Pressing challenge

ABB's DDC servo technology speeds up press lines

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From Henry Ford's adoption of the moving assembly line more than a century ago, to the large scale deployment of robots today, the automotive industry has often been at the forefront of progress in manufacturing productivity. To achieve further optimization, manufacturers and their suppliers are continuously re-thinking their processes. One candidate with potential for improvement is the press shop – the most capital intensive area of the factory.

The body of a car is typically assembled from several hundred metal parts, most of which are made in presses. The throughput of such presses presents itself as an area with potential for optimization. Unfortunately, increasing the overall speed at which a press runs compromises quality. Time can however be gained by speeding up press actions in between actual pressing. This is the purpose of ABB's DDC (Dynamic Drive Chain) technology. The solution uses servo-motors to reduce cycle times. Furthermore, the technology can be added to existing lines, decreasing risk and protecting the customer's investment.

Significant increases in productivity of flexible tandem press lines at an acceptable cost – this is what the automotive industry is looking for when investing in press shops. Since the press shop is the most capital intensive area in a car factory, investments are not directed exclusively at new lines. The life time of a large press can stretch over several decades – hence operators' desire to be able to upgrade existing lines. ABB is continuously developing new technologies to deliver higher productivity in both new and existing lines.

A press shop produces parts such as car doors, roofs, etc., from flat metal coils. After the blanking operation (in which coils are cut to blanks), the parts pass through a sequence of three to five presses 1. In the most basic configuration of this process, a de-stacker at the beginning of the line takes the blank and loads it into the first press 2 3. Further robots transfer parts from one press to the next; and at the end of the line a robot or human operators place the parts into a rack.

From the aspect of line productivity, the first thing that matters is the duration of a single press cycle 4. This cycle time consists of two parts: One part is entirely determined by the robots (designated T1) and the other part entirely by the press (T2). T1 includes the unloading and loading of the press by two different robots. Typically, unloading starts as soon as the press has opened sufficiently for the unloader to enter it. Similarly, the press will typically start its motion downwards before loading is fully completed. In an ideal configuration, robot and press motions are optimally synchronized. ABB's Stampware software 5 provides this functionality in a standard package.

The basic purpose of servo technology is to permit the press to open and close faster, while maintaining the original speed for pressing.

The motion of the press itself (in the T2 part of the cycle) can be divided into three phases. In the first of these, the press closes, ie moves downwards until the so-called upper die touches the part to be pressed. From this impact point the actual pressing takes place (second phase). Pressing is completed when the press reaches the lowest point in its travel curve, the bottom dead center. From that point on, the press is opening (third phase).

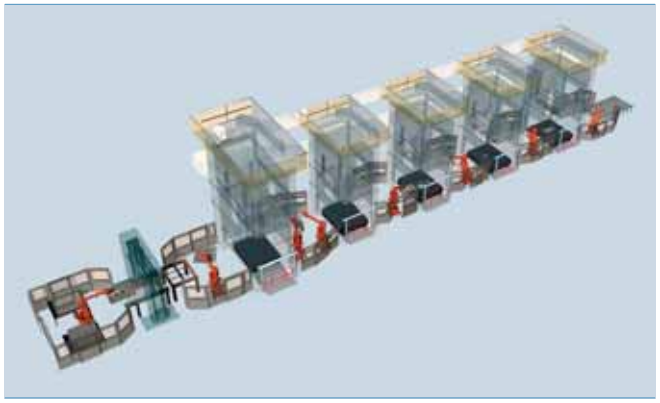
Traditionally, ABB's optimization efforts have focused on the T1 part of the cycle – the time needed by the robots. This attention has been rewarded with success: Innovations such as a special press automation robot, optimized robot placement, robot synchronization techniques and a special seventh axis for the robot have resulted in a reduction of T1 from more than six seconds five years ago to less than three seconds today – even for large parts. However, with T1 being so much reduced, T2 is increasingly becoming the bottleneck.

In a traditional mechanical press, there is no easy way to reduce T2: Speed is dictated by a large flywheel and limited by the requirements of the pressing process. So what means did ABB have to further reduce the cycle time? The addressing of this challenge led to the emergence of ABB's DDC (Dynamic Drive Chain) technology 6i. The development of this technology required intense collaboration between different groups within ABB: notably the global lead center for press automation in Spain and the electrical machines and intelligent motion group at the corporate research centre in Västerås, Sweden. Internal pooling of expertise alone was, however, not sufficient. Strong customer involvement was needed to optimize press line productivity.

