

Partners in technology

New challenges to a history of cooperation with customers

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ABB's predecessor companies, ASEA and BBC, were founded almost 120 years ago in a time when electromagnetism and Maxwell's equations were considered "rocket science." Since then several technological transitions have occurred and ABB has successfully outlived them all while many other companies vanished at some point along the way. This has been possible because of innovation and a willingness to learn from history. Understanding historical connections between products, technology and industrial economics is extremely

important when planning future technologies and innovations.

These connections rely on information channels in companies and their existence cannot be underestimated if a company is to survive. An organization can acquire more information than any one individual, and the optimal use of this information depends on the existence and types of communication channels between those working in a company and the relevant people outside it.

Force Measurement, a division of ABB AB, has a long tradition of innovation. Thanks to strong ties with its customers, suppliers, research institutes and universities, Force Measurement provides state-of-the-art equipment for accurate and reliable measurement and control in a broad range of applications. At the same time, established principles such as Maxwell's equations continue to be applied in new and surprisingly innovative ways to produce products that promote long-term growth and increased competitiveness.



Partnership and productivity

Innovation is a key factor if companies and their customers are to survive what can only be called truly testing times. The target of innovation is to find and implement ideas that reshape industries, reinvent markets and redesign value chains, and many of these ideas come from innovative customers.

Key to successful innovation is communication or the types of information channels employed by firms [1, 2]. A global company like ABB, with offices and factories spanning 90 countries, faces many challenges in maintaining information channels. First of all, there are the internal challenges. Ideas need to be evaluated from many different perspectives to determine their overall impact on the market. Selecting the most effective ones requires expertise and teamwork from the various business, marketing and technology competence groups. Just as important are the channels of communication that exist between ABB, and its customers and suppliers.

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Many of ABB's customers come from countries that are gradually develop-

ing strong technology and scientific cultures thanks to major investments in very ambitious research programs. China and India, for example, are two such countries. In fact, the Chinese Academy of Sciences is currently conducting research projects in all state-of-the-art technologies. Countries in Africa and Eastern Europe are capitalizing on their pool of young talent to create a culture of technology development. Emerging markets, while welcome, mean stiffer competition, and competition to companies like ABB encourages even greater levels of innovation.

Many customers, similar stories

Backed by 120 years of technological development and experience, ABB continues to produce products and services in many automation, power generation and robotics fields, and the examples described in the following section illustrate this broad customer range.

High precision in Venice

From the 13th century, Venice traded in copper and bronze, which was used to manufacture coins and building details. Today, ILNOR SpA, a family-owned business established in 1961, continues the tradition of processing metals for use in various industries. The high-quality brass, bronze and copper strips it produces are used for products in the automotive, electric and electronic industries.

However, the taste for aesthetical and high-quality products is centuries old in Venice, and ILNOR continues to uphold this tradition by constantly investing in technology that improves the quality of its products [1]. The choice of the Stressometer 7.0 FSA from ABB was natural. Stressometer systems provide the advanced automated control system needed to produce the high-quality flat strip demanded by producers, and is evidence of ABB's dedication to detail and perfection, something that is well recognized and appreciated in this part of the old world.

Building customer and internal knowledge networks help to raise business and people performance.

Venetian blinds from Sweden!

Alingsås, a small town in the southern part of Sweden, can trace its origins back to 1382. It is famous among light artists for its annual Lights in Alingsås festival. Alingsås is also well known as a manufacturer of high-quality Venetian blinds. In the Turnils factory, the production range varies over seven widths and six thickness ranges using three different alloys and 1,000 colors. The micron-precision thickness measurement system, better known as the Millmate Thickness Gauging (MTG) system, used in the rolling process is a unique force measurement product based on a proprietary new patented technology platform known as Pulsed Eddy Current (PEC) technology. This measurement system was developed out of a user need for more reliable and accurate thickness gauging. Though fundamentally based on the physics of electromagnetism, the existing technology had to be cleverly manipulated so it could be applied in an industrial setup. The system now in place in the factory can solve complicated Maxwell equations in a matter of milliseconds! High-precision electronics measure signals with a high degree of accuracy and within a time stability frame of picoseconds! A successful system depended on understanding the effects of induced currents in thin metal strips, and this

