SIEMENS

Background information

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A powerful driving force for 150 years

The discovery of the dynamo-electric principle has brought about greater changes to the way our society lives than practically any other scientific breakthrough. By inventing the dynamo machine, not only did Werner von Siemens help bring about the advent of electrical machinery, he was also instrumental in accelerating and facilitating industrial processes. Seen from the perspective of society, this completely changed accepted concepts of time and mobility.

Werner von Siemens was consequently justified in the confidence he expressed in concluding his report to the Berlin Academy of Sciences in 1867 with the words: “Technology now has the means to generate electrical current of unlimited strength in an inexpensive and convenient way wherever mechanical energy is available.” The first dynamo machines were then also used for the generation of electricity for “light and for galvanic metallurgy and for small electromagnetic machines that get their power from large ones” (Werner von Siemens).

18 years later, Nikola Tesla and Galileo Ferraris independently discovered that alternating currents displaced in time generated a rotating magnetic field with the ability to move an armature. Based on this work, in 1889 the head engineer at AEG, Michail von Dolivo-Dobrowolski, developed the first usable asynchronous motor, whose principle still forms the basis of 85 percent of all practical drive applications today, according to the ZVEI.

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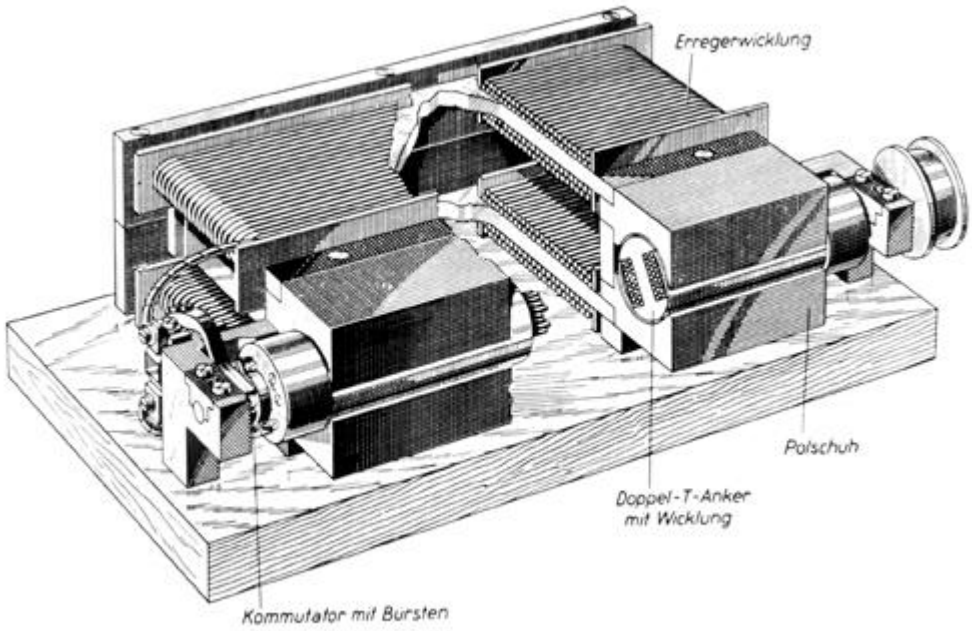

Fig. 1: Structure of the dynamo machine

This discovery paved the way for mechanizing heavy work such as rolling, drilling, milling and grinding in factory halls. Towards the end of the 19th century, the electric motor had replaced not only the steam engine but also wind and water mills as a way of powering machinery. While initially a central motor was installed in each factory hall and its power transmitted to the individual machines by means of long transmission belts, with the advent of low-cost mass asynchronous motor production, it soon became possible for every machine to be fitted with its own electric drive.

In 1879, Siemens unveiled the first ever operational electric railway in the form of a miniature locomotive which travelled around a 300-meter circular track at the Berlin Trade Exhibition. With a motor output of 2.2 kW, the train transported a total of 90,000 passengers over the four months of the exhibition, proving its suitability for everyday application.

Fig. 2: The first operational electric locomotive

In 1879, Siemens also presented the world's first electric tramway, followed in 1880 by the first electric elevator. In 1905, Siemens constructed one of the first electric cars, the "Elektrische Viktoria", which was used on the streets of Berlin as a hotel taxi or delivery vehicle. The connection of many households to the electric grid opened up wide scope for using electric motors in household appliances, particularly washing machines, refrigerators and deep freezers. Electric elevators made possible the construction of high-rise buildings, and in industrial enterprises, electric lighting, motors and automation all paved the way for higher productivity, released employees from the need for heavy physical work and improved product quality. In 1906, Siemens constructed the world's first reversible electric drive for a blooming train at the Georgsmarienhütte steel works. Its maximum output at the time was 6,800 kW. In the same year, Siemens built its Dynamowerk, a dynamo factory designed to put the dynamo-electric principle into practice in the form of industrial products. This was the first production plant built in what was to become known as the Siemensstadt district in Berlin.

