COMBINED LATHE AND NOCTHING MACHINE TECHNICAL CHARACTERISTICS AND RANGE OF APPLICATION [1]

Fabio Martecchini[2]
Augusto Ivancic[3]
Paulo Masiero[4]

Abstract
The combined lathe and notching machine can be an alternative to the traditional dedicated machines. The machine, to be able to fulfill today's rebar production requirements, has to be specifically designed and must be able to grant the accuracy and backlash absence requested by the notching and marking operations. An innovative technology based on digital ring motor, grants such accuracy and eliminates any backlash even when operating with diamond tools for WC rolls. For the present demanding rebar market, the notching machine must be a complete centre able to provide also marking engraving, measuring and certification of the indented notches and to perform all these functions in easy, automatic and safe way.
The most modern machines like the Atomat AT830 NTE CNC, combined turning and notching machine, are able to fulfil all these requests. Therefore, the choice between a dedicated or a combined machine is not anymore a technical selection based on machine performance since the combined lathe can perform exactly as good as the dedicated machine, but is only based on mill production. Since the rebar yearly cut off tonnage is not a fixed value, it must be evaluated case by case based on mill and production mix characteristics.
Key words: Combined machine; Ring motor; Notching; Marking.

TORNO COMBINADO E MAQUINA DE FAZER NERVURAS CARACTERÍSTICAS TÉCNICAS E APLICAÇÕES

Resumo
O Torno combinado e a maquina de fazer nervuras (nervuradora) podem ser uma alternativa para as maquinas dedicadas tradicionais. A maquina pode garantir todas as especificações necessárias na produção de barras; as maquinas são especialmente projetada para garantir precisão na confecção das nervuras e logomarca. Uma tecnologia inovadora baseada em motores a engrenagens, garante a precisão eliminando qualquer tipo de folga (jogo), podendo-se trabalhar até com ferramentas de diamantes para usinagen de rolos de WC. Para a demanda atual de mercado, a maquina de nervurar deve ser um centro completo e também capaz de realizar marcações, medições e certificações dos trabalhos e realizar todas suas funções de modo simples, automático e seguro. As maquinas mais modernas, como a Atomat AT 830-E CNC combinada, torneamento e frezamento de nervuras podem atender a todas essas necessidades. Então, a escolha entre uma maquina dedicada ou uma maquina combinada não é mais uma escolha tecnológica baseada no desempenho, já que o torno combinado pode executar exatamente o mesmo trabalho de uma maquina dedicada com o mesmo desempenho. Mas somente baseado na produção de laminação. Sabendo que o volume de produção de uma laminação não e fixo, deve ser avaliado caso a caso baseado na produção, no mix. de produtos fabricados e nas características de cada laminação.
Palavras-chave: Maquina combinada; Motor a engrenagem; Nervurado; Marcação.

[1] *Technical Contribution to the 45th Rolling Seminar – Processes, Rolled and Coated Products, October 21st to 24th 2008, Ipojuca - Porto de Gainhas - PE*
[2] *Sales Manager, ATOMAT Group*
[3] *CNC Machines Area Manager, ATOMAT Group*
[4] *General Manager Atomat Services Industrial, Ltda.*

