RECENT IMPROVEMENTS IN ROLL NOTCHING AND MARKING TECHNOLOGIES[1]

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Abstract
Nineties represent a revolutionary decade for the technology of roll indention for rebar production. Pushed by the growing demand coming from customers and market, and thanks to the wide potential of the new generation of CNC machines, some machine manufacturers invested in researches for advanced technologies applied to notching machines. As result of this, the best notching machines are today provided with devices and improved automations that make them able to carry out in automatic some operations that, in the past, demanded dedicated manpower.In particular the paper will analyse: the integration of marking operation in the notching machine, the automatic groove and notch centring, the new technologies for notching and marking squared rebars, the tool compensation and rib depth automatic control, the automatic wire-notch edge chamfering for improving the rebar mechanical characteristics. Together with the above, the new ROLLWORK software for Atomat CNC machines will be briefly illustrated. It is based on a revolutionary concept and integrates the programming of the roll maintenance machines, with a software designed to manage the roll shop inventory.
Key words: Rollwork

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1CNC NOTCH-MILLING MACHINES

Nineties represent a revolutionary decade for the technology of roll indention for rebar production.
On one side the extensive introduction of CNC machines opened a wide range of new performance for these machines.
On the other side the global marked required to rebar producer flexibility, low costs, high quality.
Thanks to the above, the notch milling technology has grown very fast in these years and the demand for these machine has never been so high. In fact the request for new machines came not only from the new plants, but also from several old plants for which their notching machines were not able anymore to cover the new market requests.
While these advanced machines certainly have the potential to fulfil present-day market demands, there is further scope for improvement in technique and process optimisation. Of course these developments can be achieved only if supported by a proper strategy based on a technical exchange or, more preferably, a real partnership between machine manufacturer and machine user to better understand the key points in the related operations and to accept the challenges of new and sophisticated requirements.
Based on these challenging requests ATOMAT developed, in collaboration with machine operators, major improvement in the roll indention technology.

2 ROLL MARKING

One of the most important and appreciated progress in this field, was the integration of the two operations that today are requested for the indention of rebar rolls: notching and marking.
In the past identification marks for rebar were a prerogative of some countries where standardized norms required a clear identification of the producer and/or of the quality of the product. Today, with the exception of marginal markets, the identification mark is required for the large majority of worldwide rebar production. Also, more steel plants are oriented for export production and are then required to meet different standards.
Identification marks are different for each norm, but the requirement of letter and number combination is growing quickly. This is also true in areas (like Europe) where the mark was traditionally provided by modifying the notching geometry. Considering the growing demand of sophisticated marks, rebar producers are looking for equipment able to reach performance and the quality requested by the market at minimal cost to maintain competitiveness.
A new marking philosophy applied to a modern CNC notching machine reached the goal of a low cost, accurate and flexible marking tool.

2.1 Overview of Marking Technologies

The most popular marking equipment in the past was based on the principle of electro-discharge machining. In reality, the majority of the machines are electro-arc metal disintegrators that run as marking machines.
Many years ago, electric metal disintegrators were developed to remove broken drills, taps and punches to salvage expensive components.

An arc metal disintegrator works by creating a sequence of intermittent electric arcs to break the metal into minute particles. The hollow branding electrode, fixed at the head of the machine, vibrates during operation, while a coolant is injected through the electrode for cleaning the powdered metal and to cool the working area (Figure 1). The hole created by the arc assumes the same shape as the electrode shell. Through a proper combination of electrodes, a mark can then be produced.

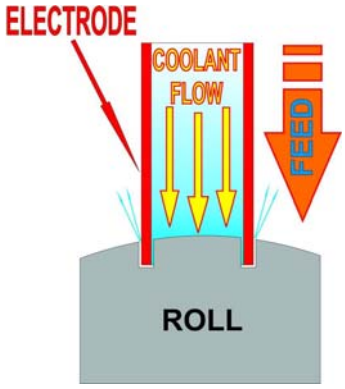

Figure 1. Operating principle for electro-arc disintegrators.