Technical progress through new structural elements

In 1980, Siemens installed the first rolling mill main drive using three-phase technology using a specially developed transvector control. The three-phase

solution offered decisive benefits in terms of maintenance, improved dynamics and lower moment of inertia, as well as providing almost unlimited output power, and this technology went on to replace practically all direct current drives over the years that followed.

The further development of thyristors turned the direct converter into the standard converter used in electric motors for low speeds. Twenty years ago, Siemens went on to develop water-cooled multi-level converters which supply highly dynamic regenerative synchronous motors with up to 27 MVA of power. These converters use integrated gate commutated thyristors (IGCTs) – power semi-conductors permitting particularly fast, low-loss switching operations which enhance the overall efficiency of the drive.

Today, Siemens offers modular Sinamics S120 control cabinet solutions for high-performance applications in industrial machine and plant building. These are particularly suited for this type of application, in which several drives have to be coordinated to work together and are connected to a common DC link. Examples of applications are typically found in conveyor belts, cranes, ships' propulsion systems, cross cutters, roll changers and roller drives.

Bild 3: Sinamics S120 Cabinet Module

New open-loop and closed-loop control technology brings innovation

Hardly any modern application exists which is not driven and controlled by some kind of motor. In Germany alone, according to the German Electrical and Electronic Manufacturers' Association (ZVEI), there are around 35 million three-phase motors in operation. Laid end to end, these would stretch halfway around the globe. German industry takes a leading role also in other areas in terms of patent registrations for electric motors, sharing the lead position with Japan. Around half of all registrations in the patent groups electric motors and controls for electric motors over the past twenty years have been submitted by applicants from one of these two countries.

Quantum leaps forward in the development of closed-loop and open-loop electric control technology since the second half of the last century have also set the stage for innovation in the field of drives. The launch of the Simatic programmable logic controller in 1958 meant that for the first time, a central machine concept could be implemented using a single central control. In the year 2000, the introduction of field buses and the Simotion motion control system also made possible decentralized concepts using distributed intelligence provided by several controllers. Distributed drives are increasingly taking direct on-site control of functions in many sectors of industry, making for lower costs and greater flexibility. At the same time, this also opens up scope for mechanics, electronics and informatics as well as wide-ranging different functions of the automation pyramid to be more closely linked to the actual tasks performed by machines and plants. New functionalities and ever faster controls enable maximum system efficiency to be achieved with optimum interaction between all the components of a drive train.

The Siemens portfolio now includes drives for every conceivable application, including pumps, fans and compressors for the oil and gas industry, water and wastewater plants, the chemical industry and mining. The company also offers drives for material transport in rolling mills, conveyor belts used in the mining industry, paper machines, discrete material handling and machine tools in production. For motion control applications, Siemens is able to draw on the world's widest range of motors. In addition, applications for mobility such as traction motors for high-speed trains, trams, regional and commuter trains, hybrid and electric buses complete the product range. Examples include the Sigentics industrial generator

series from Siemens which comprises high and low voltage, diesel genset, small hydro and turbine driven generators. These exceptionally robust industrial generators achieve an outstanding energy yield under even the most extreme outdoor weather conditions. In the wind power industry, doubly-fed asynchronous generators are to be found in the Loher wind generators from Siemens on wind farms around the world. Used in conjunction with matching wind converters, these are leading contenders in the global marketplace for both onshore and offshore applications.

Integrated drive solutions for smooth interaction

With its Integrated Drive Systems (IDS), Siemens is addressing the trend towards ever smarter drives with optimum movement patterns and faster networking – particularly given the ever more rapid and fundamental changes to production and process technologies being implemented by customers. The specific concept behind IDS is an integrated approach to the entire drive train and driven processes instead of focusing on individual components. This approach entails considering the optimum interaction of individual components of the drive train as early as the initial engineering phase. As a result, comprehensive hardware and software solutions as well as complete integration into the TIA portal are made available to customers alongside a complete product spectrum. This offers users the benefit of selecting and operating individual components which are seamlessly matched to create an integrated system with a high degree of efficiency and reliability.

One example of outstanding rugged and innovative design are the new 1PC1 crane motors. These are frequently exposed to extreme weather conditions such as high humidity levels, salt-laden atmospheres, and high wind speeds. Simotics crane motors are based on the proven 1LE1 platform for standard motors, meaning that certain identical components such as stators, rotors and housings are standardized, and the motor dimensions identical. Different versions are created by using alternative winding variants or a choice of mechanical attachments. This ensures the global availability of spare parts, short repair times and a high level of availability. Used in combination with the Sinamics converter family, these motors can be used in all typical applications and comply with the IE2 standard.