1 MAIN FEATURES OF A TURNING LATHE DEDICATED TO ROLLING CYLINDERS

A lathe dedicated to turn rolling cylinders is, in most cases, characterized by a strong structure in order to allow high speeds and simultaneously to avoid vibrations.
Roll cylinder turning is a very demanding application since the work pieces are heavy and with a high length/diameter ratio. This means that the lathe must have a strong configuration to avoid possible vibrations.
Today, the lathes for these applications are generally equipped with four guide-ways. The reason why is strictly related to the lathe performance; in particular vibration removal. In a four guide-ways lathe, the carriage and the tailstock are mounted on independent guide-ways. This arrangement, on one side prevents vibration transmission while on the other side allows a stronger tailstock design.
Tailstock is one of the critical mechanisms of the lathe. In fact, as the headstock has usually a strong structure; being that it is the foundation of the main motor, particular care must be taken into account during the design of the tailstock.
In the two guide-way lathes, tailstock and tool carriage are sliding on the same bed-way. To ensure the possibility of turning the right edge of the cylinder, the tailstock must be designed with an overhang to allow the carriage positioning under its center. Only in this way the tool can reach that end of the barrel.
Therefore, the extended distance between the left side of the tailstock base and the quill opening (Y in Figure 1) will influence the overall momentum applied on the tailstock. Moreover, due to the fact that such a configuration reduces the room available for the center shaft, its rotation has to be assured by an external box. This means a further increase of that momentum (X in Figure 2).

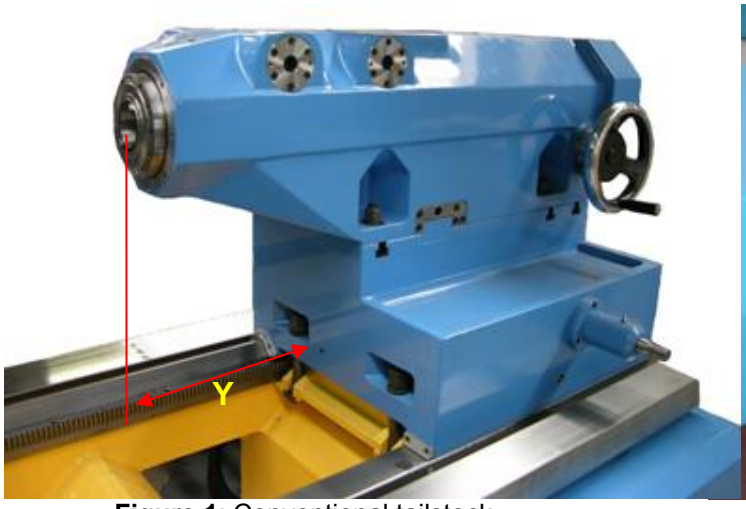

Figure 1: Conventional tailstock

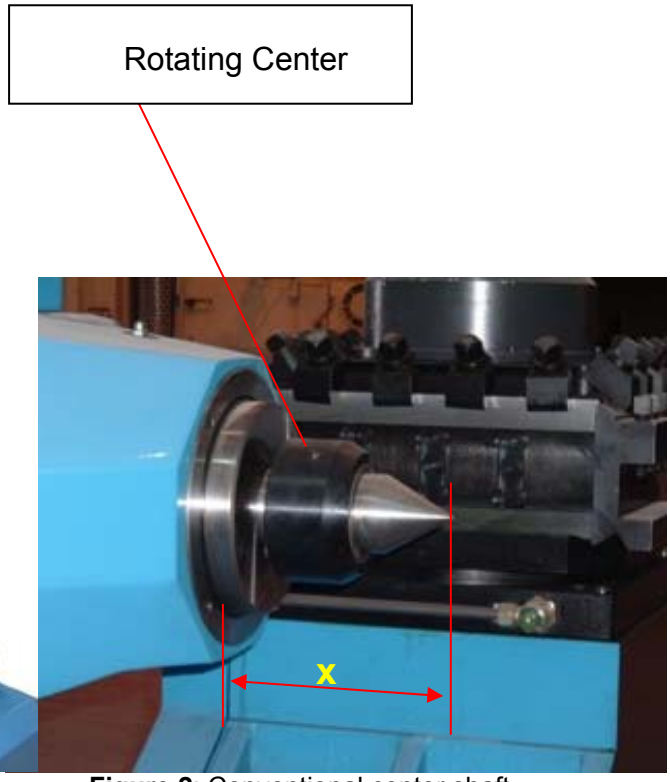

Figure 2: Conventional center shaft

In a four guide-ways lathe, the carriage and the tailstock slide on two separate pairs of bed-ways (Figure 3). The carriage is then allowed to pass the tailstock, permitting the saddle positioning even on the far right end of the cylinder.

