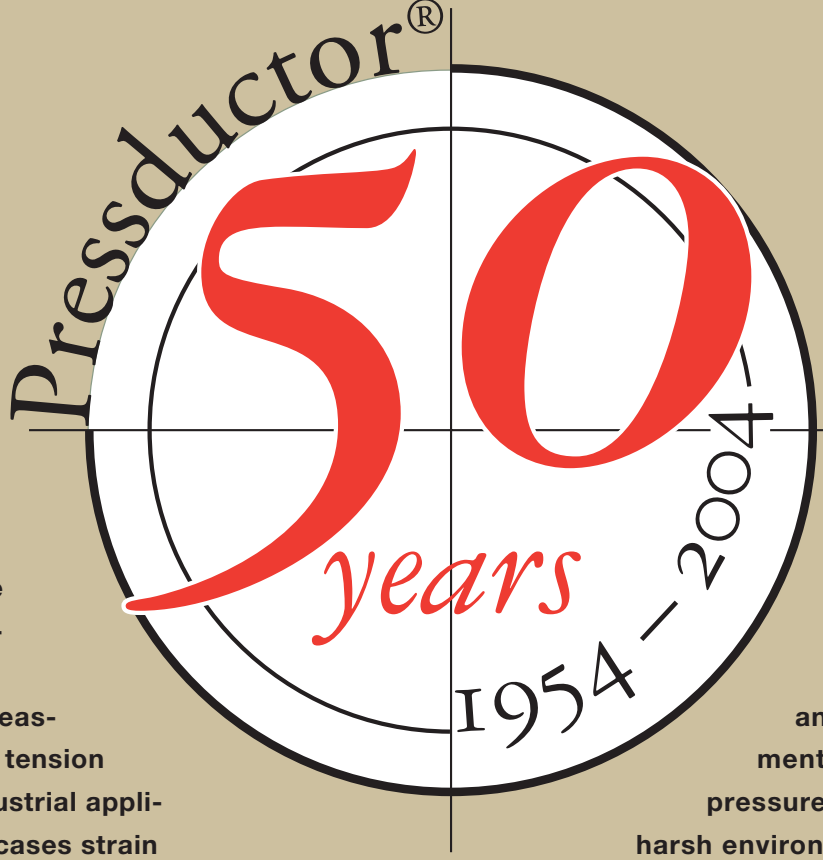
Fifty years of Pressductor®

Force measurement technology

Martin Ottosson



Down through the years, various technologies, based largely on the use of different physical effects, have evolved for the measurement of force, tension and torque in industrial applications. In many cases strain gauges were considered to be the best solution. Strain gauge load cells, however, were limited because of their sensitivity to high temperatures, electrical interference and their inability to cope with harsh environments.

In answer to industrial requirements, Dr. Orvar Dahle, a researcher at Asea, developed a new torque sensor, Torductor®, and a force sensor, Pressductor® by successfully applying the magneto-elastic effect. The introduction of Pressductor® technology based on this effect led to a revolution in the accurate and stable measurement of force, tension, pressure and torque in the harsh environment encountered in heavy industries.

The first Pressductor roll force meter was installed in a cold rolling mill in 1954 and the first patent for the Pressductor technology was granted in Sweden in the same year. Since then, ABB has launched a number of new products for different applications, such as strip/web tension measurement, weighing, torque measurement and flatness measurement and control.

The development of Pressductor technology began in the early 1950s in the research and development department of the Swedish company Asea, one of the founders of ABB. The department was first asked to develop a sensor that could measure the torque in pulpwood grinders without having to modify the shaft, and then develop a roll force meter for the electrical steel producer, Surahammars Bruk, a company subsidiary. It was during this work that Dr. Orvar Dahle 1 successfully applied the magneto-elastic effect *(see below)* in the development of Torductor® and Pressductor®.

1 The Pressductor team headed by Dr. Orvar Dahle (top row, far right) in the 1960s.

Pressductor® in industry

The very first Pressductor® roll force meter was successfully installed in Surahammar's cold rolling mill in 1954 2. The rolling force was 2,500 tonnes and each load cell had an overload capacity of 2,000 tonnes. At full load, the load cells had an output signal of 10 V.

Within a few years, Pressductor® technology became generally accepted in the metals industry. A major boost in the confidence of this technology came in 1960 when General Electric ordered 12 Pressductor® load cells (1,600 tonnes) for installation on a 132 inch finishing mill at U.S. Steel's Geneva facilities, a few miles south of Salt Lake city.

> The very first Pressductor® roll force meter was successfully installed in Surahammars Bruk cold rolling mill in 1954.

Since then the success of the Pressductor® technology has remained unbroken *(see page 47)*. Over the years ABB has delivered some 15,000 roll force load cells to most of the rolling mills in the world. This represents an impressive market share of around 65 percent. It is interesting to note that some of the units delivered in the late 1950s are still in operation today.