Servo technology helps out

The basic purpose of servo technology in large presses is to permit the press to open and close faster, while maintaining the original speed for pressing. In fact, it is even possible to start the pressing at a lower speed than used today and still gain productivity. Slower pressing means improved part quality, the second ingredient to success after speed! Iñaki Zubiete (Robotics and new investments Manager at Gestamp – Estampaciones Bizkaia) explained to the ABB DDC team, that to be able to reach sufficient quality, presses are

1 A tandem press line: blanks are destacked, washed, centered and loaded into the draw press to pass though a series of cutting and punching operations



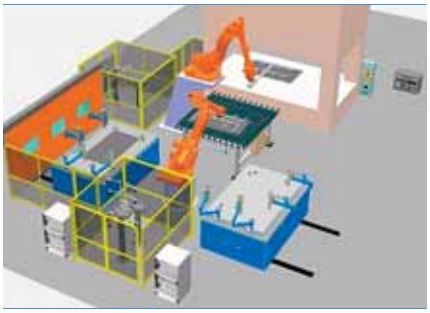
2 An ABB robotic destacker cell in PSA's Poissy factory feeding sheet metal blanks into a press line

often operated at only 80–85 percent of their highest speed, costing 7 to 15 percent of productivity. These figures were confirmed by Santiago Mínguez (Standard Equipment Engineering Manager for Renault Valladolid).

So how much productivity gain can servo technology deliver? Much depends on the dimensioning of the servo drive. To investigate the possibilities on existing press designs, collaboration was started with a press manufacturer: FAGOR. FAGOR is a medium size press manufacturer located in Northern Spain, with whom ABB has had strong cooperative ties for over 10 years. Simulations performed in collaboration with FAGOR showed that even with a rather small servo motor size, a productivity increase between 10 and 30 percent can be obtained using the servo technology alone. Combined with the latest robot automation developments, even higher increases can be obtained!

Limiting the size of the servo drive has been a core aspect in ABB's contributions to servo press development.

3 Robots transferring parts to the press line



While discussing the viability of servo presses with Gerard Lallouette (Structure and Stamping Manager at PSA Peugeot Citroën), ABB concurred that the proposed solution should take into account not only the cost of the press drive itself, but also the cost of the power network in the factory and the cost of energy and peak power. If a large servo press would require 5 MW instead of today's typical 500 kW, this would be a real concern.

A low peak power solution

ABB now offers a servo press drive with a peak power that in most cases does not require redimensioning of the factory's power grid. How is this possible? The secret lies in the control and the drive design, which both started from ideas learnt in previous research projects.

An important aspect of this design is related to the inertias of the moving masses in the press and the drive. While inertias are typically thought of as limiting the dynamical performance of a servo drive, they can in fact be used for energy storage, releasing power when the press drive needs it most.

In a first version of ABB's servo press drive, the traditional flywheel of the press 6f is maintained to give the peak power required during the pressing phase of the cycle. However, in contrast to a mechanical press, there is no mechanical braking, nor is a clutch used to bring the press up to speed. ABB's DDC technology ensures a smooth acceleration and deceleration of the press; and clutching 6g is used after the servo has controlled the press to synchronous speed. In a second version, the traditional clutch and flywheel are eliminated completely, and the servo is dimensioned differently.

A solution for existing press lines

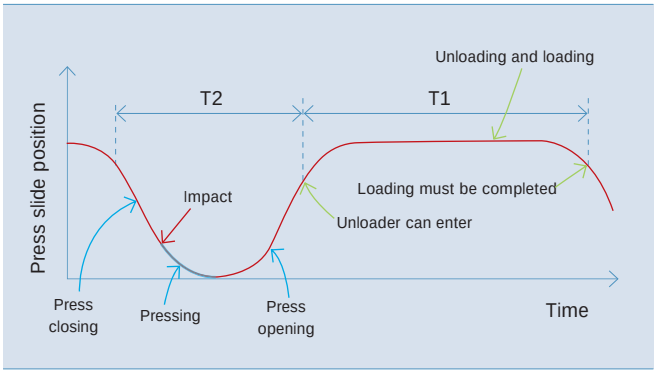
Early in the development of the servo press drive, ABB already discussed the proposed idea with customers such as Gestamp and PSA. The message from these customers was very clear: There should be a servo solution for existing press lines, and it should be possible to get acquainted with servo technology before installing a completely new servo press line. These requirements guided the main thrust of ABB's development efforts, focusing first on a solution that transforms existing presses into servo presses: the *Press Upgrade Kit*.

An important feature, strongly requested by Gestamp and other customers was that this upgrade should be easy to install – well within the time frame of a usual one-month summer shutdown. While such requirements can be considered a severe limitation, it stimulated ABB to design a solution that not only met these requirements, but also constituted a low-risk, reversible solution.

