

# Advanced Control Solutions for Flying Shears to improve both efficiency and reliability of rolling mill

## Introduction

The paper is presenting state of the art automation solution to implement high performances control for shears in long product rolling mills. The main benefits of the systems are the increase of safety and productivity, the reduction of costs as well as the efficient and consistent utilization of the equipment.

The topics are:

- Control system applied on new or existing machines & electrical equipment and for both: brake\clutch, start\stop & rotating shears
- High performances, tolerances and cut repeatability
- Solution based on standard market electronic and information technology products with specific mathematical algorithms, deep know how and field experience
- Solutions for:
  - o Roughing\Intermediate shears for optimization & pre-optimization bar length cut & cropping
  - o Dividing shears with strict precision at high speed
  - o Wire rod front head & tail positioning
  - o Axis control to optimize motor usage

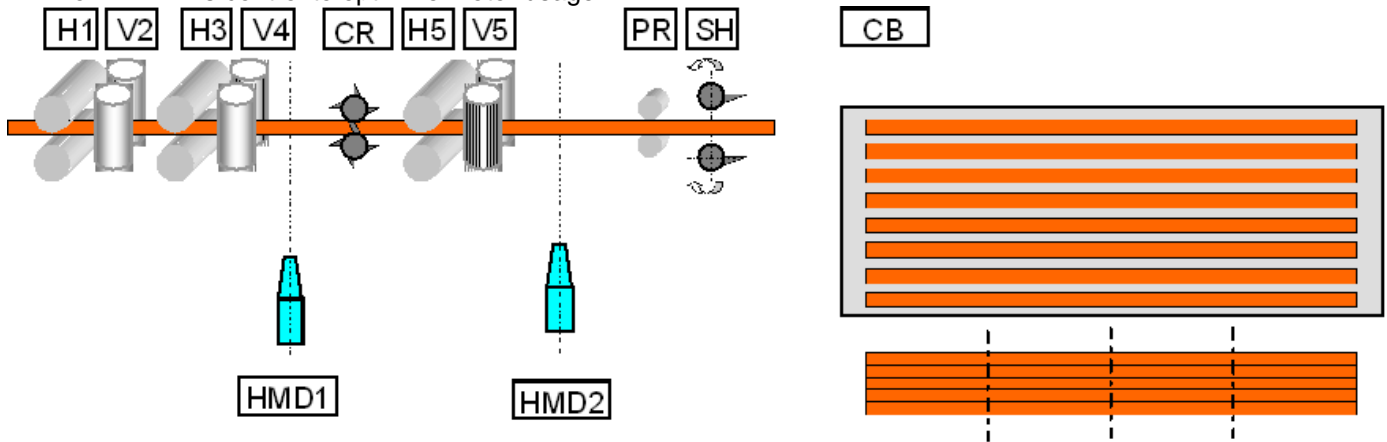


Fig.1 – Typical layout of long product rolling mill

## Description

- H : horizontal stand
- V : vertical stand
- CR : intermediate cropping shear
- PR : pinch-roll
- SH : start-stop shear
- CB : cooling bed
- HMD : hot metal detector

## Typical mechanical configuration of shears

**Clutch and brake shears** benefit of new automation, though accuracy and repeatability are limited by clutch and brake system performance. Main advantage is possibility to fine tune clutch and brake timing to optimize accuracy and friction material life. Moreover, a new control system improves cutting repeatability by minimizing the electrical error.