Since size and shape of the burned area is the same as that of the electrode shell, for each rebar size and for each letter/number, a specific set of electrodes is necessary. In the overall marking time, several other time-consuming manual operations must be considered:

- Roll handling from notching to marking machine
- Electrode centering on the groove and positioning for each letter
- Electrode change for each letter

In addition, accuracy of the mark surface generated by an electric disintegrator is limited by the characteristics of this technology. With the growing demand of quality, this can limit the application.

Together with electro-arc metal disintegrators, also sink die electrical discharge machining (EDM) devices are frequently used. In this case, the electrode is solid and works sunken in a dielectric fluid.

Today, burning tungsten carbide with disintegrators and EDM machines is still a risky operation because of rapid heating and cooling of the roll electrode surface. Depending on machining conditions used, cracks and micro-craters can appear on the surface layer. Such heat-affected zones (HAZ) cause cracks of the tensile stress in a brittle material such as the tungsten carbide (Figure 2).

Figure 2. Tungsten carbide roll breakage with EDM marking.

2.2 The Integrated Marking Device

In 2000, Atomat Group developed a new approach to roll marking.
Integration of the two operations (notching and marking) in the same machine has been requested by roll shop people for many years. Recently, this demand has become more urgent due to the growing requirement of accurate marks in international standards.
Several difficulties have postponed the integration of a marking device in the notching machine.
The prototype of such a device was realized and tested in early 2001. Now there are more than 70 IMD's regularly in operation in ATOMAT notch milling machines.
The IMD works by machining with special tools rotating at medium speed. The rotation is provided by a electrical brushless digitally controlled Siemens motor.

Figure 3. Atomat AT 820 E CNC notch milling machine with integrated marking device.

The device is installed on the notching head of the AT820 E CNC machine (Figures 3 and 4). The CNC control used is the same for both notching machine and IMD. A single tool can mark all letters or logos with a tremendous reduction in inventory costs and set up time.
The software for IMD is fully integrated on the same platform of the At820 E notching machine. The new visual interface for AT820 E machine includes all functions for easy and flexible use of the marking device.
The IMD was studied to be used in both tungsten carbide and cast iron rolls. The new IMD can be safely used in marking tungsten carbide rolls since the mechanical milling action does not affect the tungsten carbide structure

Figure 4. Integrated marking device (IMD).

Figure 5. Mark on 16mm rebar, 8-inch tungsten carbide roll

The mark in Figure 5 was performed on tungsten carbide 30 percent binder roll, 16mm re-bar. Total marking time was approximately 12 minutes with 0.8 mm letter depth. Accuracy and consistency of the mark is assured by machining technology and computerized control.
Sometimes the mark is not a simple combination of letters and numbers or the company's logo and machine is able to perform these logos as well.

Figure 6. Some mark logo examples

2.3 A Further Improvement in Marking Technology: Squared Rebar Marking

The latest development in this technology is the application of Integrated marking operation for squared rebar.
Squared rebars are getting very popular in international market for benefits related to automatic handling and bending of this product. Notching of rolls for squared rebar can be performed basically with the same technology of traditional round. It just requires a proper interface that includes also this option. Of course also this rebar has its identification marks. Marking in a squared rebar requires a special technology and a suitable device. In particular the drilling tool must work orthogonal to the surface to be marked, so the device must have the possibility to rotate for this purpose.

