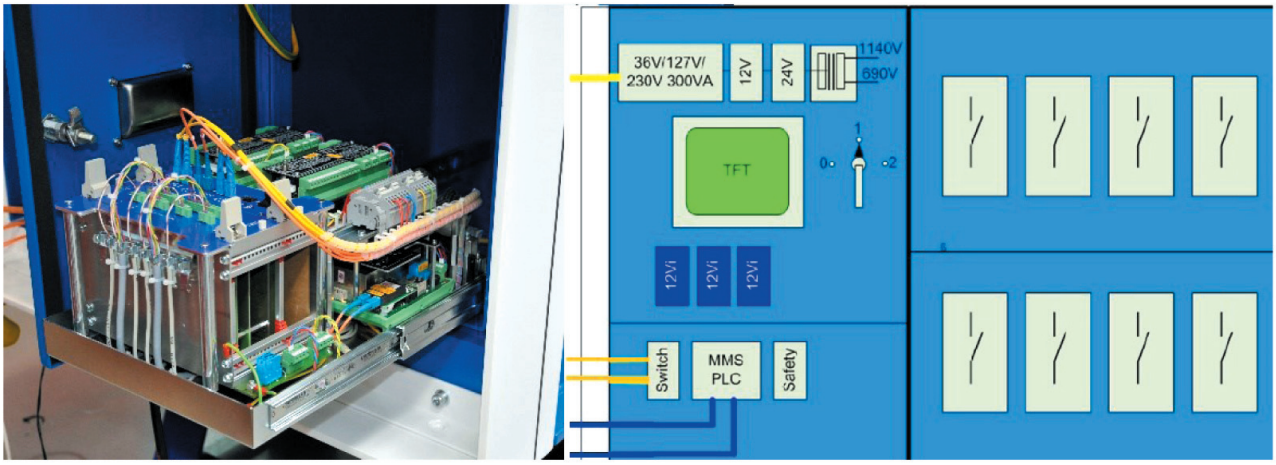

Fig. 7. Fully configurable transmission and control equipment [2]

The ENDIS 4.0 technology is fully integrated with the PROMOS 4.0 automation system and is integrated at both the hardware and software levels. The following figure shows the traditional configuration of the previous version of ENDIS and PROMOS on the left. Here, we can see a separate compact station for supplying the main motor of the belt conveyor, a stand-alone lighting module, and a Promos system controller. On the right, everything is integrated into the frames of the compact station thanks to the full integration of the ENDIS 4.0 into PROMOS 4.0.

The possibilities and functionality of the PROMOS 4.0 system are described in the article "Automation system of conveyors Promos 4.0" in the papers of the 13th International Conference on "Work safety of transport devices in mining" in 2017 [3].

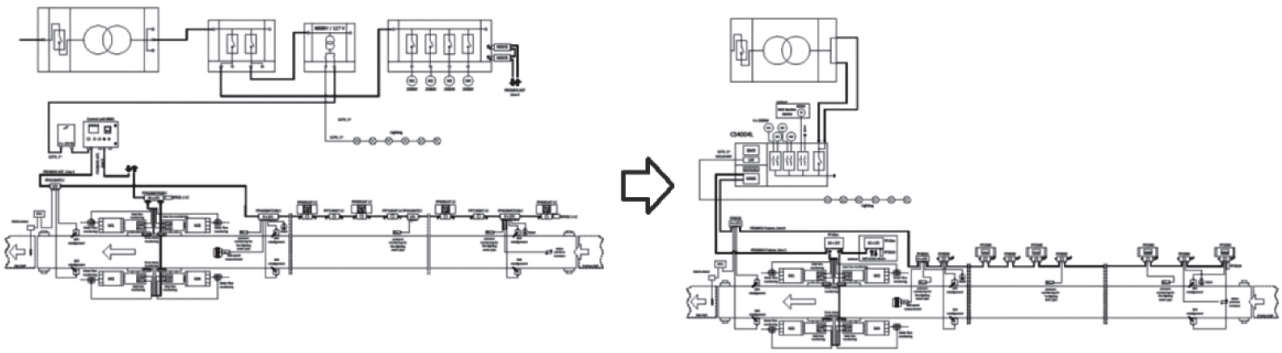

Fig. 8. Difference between traditional version of ENDIS & PROMOS integration and version 4.0 of both products

3. SUMMARY

The world's mining industry is already moving on from Industry 3.0 to Industry 4.0. The results are already visible in the control of production, shortening of the investment preparation cycle, and customer relationships. Maintaining contact with international clients at the technical level with the world's top tycoons is an essential factor influencing the increase in the profitability of extraction.

One thing we should not forget about the regulatory issues related to the access to data (among other things). Companies collect huge amounts of data and are responsible for protecting it. The scale of technological changes accelerates exponentially. No one used smartphones ten years ago, and now we have such devices available even in potentially explosive atmospheres. It is likely that the longwall will be fully autonomous in ten years' time. We are unable to predict which new solutions will be available and what we will need in the future in our industry.

It is very important to overcome one of the main barriers to the effective implementation of Industry 4.0: the low awareness of staff and regulators.

This is still a very fresh topic. The increasing use of automation systems, sensors, software, and analytical tools allows us to analyze the effects of the implemented solutions and (most importantly) focus on those changes that bring the greatest value.

A very important issue is also our education system, which should be based on projects and engineer knowledge how to solve a problem. We have plenty of talented engineers who crave for knowledge, but we lack the interdisciplinary specialists who combine the technical knowledge with business soft skills. That ones are needed to be able to fully implement the assumptions of the Industry 4.0 ideas.

The presented product group (ENDIS 4.0) is one of the components for reaching the Industry 4.0 level; however, whether and how we will use it depends only on ourselves.

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