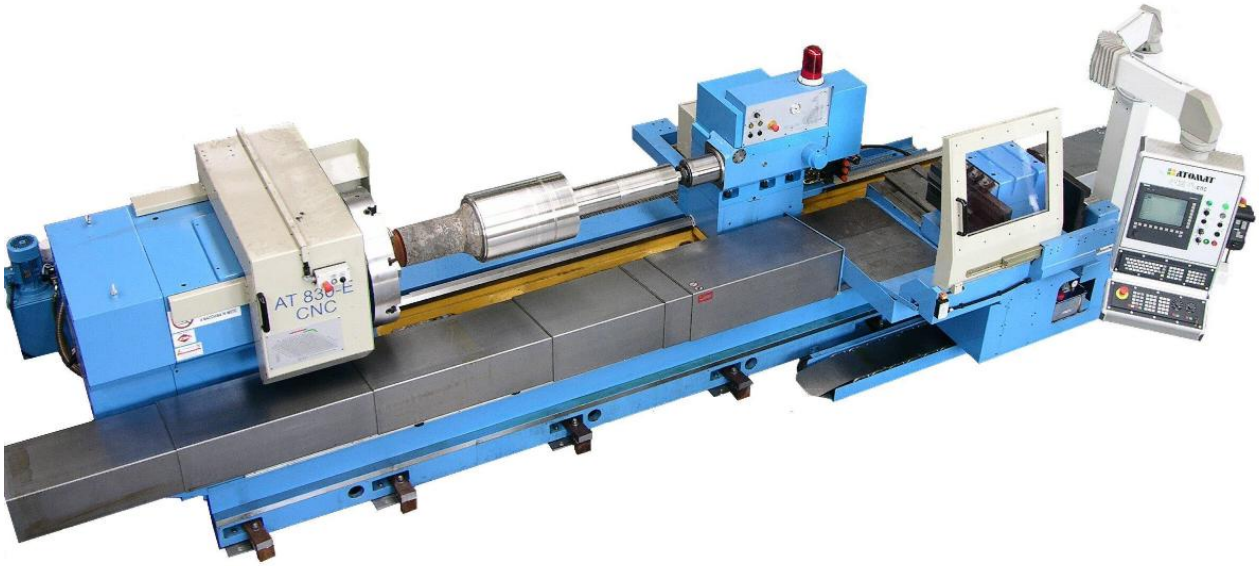

Figure 3: Four bed-ways lathe

This way, the tailstock base can travel over the whole tailstock length and its inner body space is large enough to allow the positioning of a large quill shaft complete with bearings (Figures 4 and 5). A tailstock with a rotating shaft (instead of rotating centre) increases stability and avoids vibrations thanks to the much larger bearing and the shorter momentum put on the tailstock itself.

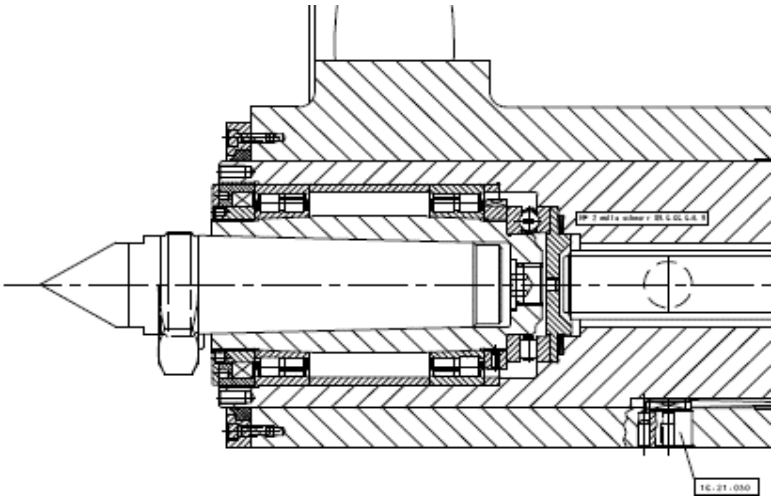

Figure 4: Atomat's tailstock detail

Based on the previous explanation, the four guide-way lathe became much more popular with rolling cylinders applications.