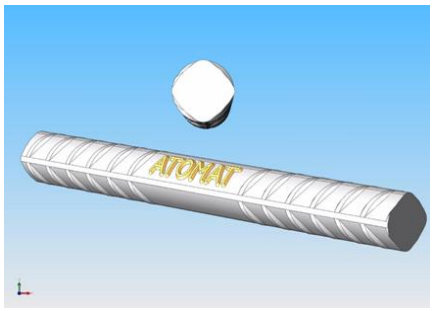

Figure 7. Squared rebar

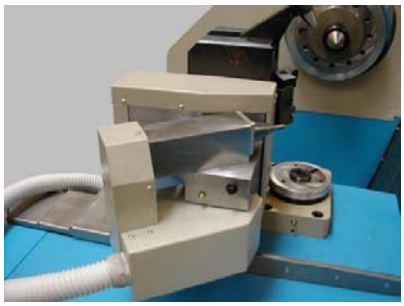

Figure 8. IMD at 45°

3 GROOVE CENTERING AND MEASURING CHECKS

One of the main request coming from notching machine operators, was a quick, easy and safe method to center the grooves. This brought in the past to quite complex systems. Some of them where based on optical devices, some other on two dial gauges. All those methods were in any case demanding operator time and accuracy was in any case based on operator's accuracy.
Finally in 2002 Atomat introduced an automatic system based on an electronic probe for quick an accurate automatic groove centering. With such a device the centering operation can be carried out in automatic, in few seconds and with extreme accuracy. In addition such a devices allows the centering of the existing ribs. This represents a great roll save, since it not necessary remove completely the old notches. Just the minimum worn layer has to be removed, and machine can re-notch the traces of old ribs. For each redressing operations a considerable layer of material can be saved in such a way, ensuring the longest roll life.

3.1 Further Improvement in Groove Centering and Measuring checks: AMCD

Also in this case, based on customers' suggestions, the device was improved to cover new additional operations.
The last version of this device, based on a different and more sophisticated probe and integrated with a new software, is able to measure with accuracy also the depth of the ribs. In such a way it's possible to grant and certificate ribs accuracy of 0.01mm. The tool wear, that is source of modification of rib depth along the notching cycle, can be compensated in automatic. In fact the new AMCD can take measure for each groove of the rib depth and in case of need through the reprise function make necessary adjustments.

Figure 9. Automatic Measuring and Centering Device

4 REBAR CHAMFERING

The geometry of the edge between the bar and its indented notches, largely affects the mechanical characteristics of reinforced bars. Sharp edges represent a weak point in fatigue and bending tests. Frequently mills are requested to avoid such sharp edges (Figure 11).
Smoothing or chamfering of this joining edge can be carried out in different way depending on rebar indention methods, rebar standard and roll characteristics.

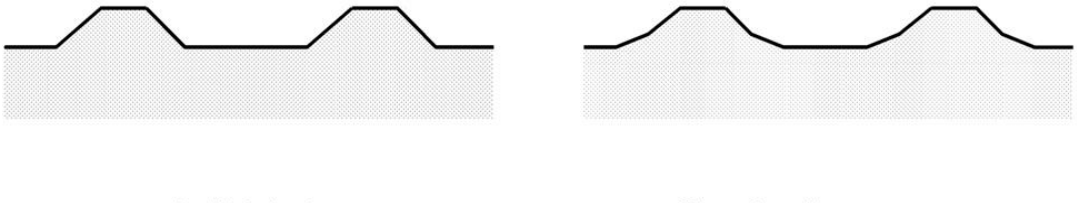

Figure 10. Edges between rod and notches

The major difference is between crescent and concentric rebar.
Transverse section of a crescent rebar, looks like a crescent moon (Figure 11). To achieve this geometry, the notching tool path radius must be shifted from the center of the groove radius. The tool will indent the groove at various depth: it will reach its maximum depth at the groove root and will have its minimum depth close to the groove ends where it leaves the contact.