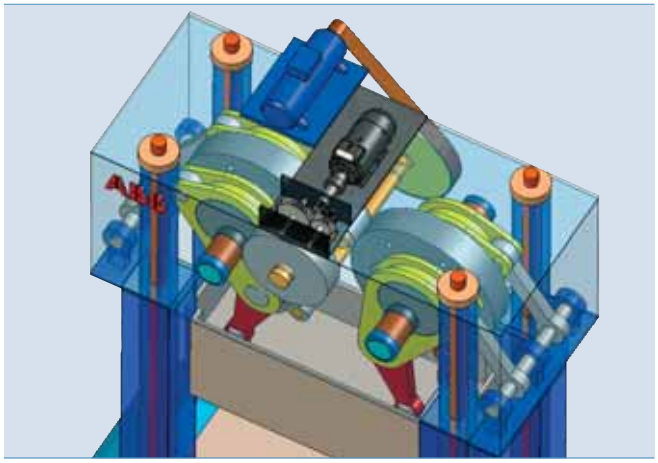
A low risk solution

A customer who is upgrading a press line is usually doing so for a good reason: It can be the production start of a new car model, or – for a Tier-1 – an important contract. So when FAGOR and ABB started to investigate

4 Typical position profile of a classical mechanical press, of which one part (T2) is determined entirely by the press (closing, pressing, opening) and the other part by the unloading and loading equipment (T1)



DDC mounted on a press

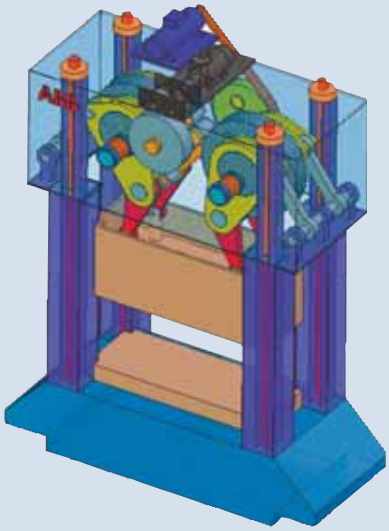


the construction of a first prototype, a main question was whether it could be installed within a very limited time schedule. The solution we designed – the Press Upgrade Kit – can not only be installed in a very short time. If anything unexpected would prevent completing the installation in time, the kit can simply be removed and production can start as planned, using the press in the traditional, mechanical way.

Meanwhile, ABB's discussions with Mr. He, (assistant manager of the No. 1 Pressing department of Honda, Guangzhou, China) led the company to go even one step further: the first DDC servo presses have been designed with a switch that can completely disable the new technology. When switched off, what remains is a classical mechanical press, which can be used in the same way as it has been in the last 50 years.

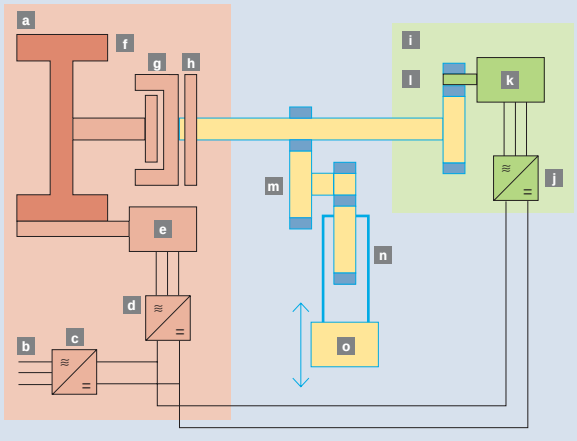
Although the DDC represents a technological leap (the R&D innovations involved go from the new press topologies to the advanced control software), it is built on existing ABB products such as the ACS800 drive and the IRC5 robot controller. This is of great value for the traditionally conservative automotive industry, which will enjoy the benefits of a cutting edge technology while relying on known and proven products that are well supported by local ABB units already serving the industry.

An important question that was raised by both Honda and Gestamp was how the servo speed and acceleration



5 ABB's Stampware is a dedicated software package for ABB IRC5 robot controllers in press shops

6 Schematic diagram of a servo press, showing both the classical mechanical press drive a and the press upgrade kit i



- a mechanical press drive
  - b grid
  - c rectifier
  - d inverter
  - e motor
  - f flywheel
  - g clutch
  - h brake
- i press upgrade kit
  - j inverter
  - k servo motor
  - l auxiliary gear
- m press gears
- n eccentric wheel
- o slide

Factbox 1 DDC (Dynamic Drive Chain)

Traditional automation and press drive systems constituted a typical "discrete" automation case. The different steps of the production process were interlinked by a sequence of "permission signals". The press clutch was engaged when the loading job was finished, and the unloading started when the pressing was done to enable the next loading cycle. This method of operation involved many gaps between the operations resulting in low efficiency. Also, the system failed to adapt itself to the changing conditions on the line, requiring continuous fine tuning to keep a good optimization level.