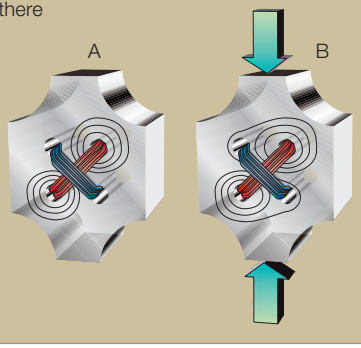
Since their initial development, the Pressductor® roll force meters have evolved and benefited from technological advances, and today form part of the ABB's Millmate series.

Strip/web tension measurement and control

The launch of the roll force meter was later followed by the development of strip tension measurement systems for cold strip mills and processing lines. Web tension measurement and control systems were designed to help improve production in industries such as paper, board, printing, plastics, rubber and textiles. This means maintaining constant paper or board quality. Therefore, in answer to the special requirements of web tension measurement, ABB developed PillowBlock type load cells. Also based on Pressductor® technology, PillowBlock type load cells are rigid and totally insensitive to electrical interference from the mains supply. To date, the company has delivered more than 35,000 of these load cells, most of which are used in paper machines. Cur-

Magneto-elasticity and Pressductor® technology

According to the magneto-elastic effect, the magnetic properties of a ferro-magnetic material are influenced by the mechanical forces acting on it. The Pressductor® sensor was originally constructed from a number of laminations of a specially developed electro-steel material, bonded to one another to form a solid block. Today, most sensors are made from a solid machined block. A typical sensor has four holes through which two windings pass at right angles to each other. One of these serves as the primary winding and the other one as the secondary winding. No coupling exists between the two windings as long as there is no load acting on the sensor (A). If a mechanical force is applied to the sensor (B), the permeability of the material in terms of magnetic flux is changed in such a way that a voltage is induced in the secondary winding.



The induced voltage is proportional to the applied force up to a given value. A Millmate roll force load cell, for example, may contain up to 1,500 sensor elements.

rently, ABB is marketing a complete range of radial and strip/web tension load cells and electronics for applications in many industries 3.

Weighing

ABB's Pressductor® sensor has also been applied to processes where weighing is required. Due to their extreme robustness, Pressductor® weighing load cells were well suited for use in melt shops, and the success of these reached a peak in the 1980's. Advances in technology, however, have meant that the weighing process in the metals industry is now performed using sophisticated software systems. Furthermore, with tougher competition and continuously shrinking volumes, ABB decided to phase out its weighing business in 2001.

Stressometer®: flatness measurement and control system

Customer demands in the 1960's meant that the metals industry needed a measurement system to enable it to control flatness in rolled steel, aluminium and copper flat products. Automatic gauge control had helped rolling mill operators achieve closer thickness tolerances, but the problem with strip flatness still remained.

In 1967 following a request from Dr. O.G. Sivilotti of Alcan in Ontario, Canada, a prototype system to measure strip flatness, called Stressometer®, was installed in the plant. Following comprehensive tests, the Stressometer® flatness measurement and control system allowed Alcan to substantially improve the shape of a cold rolled strip by providing frequent, accurate and reliable flatness measurement data.

2 The cold rolling mill at Surahammars Bruks AB was equipped with the world's first Pressductor roll force meter in 1954.

Milestones in the development of Pressductor® technology

1953	Swedish patent application; U.S. patent application made in 1954.
1954	First roll force meter delivered to Surahammars Bruk.
1967	World's first delivery of a flatness measurement system to Alcan, Canada.
1977	World's first delivery of a flatness control system to Kobe Steel in Japan.
1986	Launch of Millmate roll force system.
1992	Launch of Millmate strip scanner, development of pulsed eddy current technology (PEC).
1996	Sale of 1,000th Millmate roll force system
1997	Delivery of 300th Stressometer system
1998	Delivery of 25,000th PillowBlock load cell
1998	Launch of new PillowBlock series – Mini PillowBlock
2001	Launch of Stressometer system version 6.0
2002	Launch of Millmate Thickness Gauging system with PEC technology
2002	Launch of Cylmate system
2003	Launch of Web Tension electronics PFEA
2004	Launch of Stressometer seamless roll
2004	Delivery of 500th Stressometer system

In 2001 ABB introduced the Stressometer® system 6.0, the most up-to-date version of the flatness measurement and control system 4. It measures flatness, analyzes and stores flatness data, generates output for automatic flatness control, and presents data in clear, informative displays. Certain features include:

- A flatness server architecture which facilitates upgrading in an open and standardized way.
- Accurate flatness control from the start of the rolling process.
- Improved real-time control and reduced need for constant supervision

Besides the obvious benefit of controlled and improved sheet flatness, the Stressometer® system has contributed to a very clear increase in productivity. Today ABB has an installed base of over 50 percent in heavy applications, and this represents over 500 installations. The average market share over the past ten years has been 65 percent.