1 ILNOR SpA in Venice constantly invests in quality improvements



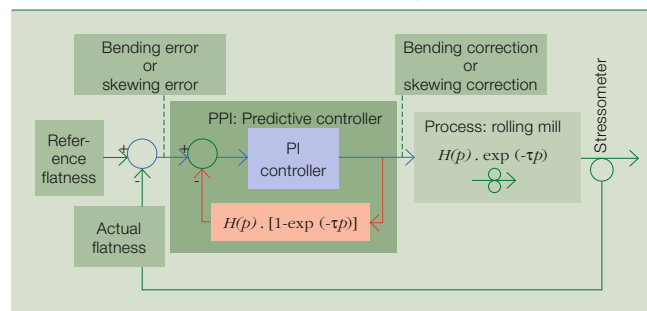
was acquired through extensive laboratory work.

ABB has thus created an intelligent product and platform with superior accuracy and long-term stability. For customers, it is a cost-effective means for process improvement that will definitely withstand the test of time.

Excellence in China

Union Steel of Korea takes pride in describing itself as “a high technology steel producer.”¹⁾ ABB has contributed to this claim as several generations of its Stressometer Flatness Measurement systems can be found in one of Union Steel’s daughter companies, the Wuxi Changjiang sheet metal plant in China²⁾. Mr. Shen Zhong, the technical manager of the plant, describes the features of the different releases running in the mill: “The earlier version 4.0 has a more traditional industrial interface; the new version 6.0 has a

2 Classic versus predictive proportional-integral (PPI) control



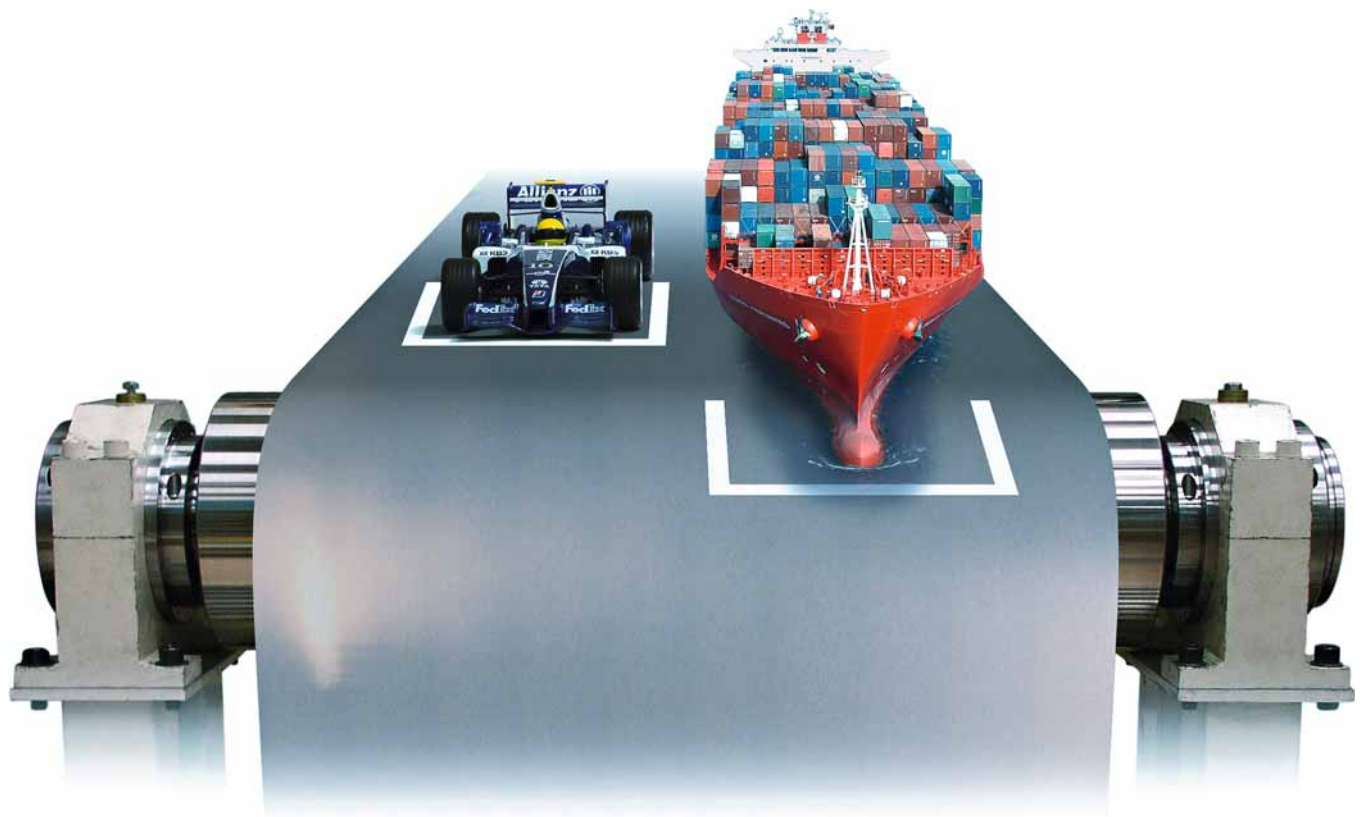
modern human interface; more safety and more computing power. But all versions are excellent products.”