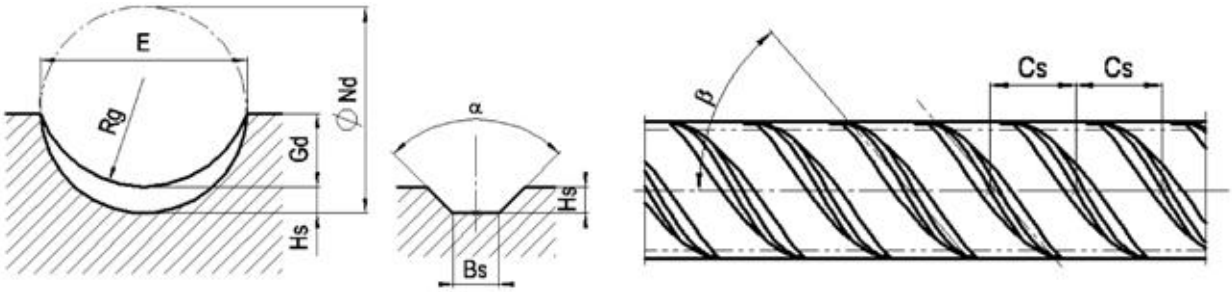

Figure 11. Crescent rebar

In the Concentric Rebar the tool rotating center is the same of the groove and the notching tool enters with the same depth along the whole rib (Figure 12).

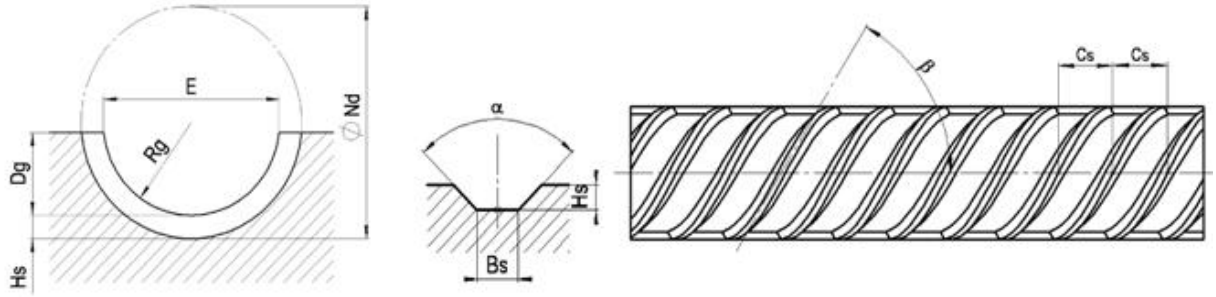

Figure 12. Concentric rebar

4.1 Notch Edge Smoothing

In Concentric ribs the edge smoothing operation is easily carried out during notching, just by using a proper tool shape with a radius on the edge area (Figure 13)

Figure 13. Notching tool for chamfered concentric rebar

The edge chamfering will be homogeneous throughout the whole rib profile (Figure 14)

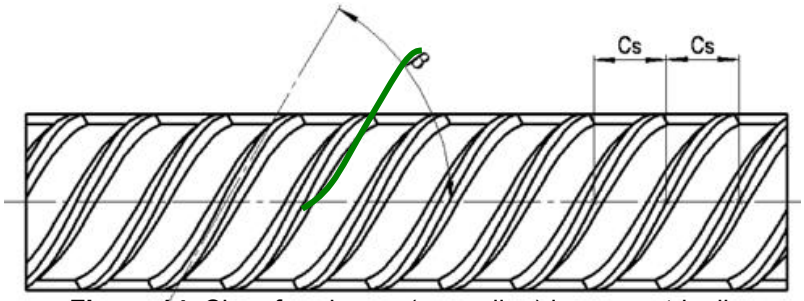

Figure 14. Chamfered zone (green line) in concentric rib

If same tool shape is used in Crescent rebar, since the indention depth changes along the rib path, the tool radius will work only on the central area, where the tool fully enters in the groove. By proceeding toward the groove ends, the tool will work only partially, with its top area, far from the radius and without chamfering performance (Figure 15).