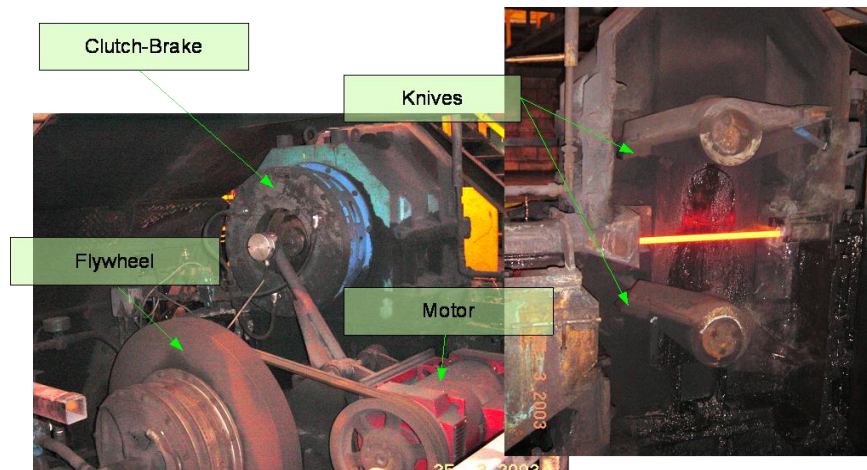


Fig. 2 – Example of brake/clutch shear and its main components

**Start/stop shears** are very similar to the clutch and brake shears, but in this case the motor and the shear gear box are permanently connected. This kind of shears needs a very accurate blade position control to assure high precision and reliability. In existing application, usually it is not necessary to replace the entire system, but it is enough to apply a new motion control system to the existing drive.

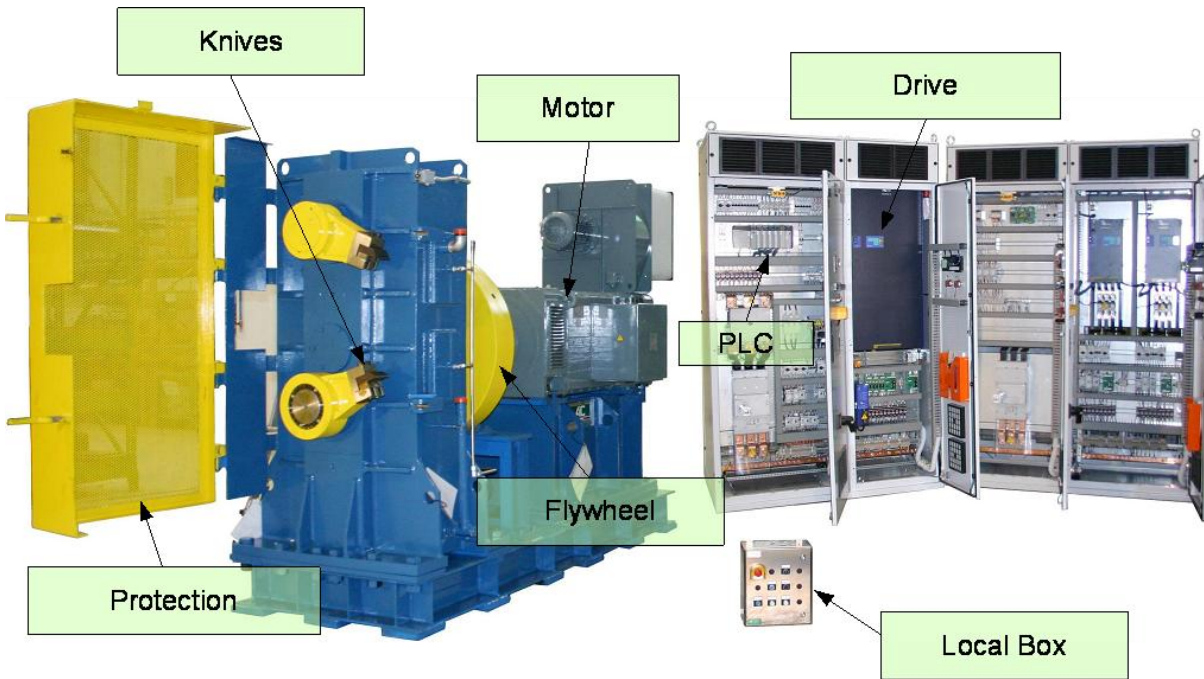


Fig. 3 – Example of start/stop shear with related DC Drive Panel

**Rotating shears** are the leading edge technology when high speed and accuracy are required. These targets are achieved by an optimized combination of motion control strategies aimed to get the best performance with the minimum effort from the machine.