Knowledge sharing with customers

Increasing globalization and competition are two of the main issues facing companies today. These challenges can be met through long-term collaboration when companies and customers share expertise and experiences with one another. Building a team consisting of reliable partners with proven track records is critical. How-

ever, creating and maintaining appropriate long-term communication channels is a challenge facing this form of collaboration. In particular, developing the necessary language translators and tools is costly and time consuming. For example, transferring specific technological knowledge via general-purpose Matlab or Mathematica syntax; process knowledge via IEC61131/IEC61499 languages; specifications via traditional mathematical formulae; or software design via UML (unified modeling language) takes years of education and experience.

The solution therefore lies in building customer and internal knowledge-sharing networks that enable employees, partners and customers to contribute and use knowledge by utilizing familiar tools. This not only enables a new combination of knowledge, but



Footnotes

¹⁾ <http://www.unionsteel.co.kr/eng/about/intro.asp>, Retrieved December 2008.

²⁾ Together with its parent company, Union Steel of Korea, the Wuxi Changjiang sheet metal plant in China takes pride in contributing “to make the world beautiful with steel.” Steel is considered a fashionable art material and every year the plant supports design students in the creation of art with steel. Internationally, the Eiffel tower and pieces by Jack Howard-Potter are examples of steel artwork.

Partnership and productivity

information can be expressed in a more abstract and compact way. At the same time, business and people performance is raised and competitive power³⁾ is increased because the technological and scientific experience a company has is being continuously enhanced.

The Torductor-S sensor ensures continuous and contactless high-speed torque measurements in the most demanding of mechanical conditions.

Successful cooperation between experts from ABB and its customers can make a difference. For example, when a plant expert identifies a problem or the possibility for some process improvement, models, simulations and optimization techniques available on high-end automation equipment can serve as real-time tools. Thus process improvements can be immediately carried out on the spot, something that was not possible in the not-too-distant past. In such a situation, the following steps are typically taken:

- 1) The problem is identified and isolated.
- 2) Experts create a model that illustrates the problem.

3) Simulations are performed with the model to determine the parameters of the problem in the simulation environment.

4) Optimization searches for so-called "indifference curves" that may provide a solution to the problem are begun. This is the (abstract) space of parameters that give an optimal solution to the problem. The solution is a specific point within this space.

Optimization techniques that might typically be used include Pareto, an internal point method, or the simplex method.

Consequences for high-end control equipment

This kind of cooperation between experts in control equipment and experts in plant processes is a means towards greater competitive power for all concerned. Additionally, quick modeling cycles and testing are an easy way of proposing and verifying new technologies and products. From a technological perspective, however, such modeling and testing can be done only when the equipment fulfills some design properties. These properties include [3]:

- **Component design.** The system should have software components that can be easily designed, connected and modified. The size (granularity) of these components is important to reach the correct balance between flexibility (ie, the number of components that can be connected and observed) and a manageable number of parameters (ie, the average number of parame-

ters for each component versus how many connectors are needed for all components in an application).