Figure 5: Atomat's tailstock assembly

Normally, when dedicated to rod production, these lathes are best suited with a fixed strong saddle. In fact, in this application, the tool changing is less frequent and a strong fixed saddle (that sometime is able to contain tools ranging up to 60 x 60 mm) provides more suitable performance, both from the technical and commercial point of view (Figure 6).

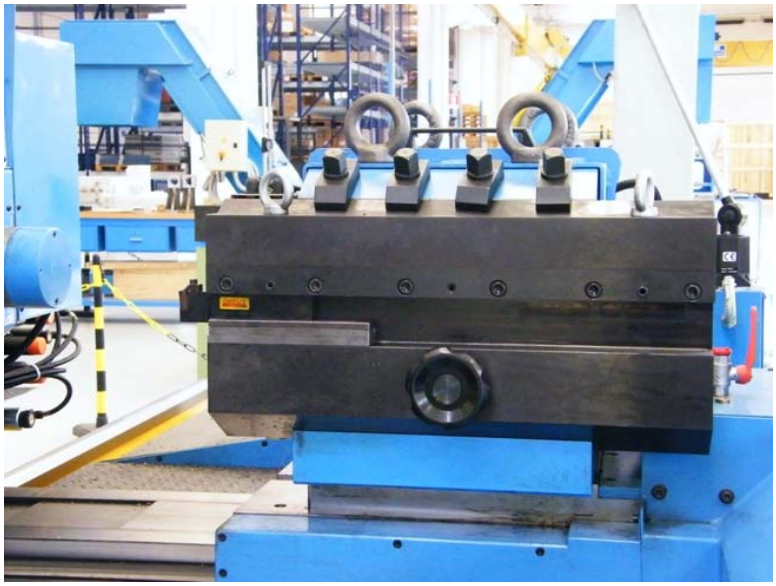

Figure 6: Atomat's tool saddle group

Additional features that are also appreciated, because they grant a fast and secure job, are: the quill and tailstock motorization, the automatic thrusting system and the work piece thermal stretch compensation during operation. Nominal thrusting (as well as maximum and minimum thrusting) is set on the panel screen. In case of variations, the hydraulic system will bring the pressure back to the nominal values by acting on electro valves.
With interrupted cutting operations this system can be switched off. In case of power loss or machine switched off, the expansion elements will automatically put the tailstock in safe position avoiding thus, the cylinder dropping (Figure 7).

Figure 7: Quill and tailstock motorization

2 THE COMBINED MACHINE: LATHE AND NOTCHING MACHINE

The combined machine such as Atomat AT 830 NTE series, has the base structure of the standard cylinder lathes and its saddle is equipped with a notching head that has the same characteristics of the one used in the notching machines (Figure 8). The fastening system on the saddle allows switching from one operation (turning) to the other (notching) without disassembling either group, granting significant time saving if compared with traditional replaceable elements.

Figure 8: Turning and Notching group

The main technical challenge in the design of this machine resides in the fact that speed and accuracy required for the two activities (turning and notching) are completely different. In particular, for notching, it's necessary to operate at very low r.p.m. with extreme accuracy. The two speed ranges cannot be covered efficiently by a single motor. For this reason, all the combined machines are provided with two motors driving the main spindle: one for the turning lathe process and one for notching head operation.

During turning operations, transmission from motor to spindle occurs through gears or belts (Figure 9).