Fast dynamic motion applied to rotating blades and diverter are necessary to deliver highly versatile and accurate rotating shears, capable of doing head and tail crop, scrapping and cut to measure at a speed of up to 100m/s.

A peculiarity of rotating shears is the synergy between a high inertia system (the shear blades) and a low inertia system (the diverter). The big challenge is to use the same motion control system for both parts, optimizing it for the two different tasks.

This is the approach followed by AIC, requiring deep knowledge in both steel process and motion control technologies.



Fig. 4 – Example of rotating shear during the test phase in AIC workshop

### Optimized motion control

AIC combined know how in steel processing and high performance motion control is the key factor to the optimized behavior of high performance shears.

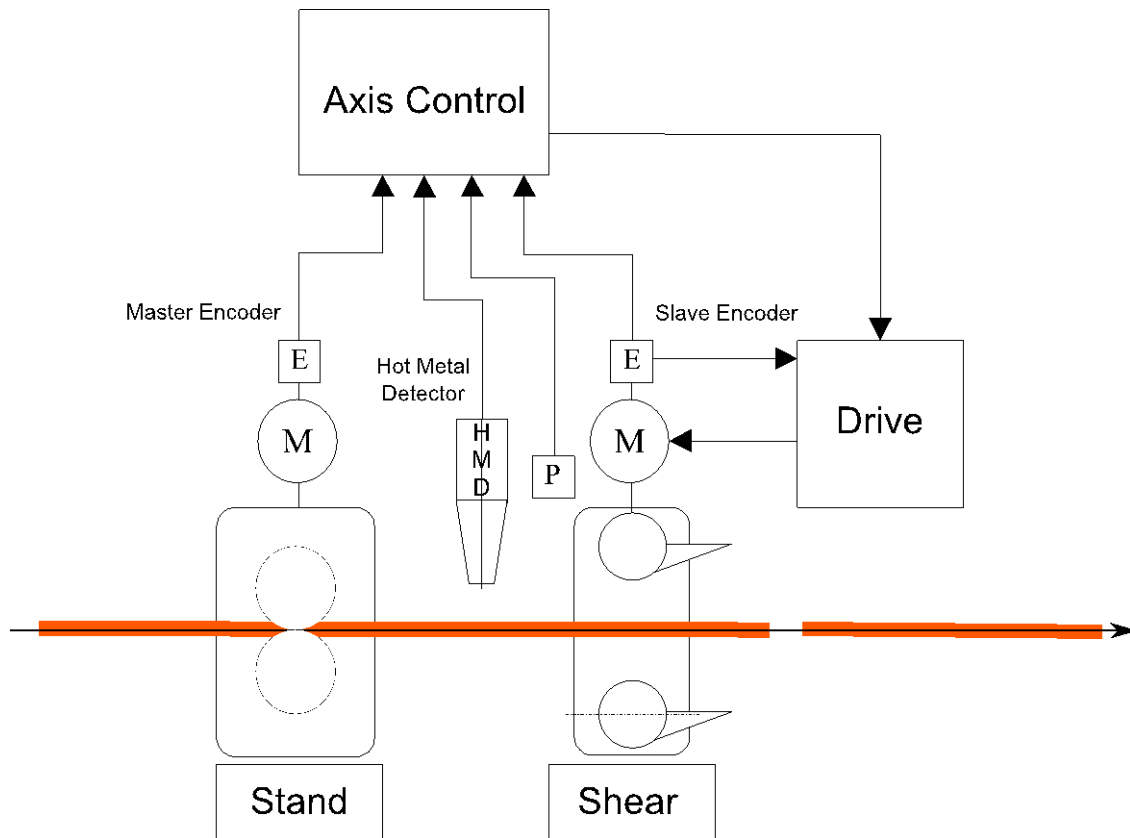
Both start-stop and rotating shears take advantage of AIC motion optimization technologies. These include dedicated motion planning algorithms, drive parameter optimization and fine tuning parameters recording.