- **Discrete and continuous state observers.** When connecting new components online, the active ones should take care of the process in a seamless fashion. A period of time exists between component switchover in which observers can identify the current state of the component removed while enforcing a corresponding state on the new component.
- **Mathematical, statistical and optimization library.** The system requires a powerful mathematical library that can be used to perform all the correlation, optimization and analysis functions. This is not a trivial task as there are few industrial-strength mathematical libraries available today.
- **Transparent communication.** Different sensor-based systems and control systems should work transparently. In other words both local and remote (ie, over the internet) interaction should be done in the same way. This is important for fast access to a remote plant by experts who might otherwise not be available locally. A steel company, for example, might have a team with expertise in plant parameter tuning. These experts should have the possibility to observe and tune plants around the globe in the same way.

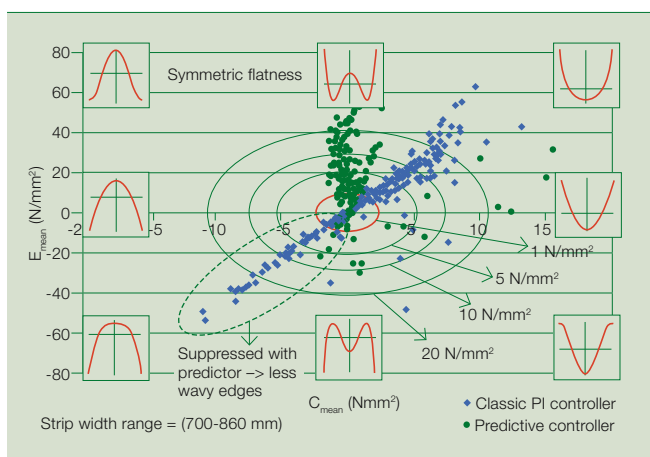
Successful collaborations

ABB is no stranger to long-term collaboration, and its willingness to share expertise and experiences with other

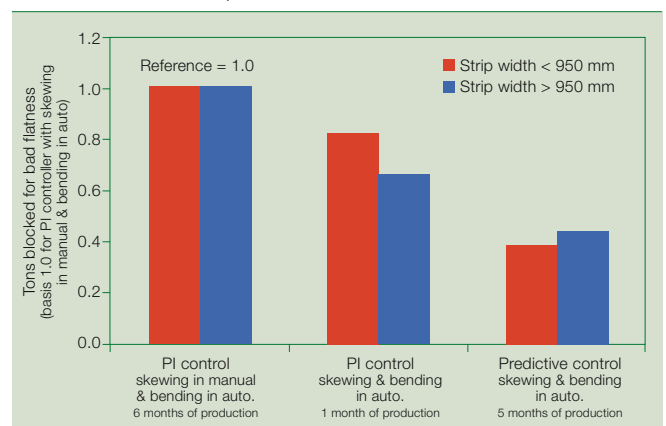
Footnote

³⁾ In most cases, the companies and customers in collaboration will have complementary expertise and share a common goal of creating value for their customers.

3 Flatness distribution: versus PPI



4 Over a period of time PPI control leads to a reduction in downgraded material of about 50 percent



companies has proven very successful. One such collaboration involves the Arcelor-Mittal Research Center in Maizières, France.

Using ABB's Stressometer 7.0, which is designed for heavy matrix-oriented computations for dynamical systems via a component-based architecture, ArcelorMittal Research wanted to test a new adaptive-predictive control algorithm, and ABB experts were more than happy to participate. The idea was to add a predictive control loop to the classical proportional-integral (PI) control [2].