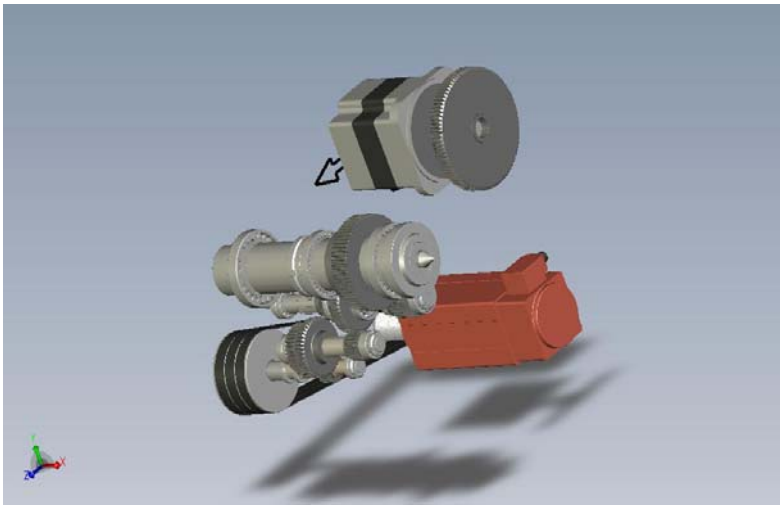

Figure 9: Turning operation driving transmission

Given that notching (but marking even more) requires a very high accuracy and position repeatability, lathe manufacturers always tried to achieve these requirements with brakes, belt pushing, etc. to reduce the backlash generated by power transmission when the machine operates in such configuration. However, these type of mechanical solutions cannot completely eliminate the trouble and, as a result, big problems can occur when exact repositioning in both +/- C-axis is absolutely indispensable. In reality, even a small amount of backlash can cause tool breakage. This situation represents an even bigger economical problem when notching or marking with diamond tools.
Atomat has introduced a revolutionary and proven concept. The notching and marking motor, is a special torque motor, i.e. a digital motor where the rotor is fixed on the main axis (Figure 10 and 11). This configuration avoids any transmissions problems and backlash, and grants the maximum accuracy and the longest tool life.