All presented control technologies are flexible and support different set ups, that are required for different products and different mechanical arrangements, such as shears with a combination of flying and crank arms and optional flywheel.

Optimized parameters for different productions are easily selected by an integrated recipe system, and combined with automatically computed motion paths bring several advantages:

- Reduce mechanical stress and wear
- Reduce operating noise
- Reduce electrical stress on both drive and motor
- Reduce energy requirements
- Allow a cost effective selection of motors and drives

Fig. 5 – Shear control system block diagram:



The main components of the system are:

- Axis control. It is the heart of the control system. It controls the position of the shear knives to assure precision and repeatability of the cut length. To perform this function it receives as inputs the encoder of the stand, the encoder of the shear, the hot metal detector and the proximity switch and generates as output the speed or torque request for the shear drive.
- Master encoder. It is the incremental encoder connected to the stand motor used to detect the material position.
- Shear encoder. It is the incremental encoder connected to the shear motor used to detect the shear knives position.
- Hot metal detector. This sensor is necessary to determine the head and the tail of the bar for the bar position tracking.
- Shear proximity switch. This sensor it is used to reset the shear position at the moment of the cut.

Start-stop shear typical configuration:

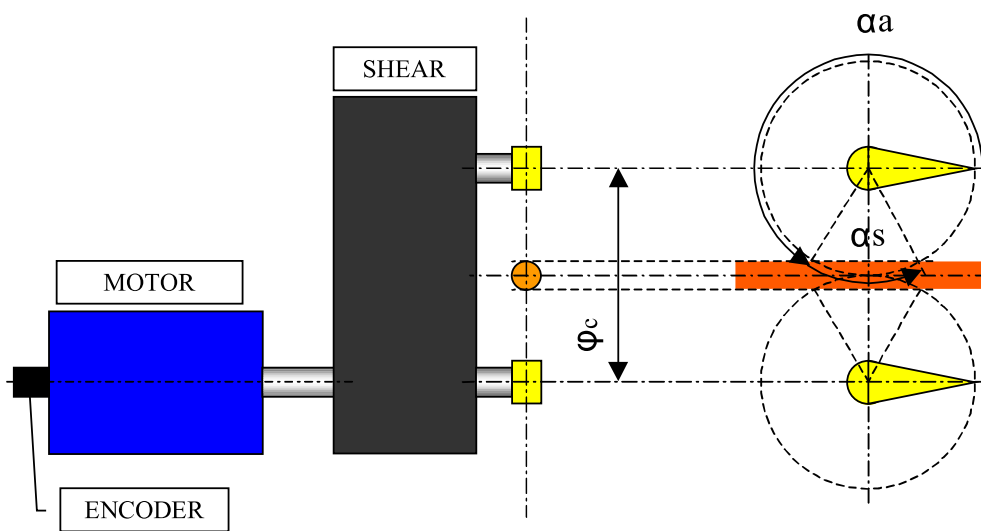
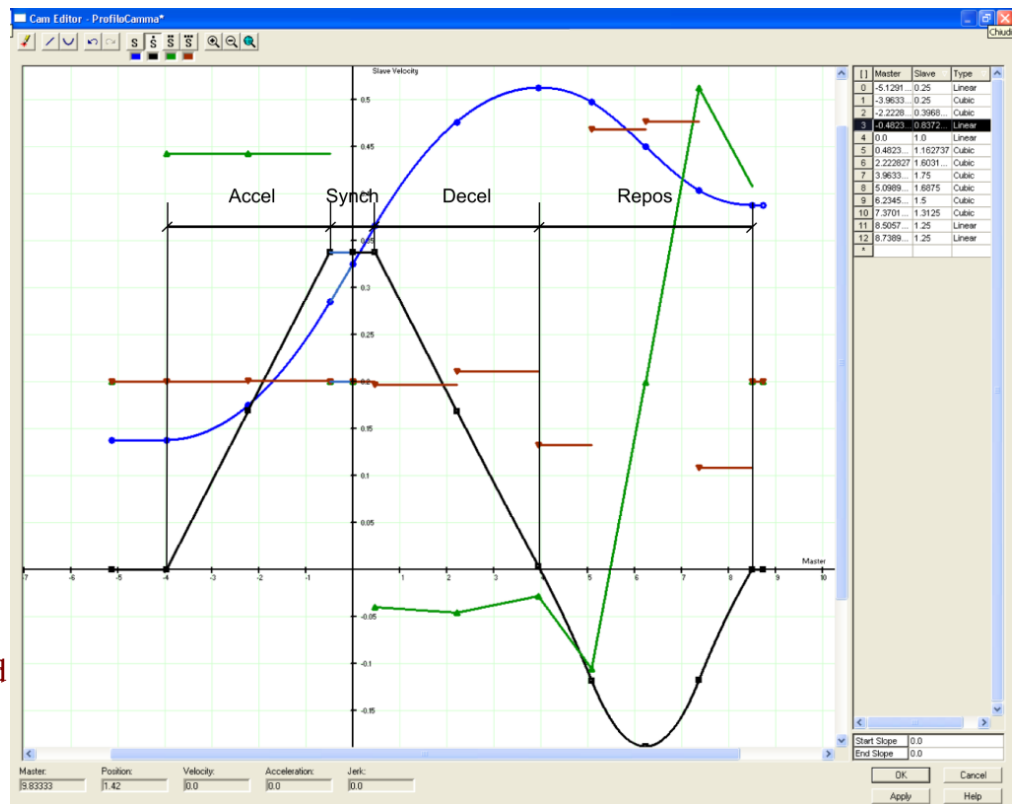
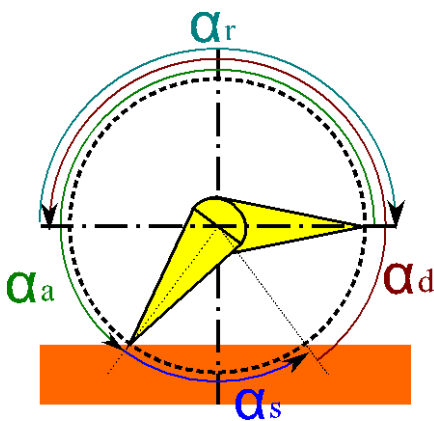
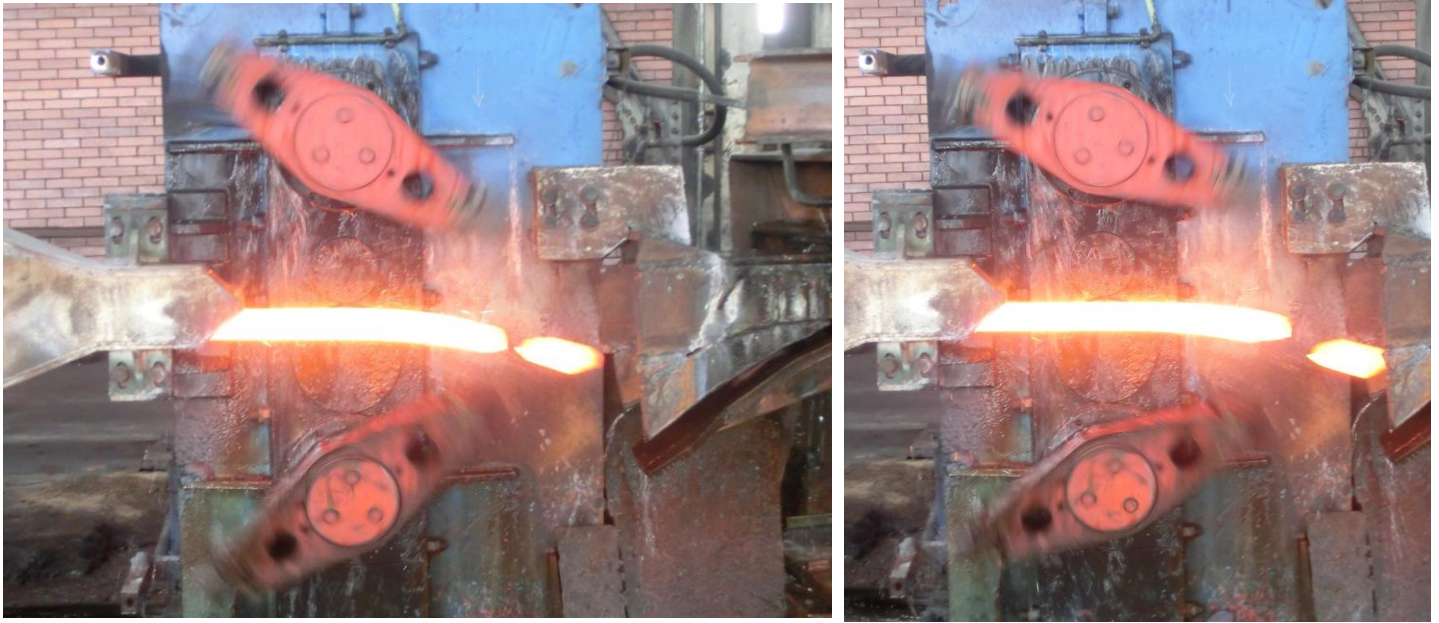