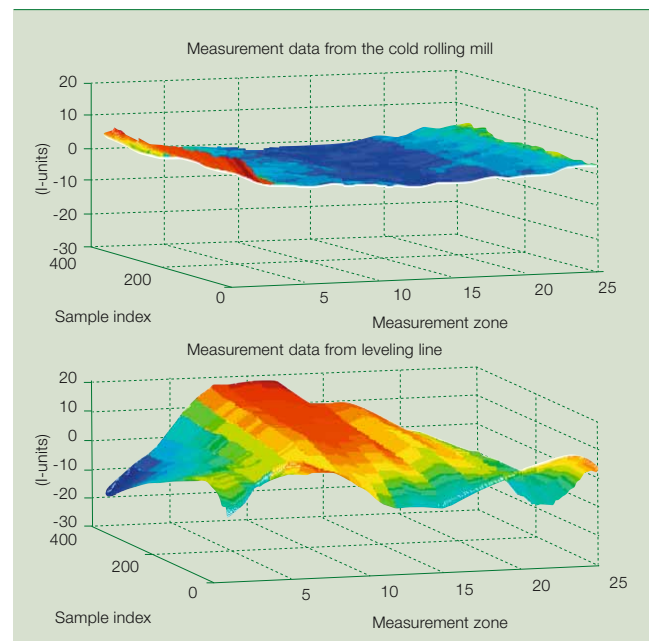
The resulting flatness distribution across actuators using traditional PI versus predictive proportional-integral (PPI) control is shown in 3. Besides some wavy edges along the strip (drawn with a dotted line), the overall difference isn't significant. However, after a test period of five months, the results clearly showed that PPI control leads to a reduction in downgraded material of about 50 percent [4] 4.

Customers with a thorough knowledge of post-rolling conditions can use ABB high-end control equipment to implement very effective post-rolling compensation methods of their own, as the following example illustrates.

Cooperation between experts in control equipment and those in plant processes is a means towards greater competitive power.

Flatness is an essential property for industrial plants that use metal strips as the input material. Some processes used in the manufacturing of aluminum cans right up to aircrafts, for example, cannot be executed unless metal strips are of the highest quality. In other words, flatness quality is what ABB's customers are promising

5 Post-rolling flatness effects



6 Torque sensors for automotive applications



their customers. However, data from aluminum strip users indicate that although the strip might have had close to perfect flatness after cold rolling, heat and mechanical conditions during transportation combine to deteriorate the flatness profile.

In 2007, ABB experts together with experts from its customer, SAPA Heat Transfer in Finspång, Sweden, decided to analyze the difference between the flatness quality of a product at a customer site and the quality reached immediately after strip rolling. Based on an ABB patent, experts knew that if this difference was described mathematically, the problem could be identified and solved by using the Stres-

someter 7.0 Flatness Control equipment.

SAPA reproduced, as close as was possible, the thermal and mechanical conditions of post-processing using batch annealing. They found that the flatness did indeed deteriorate quite significantly [5]. With the aid of statistical analysis and artificial neural network tools, these effects were identified and documented [5, 6]. This deterioration can now be compensated for using patented multi-dimensional statistical methods.

Torque sensors in F1 cars

How fast is fast enough when changing gears in a Formula One (F1) race? The

answer goes through the ABB torque sensor used in the most prestigious competition race cars.

The design of the Torductor-S sensor ensures continuous and contactless high-speed torque measurements in the most demanding of mechanical conditions [6]. It can withstand the temperature and vibration levels that exist in a typical racing car.

Working with the technical experts from the racing car industry was a very enriching experience for ABB's Force Measurement team. They witnessed firsthand how F1 engineers:

- Tuned a racing car's engine with the Torductor in the powertrain to achieve optimal performance
- Monitored wear and degradation of the engine during competition
- Monitored and controlled transients and oscillations due to backlash, wheelslip or from the road surface
- Performed condition and overload monitoring, misfiring detection and individual combustion sensing

Cylmate

There is a quiet but ongoing revolution in the design of large, slow-speed, two-stroke diesel engines, the type usually found on marine vessels. In fact more than 50 percent of all ordered vessels now have electronically controlled engines installed. In this