Fig. 4: Simotics DP crane motors

Systematic energy savings

In future, drives will be expected to generate greater power using less energy in a smaller space, in other words to demonstrate maximum energy and material efficiency. To achieve this, Siemens has insisted for many years on using only top quality materials and the latest production techniques in the field of asynchronous technology, with a view to keeping motor dimensions as compact as possible. Taken overall, Siemens offers the world's most comprehensive motor spectrum with its Simotics series. Starting with high-efficiency IE2 to IE4 low-voltage motors for network and converter operation, through motors for motion control applications and direct current motors to high-voltage motors, Siemens has the right motor to offer no matter what the application. Its performance spectrum ranges from the smallest general-purpose motors with just 0.09 kW right through to high-voltage motors delivering up to 100,000 kW. When it comes to motion control applications, Siemens differentiates between servomotors for highly dynamic, exact positioning and precise motion control, main motors for precise rotation in rotary axes and main drives, as

well as torque motors for gearless direct drive of rotary axes and linear motors for the highest dynamic performance and precision.

But further-reaching technological changes will be required to achieve compliance with efficiency class IE4. The most promising of these is the use of synchronous reluctance technology. In the partial load range, reluctance motors offer a substantially improved level of efficiency over asynchronous motors with the same output. The synchronous principle means that the speed remains constant, while encoderless vector control additionally ensures optimized operating behavior. Both of these characteristics enable efficient control of the drive system. Well timed to coincide with Werner von Siemens' 200th birthday, Siemens is presenting its integrated drive system comprising a reluctance motor from the Simotics 1LE1 motor platform and specially coordinated Sinamics G120 converters with vector control. From this perspective, introduction of the next generation of energy saving motors will make for increased product diversity and greater specialization.

Fig. 5: Simotics reluctance motor from Siemens

Outlook

The headlong pace of digitalization in industry and society as a whole will permanently change the way in which we work and manufacture products over the coming years. With digital services and the evaluation of data supplied by smart products and production processes, suppliers will be in a position to offer new user-oriented and context-sensitive services. These can then form the basis for producers to offer their own digital services, for instance in the field of predictive maintenance, energy data management or resource optimization and for the online monitoring of machine tools, industrial robots or industrial equipment such as compressors and pumps distributed around the globe. With MindSphere, the Siemens Cloud for Industry – an open IoT / cloud platform for the acquisition, transfer, secure storage and provision of data – Siemens also provides the ideal digital infrastructure to enable the trouble-free integration of drives.

Text box

110 years of the Dynamowerk in Berlin

The presence of a network of major corporations such as Siemens, AEG and others was in itself enough to ensure Berlin's role as the biggest industrial metropolis between Paris and Moscow at the beginning of the 20th century. Dubbed the "Electropolis", the city rose to become the worldwide hub of the electrical engineering industry, still then in its early infancy. In its heyday, Berlin's industries provided employment to a workforce of almost 600,000. The city's population grew as it attracted an ever increasing workforce, and it became Germany's undisputed industrial metropolis.

The secret of its success lay in the continuous development of new products. Some of these were engineered and produced in the Siemens Dynamowerk, founded in 1906 in the Siemensstadt district. The historic achievements of the development team working at the site include the world's first welded-construction electric locomotive (1930), the world's biggest steam turbine with a turbo set of 60 MW (1935), the first hydropower generator with an electrical output of over 100 MW (1938) and many more.

After the end of World War II, the damaged factory buildings were rebuilt and the Siemens company headquarters were relocated to Munich. Berlin remains Siemens' biggest production site worldwide, and it is still the city's second biggest industrial employer. A workforce of just under 13,000 is employed at the Berlin location in development, production, sales and administration.

Siemens uses the Dynamowerk to construct high-performance special drives and generators. This is the location for development of the first gearless wind turbines, powerful main drives for rolling mills, integrated drives for shaft winders, ring motors for ore mills, drives for dragline excavators and drives for cruise ships or gas liquefaction plants.

The spirit of the company founder Werner von Siemens is still very much a presence here in the factory, and can be summed up with the simple worlds "Ingenuity for Life."

This background information and further material are available at www.siemens.com/presse/

For further information on dynamo-electric principle, please see www.siemens.com/press/150-years-dynamoelectric-principle

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Siemens AG (Berlin and Munich) is a global technology powerhouse that has stood for engineering excellence, innovation, quality, reliability and internationality for more than 165 years. The company is active in more than 200 countries, focusing on the areas of electrification, automation and digitalization. One of the world's largest producers of energy-efficient, resource-saving technologies, Siemens is No. 1 in offshore wind turbine construction, a leading supplier of gas and steam turbines for power generation, a major provider of power transmission solutions and a pioneer in infrastructure solutions as well as automation, drive and software solutions for industry. The company is also a leading provider of medical imaging equipment – such as computed tomography and magnetic resonance imaging systems – and a leader in laboratory diagnostics as well as clinical IT. In fiscal 2015, which ended on September 30, 2015, Siemens generated revenue of €75.6 billion and net income of €7.4 billion. At the end of September 2015, the company had around 348,000 employees worldwide. Further information is available on the Internet at www.siemens.com.