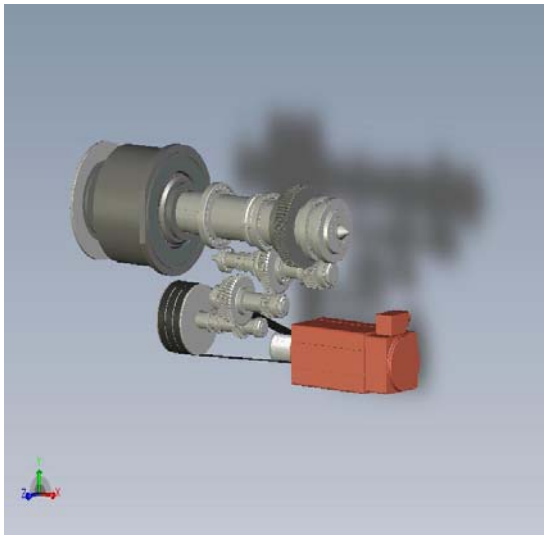

Figure 10: Notching transmission

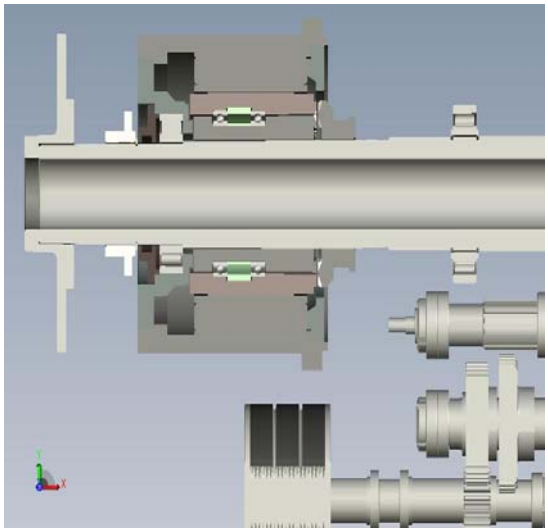

Figure 11: Torque motor detail

The ring motor and relevant power transmission, avoiding any accuracy limitation of a traditional lathe, allows the machine to perform exactly as a dedicated notching machine. Consequently, this new generation of combined machines can be equipped with all the most advanced technologies designed specifically for the notching machines.
That is why our Atomat AT830 NTE, combined machine, can correctly utilize also the Integrated Marking Device (IMD) as well as the Automated Measuring and Centering Device (AMCD).
The first appliance (Figure 12), installed on the saddle, performs the mill marking of all letters and logos; both on Cast iron and Tungsten Carbide rolls with the same accuracy, speed and reliability of any standard Atomat AT820 E notching machine.

Figure 12: Integrated Marking Device

The Automated Measuring and Centering Device (AMCD) can also be installed on our combined machines. These devices (Figure 13) were designed in order to provide fast, automatic and accurate centering of each groove plus rib depth measurement and automatic tool wear compensation.

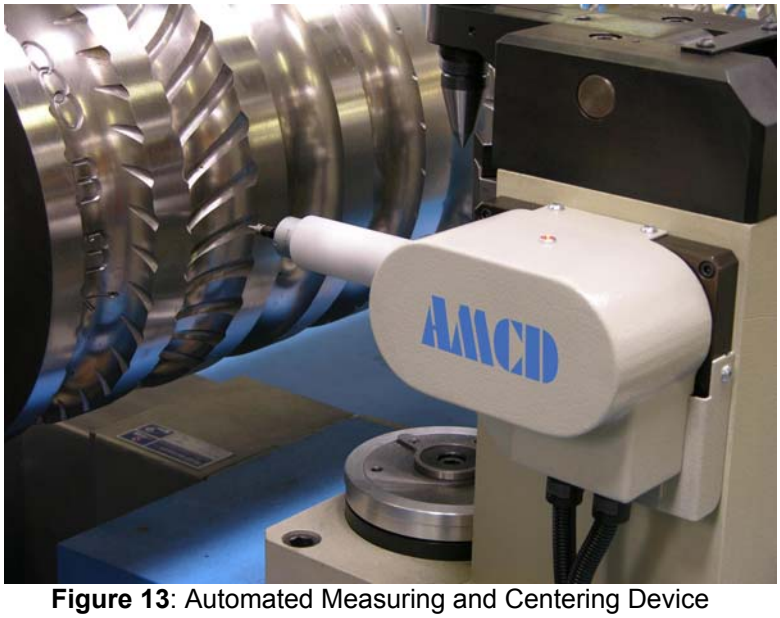

Figure 13: Automated Measuring and Centering Device

The edge chamfering (a practice frequently used to improve break resistance of the final product) can be automatically performed even with Tungsten Carbide rolls as a result of the Automatic Corner Breaking System mounted in the AT 830NTE CNC (Figures 14 and 15).

Figure 14: As Notched Rib

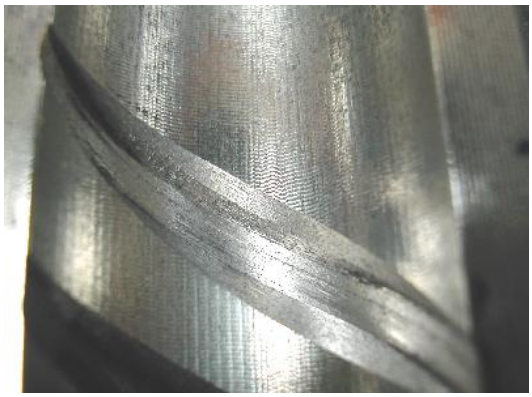

Figure 15: Chamfered Rib

3 ROLLWORK SOFTWARE

In order to manage all turning, notching and marking operations, an easy and powerful software interface is of absolute importance.
Atomat developed the Rollwork software to provide its customers with a simple and easy-to-use device, ready to be employed by any operator (even if unskilled in CNC programming or without machine tool experience).
The software includes:

- a database to manage all roll information; both in stock and rolls to be included in stock;
- an easy visual editor for all operations;
- an interface for machine programming;
- a powerful embedded CAM software.