Fig. 6 -7 Details of knives

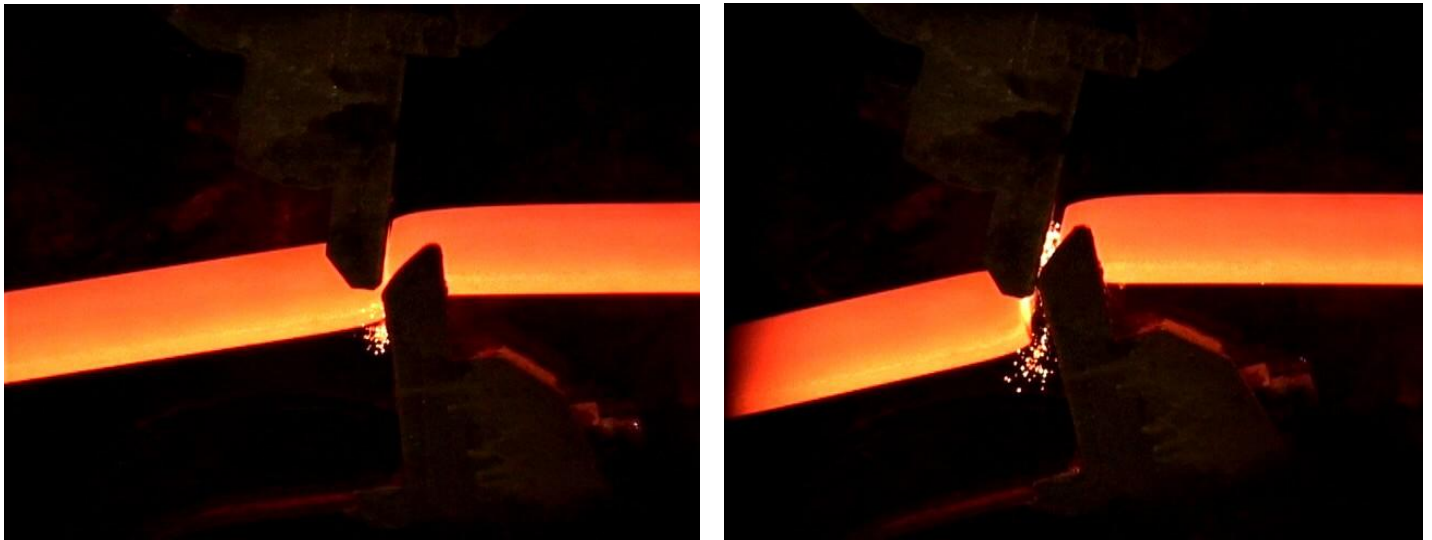
The start-stop shear cycle can be summarized in the following phases:

1. Acceleration. The motor starting from the home position accelerate to the speed needed to perform the cut (synch speed).
2. Synchronization. The motor remains at constant speed from the moment the knives impact on the bar until they exit from the synch angle.
3. Deceleration. During this phase the motor decelerate from the synch speed to zero speed.
4. Repositioning. Starting from the stop position the motor is moved to the initial home position ready for the next cut.





*Fig. 8-9-10-11 – Details and images of cut cycle*



*Fig. 12-13 – Close-up of the cut of a bar*

## Case histories: revamping of obsolete control systems and new automation solutions

### W Silver Inc – El Paso, TX : Conversion from Ward Leonard to Start\Stop control for cropping shear

The long-time know how in shears control system supplies or upgrades allow AIC to help one of its customer to deeply modify an old cropping shear, controlled by a Ward Leonard technology.

This existing system was implemented through mechanical cams and a set of proximity switches that often caused regulation and precision problems; furthermore a similar kind of control system was almost lacking of spare parts and represented a possible threat of plant stops.



Fig. 14 – The existing shear

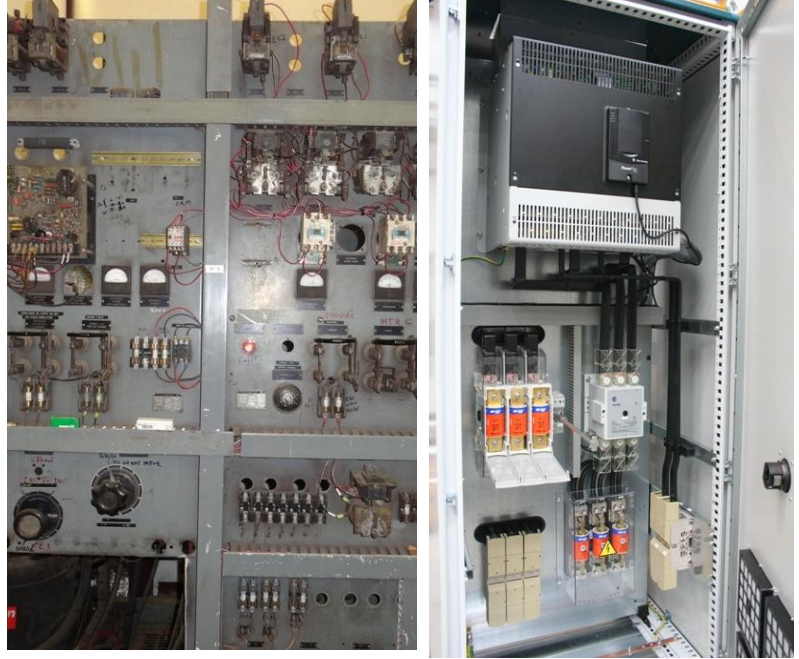


Fig. 15-16 – The old control panel and a new DC Drive Panel (UL Listed)

AIC manufactured and commissioned a **new DC Drive panel**, designed according to **NEMA** rules and **UL listed**, suited to control the existing DC motor (50HP, 230V, 180A at 650 rpm) with a Rockwell Automation DC Drive PowerFlex, rated 667A.