Torque measurement – Torductor®-S

ABB's Torductor® torque meter was originally developed in the 1950s to measure the torque of pulpwood grinder shafts as well as propeller shafts in large ships. Even though a few thousand units were delivered, this solution had two major weaknesses: It could only be used on very large shafts and it was unable to measure instant torque.

These weaknesses have now been overcome in the form of a true non-contact and rugged torque sensor without moving parts. Known as Torductor®-S, it has opened up new and diverse markets for

direct torque measurement, including the automotive and aerospace industries, industrial tools and machines, and bicycles. Since the sensor is part of the load-carrying shaft, the measured torque is the true transmitted torque, and a high output signal ensures integrity against electrical or magnetic interference from the surroundings. Therefore, in the case of vehicle engines, the actual torque measured can then be used to lower emissions and improve engine performance. In addition these sensors are also being used to improve power steering and gearshifts. Torductor-S sensors are currently used in many motor sport cars and racing bicycles. They are also undergoing tests in various automotive gearbox applications.

Cylmate®: Diesel engine performance monitoring

In the early 1970's ABB introduced its Cyldet sensor for the continuous monitoring of combustion pressure in large diesel engines. In 2002 the company released a substantially improved version of this sensor together with a new measuring system. Known as the Cylmate diesel engine performance monitoring system, it is the most advanced system for continuous engine performance monitoring. It is designed for diesel engines running at low or medium speeds.

The quality of the data from ABB's Cylmate system means that propulsion machinery can achieve maximum reliability, availability and efficiency; the ship's owner benefits from significantly reduced fuel consumption and maintenance costs, as well as being in compliance with strict environmental standards.

3	PillowBlock Strip/Web tension measurement System.

The Cylmate system is the most advanced system for continuous engine performance monitoring.

4	Smooth as a millpond

The new Stressometer seamless roll with tungsten carbide surface enables mill operators to achieve outstanding flatness of their rolled aluminium and bright-annealed stainless steel strip.

ABB received its biggest order in 2004 from the German shipping company NSB, Buxtehude, for the delivery of 16 complete Cylmate systems, each serving a 12-cylinder diesel engine.

Supplementary products

To complement the Pressductor® and Stressometer® systems, ABB has introduced a thickness gauging system and a strip scanner system. The unique thickness gauging system provides a non-contact measurement technology that is insensitive to strip material and grades, thus eliminating the need for complicated calibration. Both are based on the proprietary pulsed eddy current technology. This ABB technology is based on the measurement of the voltage pulse induced in the coil when the current is suddenly interrupted. After the abrupt interruption of the constant excitation current fed to the coil, the magnetic field produced by the eddy current in the metal sheet is measured as a factor of the voltage it induces in the coil.

By tracing the entire penetration sequence via the voltage induced across the coil, three unique signal values are derived, the distance, the electrical resistivity and the thickness at three different times.

Customers

Customers appreciate the reliability and quality of ABB's Pressductor® load cells, especially those who own and operate flat rolling mills where many of these load cells are to be found. In many cases, Pressductor® load cells are

Torductor-S sensors are currently used in many motor sport cars and racing bicycles.

delivered directly by ABB to end-users but they are also channelled through original equipment manufacturers (OEMs). In fact, the biggest customers in the metals industry are OEMs such as Hitachi, Mitsubishi and Siemens. Large end-user customers in the steel industry include Posco, China Steel, SSAB, Thyssen-Krupp, Union Steel and Bao Steel. In the non-ferrous metals industry, Alcan, Alcoa and Outokumpu Copper are major customers.

In paper and paper-related industries, the largest OEMs are Metso Paper (Valmet), Voith, IHI and Goss Graphics. The biggest end users are companies like Tetra Pak, 3M, Fuji Film, Stora Enso, UPM Kymmene and SCA.

Many new products are directed at new market sectors such as shipping, where customers include shipowners like AP Møller and NSB, and engine designers, for example, Sulzer, MAN B&W and Mitsubishi. Currently, torque sensors are finding use in the motor sports industry where customers include well-known Formula one racing teams such as Ferrari, BAR and Renault, and rally and racing teams, eg, Subaru, Audi and VW.

Current situation and future trends

ABB products based on magneto-elastic technology have been extremely successful in the metals industry, and in particular, in flat rolling mills. In fact, the business has quadrupled over the past 15 years despite the tough market situation created when the Asian crisis began in 1998. In the immediate future, the metals industry will continue to be the largest market for ABB's magneto-elastic sensor products. However, this market is slowly becoming saturated and because of this, increased research and development has been and will continue to focus on new markets and applications. Long-term growth will come from other areas such as engine control and supervision (in the marine and power industry), automotive and aircraft industries. Here's to another successful 50 years.

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