The Rollwork database was specifically intended to handle information of physical roll inventory. When a roll is positioned on the machine, it will only be necessary to enter its code (ie; serial number). 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 have to be changed.
At the end of the process, the database is automatically updated with the new date and roll data.
When a roll life cycle 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, this 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, in a single network, all Atomat machines installed in the roll shop.
Because the Rollwork software can handle the entire 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

aspect ensures that the roll data are always updated no matter what operation is carried out on the roll.
The embedded CAM software includes a library with all requested grooves for every application, with the possibility of easy implementation of new profiles. The CAM software automatically manages the turning functions, thus not requiring special operator programming skills. In fact, the Rollwork interface just requires the technician to select the profile then it guides him along the data input process.
No separate software, training of specialized personnel or dedicated time for programming will ever be required. In a few easy steps, the machine defines the right sequence for the selected groove (Figure 16 and 17).

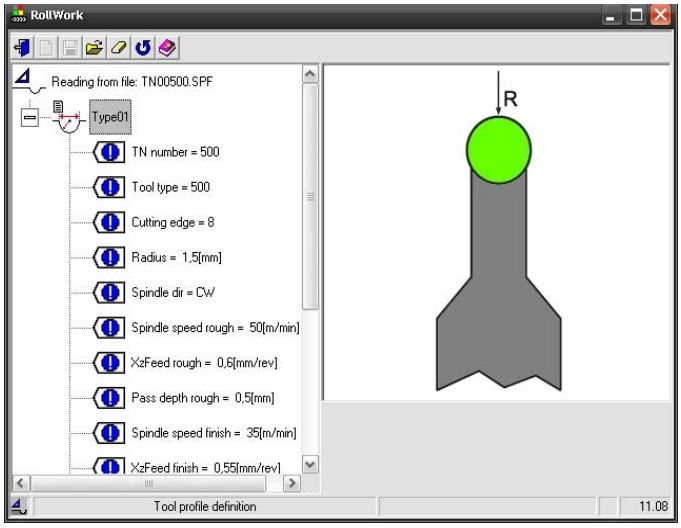

Figure 16: Rollwork display

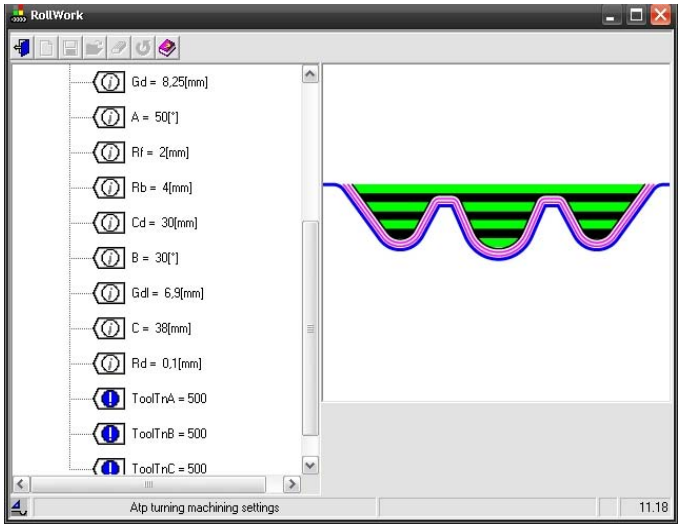

Figure 17: Rollwork display

4 DEDICATED vs. COMBINED MACHINE

Today, the choice between a combined lathe-notching machine and two separate dedicated machines is not anymore associated with the technical performance of the combined machine. In fact, as analyzed in the previous paragraphs, the technology of the combined machines; in particular the backlash-free ring motor system enables the combined machines to have the same performance as the dedicated notching machine.
In the past, with traditional combined lathes, the machine was recommended almost for Cast Iron applications only, since the backlash from a traditional gear transmission was too great for diamond tooling to notch & mark Tungsten Carbide rolls, in particular for the marking operation.