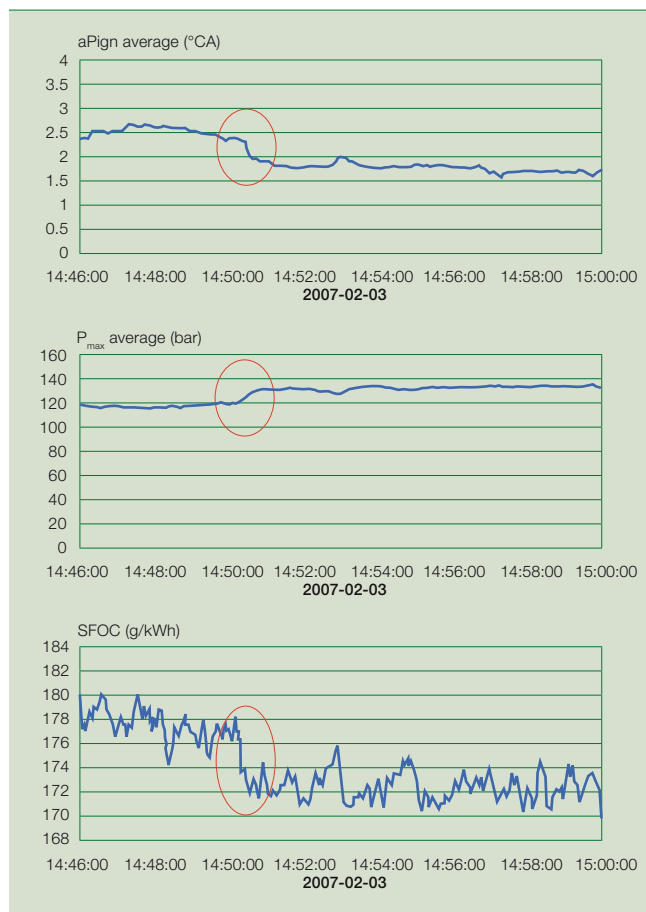
Partnership and productivity

type of engine the mechanical cam has been replaced by electronics, and the combustion process can be automatically tuned by means of a closed-loop control function. Control is applied directly to the firing angle of each engine cylinder. There is a strong correlation between the maximum firing pressure, P_{max} , and specific fuel oil consumption (SFOC, g/kWh). Even small changes in the injection fuel angle (such as 0.5 degrees) can lead to a sizable fuel reduction [7]. As shown in 7, the relationship between P_{max} in the cylinder and SFOC changes when the timing of the fuel injection decreases by half a degree, ie, from a crank angle (CA) of 2.5 degrees to 2.0 degrees. The average value of P_{max} has increased from 120 to 130 bar. The 10 bar increase instantaneously reduces fuel consumption by 2.2 percent, from 177 to 173 g/kWh. Although this may seem small, when viewed as part of a bigger picture it makes quite an impact. According to a 2000 report on the study of greenhouse gas emissions from ships to the

ABB's Cylmate sensor can withstand high pressure and thermal shocks, and its controller can analyze and communicate the cylinder data.

International Maritime Organization (IMO), 138 million tons of bunker fuel was consumed by the global maritime industry in 1996. A saving of 2.2 per-

7 The relationship between P_{max} and fuel consumption obtained at the Wärtsilä engine test center in Winterthur, Switzerland



cent is equivalent to about 3 million tons of bunker fuel, or \$1.8 billion. For a typical 6,700 TEU vessel traveling from Rotterdam to Singapore, this would mean savings of about \$60,000 plus decreased greenhouse emission effects.

The relationship between P_{max} and the CA is determined by a pressure sensor placed in the cylinder. Known as the ABB Cylmate sensor, it can withstand high pressure, a noxious environment and thermal shocks, and it can analyze and communicate the data during the time available between two cylinder firings. A paper describing how

diesel engine performance was measured using the Cylmate engine pressure sensor and analysis equipment was awarded the CIMAC⁴⁾ President's Award in June 2004 at the 24th World Congress of Combustion Engine Technology in Kyoto, Japan.

The importance of communication

Innovation is a key factor for ABB's future and the future of its customers. The sample results shown in this article highlight the importance of cooperating and communicating technological and scientifically relevant results with customers, suppliers, research centers or universities. Working with these enthusiastic groups of people is necessary both for survival and progress.

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Footnote

⁴⁾ CIMAC stands for Conseil International des Machines à Combustion, and the President's Award is very prestigious in the engine industry.

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