The scope of supply included the PLC control system upgrade and the integration of the shear control into the general automation control system as well as into the HMI supervision system, allowing the customer to achieve a great improvement of shear management and, at the same time, a radical rising of precision, repeatability and reliability of the cut cycles.

### **ORI Martin – Ceprano, Italy: Conversion from brake\clutch to Start\Stop shears**

During a last year project, AIC successfully completed a revamping of n°2 existing shears placed after the finishing stands, installed in ORI Martin Ceprano plant – Italy.

The first step of the job was the mechanical revamping of the machines, accomplished by an AIC's mechanical partner and targeted to transform the shears from brake\clutch to start-stop, through to the elimination of both clutch and brake and the coupling with new motors.

The re-design of the machines was completed by the supply of a proper DC motors (286 kW, 400V, 795A at 660rpm) and a new DC Drives command system, realized with Ansaldo DC Drives 1600A (installed on a new control panels).



Fig. 17 – Shears after mechanical upgrade



Fig. 18 – New auxiliary DC Drives panel

The last step of the job has been the design & commissioning of a new PLC control system with axis control, based on Allen Bradley ControlLogix platform; the scope of supply included not only the head/tail control cut, but also the better control of head/tail positioning in Laying head, thanks to a fine regulation and synchronization of respectively head/tail cut length.

The implementation of this job allowed the customer to achieve an improvement of productive performances from 24 m/s with brake/clutch shears up to 30 m/s with start/stop shears for both wire rod lines 1&2.

### **Feralpi – Lonato Italy: Rotating shear before wire rod block**

The target of the job was the supply of a state of the art control system for a rotating intermediate shear designed to perform head, tail, and cobble cut in a high speed wire rod line.

Mechanical setup included a double pair of rotating blades, installed with an angle from the pass line to help discharging cut pieces, and a low inertia, high speed and high precision diverter.

Rotating blades of the installed shear are driven by a DC motor 250kW – 400V – 683A – 2400 rpm and Ansaldo DC Drive, while diverter is connected to a special fast response and water cooled brushless drive.

Both blades and diverter are controlled by a PLC ControlLogix based motion control system in order to meet the design requirements:

- High cut length precision
- Possibility to cut any length, independent from the blades cutting radius
- Maximum cutting speed up to 30 m/s

All targets were achieved by AIC integrated approach, from drive selection to specific motion control algorithms and commissioning planning.

Commissioning of such a high speed machine required specific tools, like *high speed cameras* with frame rate up to *1000 frames per second* that allowed AIC technicians to prove motion paths to be as designed before hot tests. This helped save both time and cost for hot commissioning since the shear worked fine from the very first bar.

## Conclusions – optimization of each solution

The shears are the most critical equipment in a long products rolling mill and poor performances of those machine dramatically affect the whole mill. The most important part of a shear is its electrical & automation, especially in the start\stop and rotating types; for this reason an excellent control system is mandatory for an efficient process.

Shears have different locations and functions that require several and proper types of controls based on mathematical calculations and algorithms all aimed to optimize each different areas of the plant.

Typically rebar and wire rod productions require shears with high speed control while medium section requires bigger power control, in all cases the designer need deep process know how and experience.

In the case histories the shear control was totally integrated in the mill architecture with great benefits in terms of maintenance, troubleshooting and yield improvement.

As presented above the experience can be the key factor to approach the revamping of the plants and in particular for the shears. In some cases it was possible to improve the speed from 24m\sec to 30m\sec or to improve the tolerances up to  $\pm 1$ cm just replacing the automation part without impact on plant layout or mechanical equipment.

The mechanical and electrical upgrade from old brake\clutch to start\stop shear type helped the producer to achieve better performances and to reduce the maintenance and operational costs.

In conclusion a skilled system integrator is the strategic partner to find the most suitable solution according to desired results of the application and different production.



*Fig. 19 – Example of Start/Stop shear for Bar Rolling Mill*



*Fig. 19 – Example of Start/Stop shear for Bar Medium Section Mill*

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