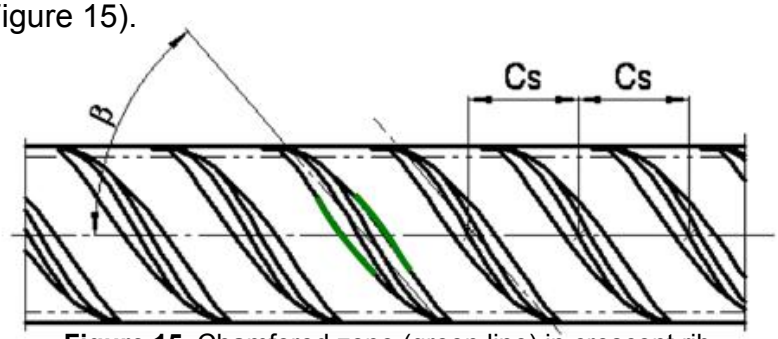

Figure 15. Chamfered zone (green line) in crescent rib

So in crescent rebars, the edge chamfering was always a separate operation carried out by hand with relevant time demand and operator costs. In particular when this operation is carried out on Tungsten Carbide rolls, time for this operation becomes very long and expensive, without considering that a manual operation is typically inconsistent and depends on different performance of and between each operator.

4.2 The Automatic Corner Breaking System

Automation of edge chamfering was pursued for long time and finally became recently a reality with the Automatic Breaking Corner System. The system is based on the operating interface of the AT820 E CNC machine, and does not require additional devices. It can provide a consistent and fast edge chamfering in automatic even in Tungsten Carbide rolls. The operation is performed by the same machine just after the notching operation without moving the roll.

Figure 16. As Notched Rib

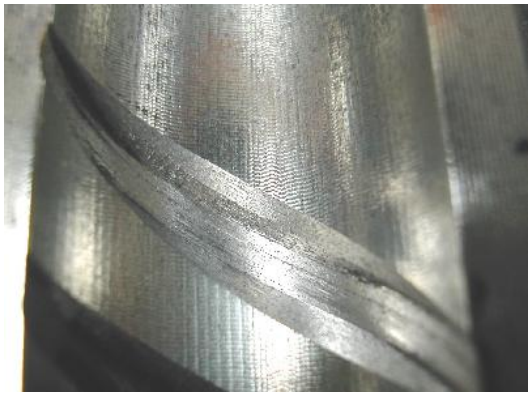

Figure 17. Chamfered Rib

5 ROLLWORK SOFTWARE

In order to manage not only the notching operations, but also all the new additional functions of a modern notching and marking machine, an easy and powerful software interface is very important.
Atomat developed the ROLLWORK software in order to provide customers a simple, easy-to-use device ready to be used by any operator, even if unskilled in CNC programming or without machine tool experience. The software is today a single package able to operate in all Atomat machines for roll maintenance: Turning lathes, Grinders, Notching and Marking machines.
It includes:
- a database to manage all information of rolls in stock and rolls to be included in stock;
- an easy visual editor for all operations ;
- an interface for machine programming;

The ROLLWORK database is specifically designed to handle information of physical roll stock. When the roll is positioned in the machine, it will only be necessary to indicate its code: the database automatically chooses the right program, recalls the data of the roll and selects the working cycles. The machine will operate fully automatically without any further operator intervention, unless the settings given by the machine are to be changed.
At the end of the operation the database is automatically updated with the date and the new roll data. When the life cycle of a roll ends, the following information can be retrieved:

- Date of start up;
- Number and type of operations;
- Average time for each operation;
- Total time (for all the operations).

Through the network interface the data can also be utilized by an external PC for statistic purposes or daily data storage.
The ROLLWORK software is designed to offer the possibility to link all ATOMAT machines installed in the roll shop in a network.
Since the ROLLWORK software can handle all the roll shop operations (turning, grinding, notching and marking), performed by Atomat machines, these machines share one database and exchange roll information via a network interface. This ensures that the roll data are always updated no matter what operation is carried out on the roll.

6 CONCLUSIONS

Partnership between customers and machine manufacturers, can really bring to valuable results. The exact knowledge and the daily practice of the operating procedure are the basis in order to convert the huge potential offered today by the new technologies in effective innovations aimed to improve automation, consistency and accuracy of the notching and marking operations.
The results of these developments are both in cost reduction and quality improvement of the product, i.e. competitiveness in the global market.

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