Some steps were taken to improve this situation, such as ABB's robot to press or robot to robot synchronization. However a total integrated motion control system including the presses has long been unachievable.

In response to this, ABB with its unique combination of robotics and motors and drives expertise, is introducing a revolutionary control and drive architecture that will transform the press lines into a continuous/adaptive manufacturing process: a real Dynamic Drive Chain.

Factbox 2 DDC for press automation

What exactly do ABB's customers expect when working with ABB to automate a press line? While the final goal if of course productivity, there are three key factors for the press shop profitability:

Speed

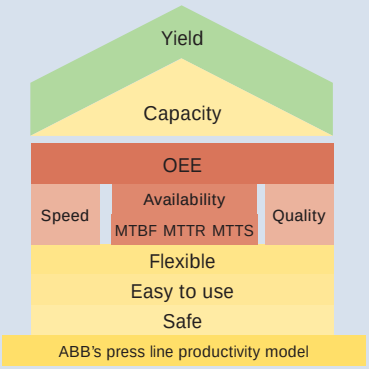
The higher the production rate that equipment can deliver, the lower the capital investment and the running cost needed to run the line (fewer press lines and operators are needed). *DDC brings 10–30 percent increase in production rate.*

Availability

Production equipment has to work without faults for the longest periods possible. *DDC eliminates the clutch and brake failures which are amongst the top 5 downtime sources.*

Quality

Scrapped parts represent a direct loss for operating companies. To minimize the number of rejected parts it is crucial to assure a smooth and slow stamping process. *DDC can bring up to 40 percent slower stamping speed while keeping the same cycle time.*



OEE: Overall Equipment Effectiveness
MTBF: Mean Time Between Failures
MTTR: Mean Time To Repair
MTTS: Mean Time To Service

would affect the press mechanism. As Iñaki Martinez (Stamping Technical Manager, FAGOR) was quick to point out, ABB's servo solution involves much smoother acceleration and deceleration than the clutch and brake for which the current press mechanisms were designed – so the servo will actually increase the life time of the press! In fact, the highest acceleration forces affecting the press die do not occur while using servo control or during pressing, but as the press is starting from standstill using the clutch.

It should also be noted that in the DDC version in which the flywheel is maintained, pressing will be exactly as it always has been, ie, affected by press and flywheel dimensioning only. There are no unknown parameters or settings here – the only setting is flywheel speed. The Dynamic Drive Chain technology automatically and dynamically (hence the name) optimizes the rest of the motion.

Don't stop the presses!

The message ABB received from both Daniel Eguia (Corporate Equipment Manager at Gestamp) and Gerard Lallouette (Structure and Stamping Manager at PSA) was "don't stop the presses!" Today's press lines have intrinsic inefficiencies (start and stop movements, gaps and waits). These must be eliminated by achieving a continuous, optimal and adaptive motion system, a Dynamic Drive Chain. ABB's DDC does this by integrating the control of the press with the control of the robots.

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Future

Recently ABB was told by Schuler, the world's largest press manufacturer that "in the near future, all new presses will be servo presses". ABB agrees but would like to add: "not just new presses…". The trend from mechanical to electrically driven systems in the pressing industry has just begun and will not be reversed. ABB is positioning itself as a major player in this new market with its DDC – while boosting its competitiveness in the automation systems and motors and drives businesses. The first DDC servo press drive will be installed on a 1200 T FAGOR press this fall. Both FAGOR and ABB are looking forward to demonstrating this servo press to their customers!

While the addition of servomotors to the existing mechanical presses is a first step, it is expected that in the mid to long term, totally electrical-driven presses will take over. In strong collaboration with customers such as Gestamp, Honda, Renault, PSA and Nissan, ABB is defining the parameters of the ideal servopress. Through collaboration with partners such as FAGOR, the company can design the drive to fit future servo press topologies of these companies and others. This development should bring even lower cost, simplicity (no clutch-flywheel) and more pressing controllability.

ABB will continue its close cooperation with both customers and press manufacturers to develop the next generations of automated press lines, anticipating customers' future needs and requirements and providing technology that brings more value to their stamping operations.

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