The equipment configuration today is based only on the time demand for each operation, which can depend on several factors. The overall yearly production and the percentage of rebar are not enough to define a cut-off value: mill characteristics and mix of sizes are also two variables that deeply affect it as well the as particular needs in each roll shop.
Whether the mill has a finishing block, or includes Tungsten carbide rolls in finishing stands largely affect the charge of turning operations. The mix, and then the relevant life of the grooves are also very important.
In order to provide a guideline, at least for a defined mill configuration, a 16 stand mill for rod and rebars product was simulated for different yearly tonnage and rebar productions.

The Mix size was based on an average distribution ranging from 8 to 32 mm and the turning and notching parameters, used in order to calculate the time for each operation, are based on average values normally employed in feasibility studies for a new mill.
Of course, case by case results may be different due also to the organization of each mill and its personnel skill level.

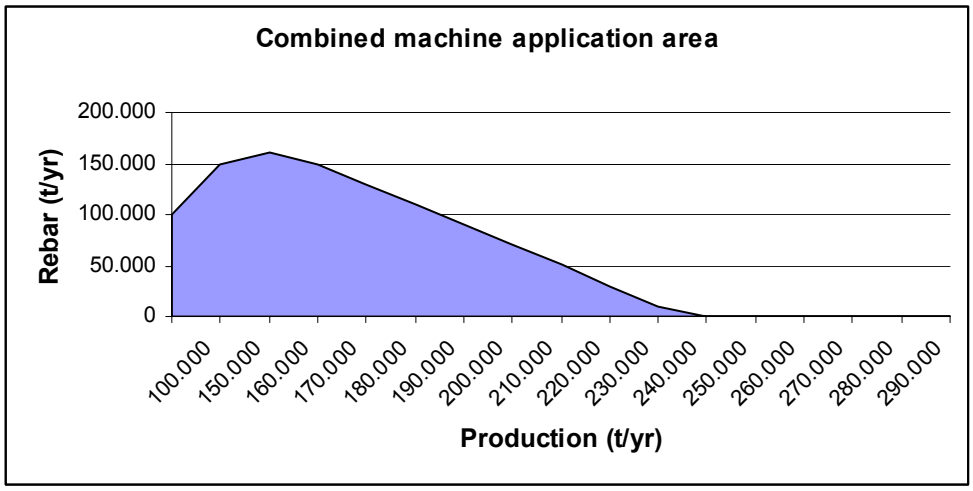

Figure 18: Indicative application diagram for a combined lathe

In the graphic of Figure 18, estimated on the above mentioned simulation, the shadowed area represents the application region for a combined machine.
It must be considered just as an indicative starting guide, from where a dedicated study on each specific rolling mill will be able to provide the data for the final equipment choice.

5 CONCLUSIONS

Nowadays, the modern combined lathe and notch milling machine is a specifically designed machine, not just a modification of a traditional lathe. In particular, the problem of accuracy and backlash freedom for the notching and marking operation has definitively been solved thanks to the introduction of the spindle ring motor. The combined machine is then able to grant the same performance of a dedicated notching machine, including marking, automatic chamfering, etc.
The advanced software programs today available (like Rollwork), are able to grant easy machine programming even for unskilled operators, without the need of other separate software like traditional CAM.
In summary, there are no technical limitations that can exclude the choice of a combined machine.
The machine configuration is only based on the time demand for the various operations. There is not a simple rule that can indicate the precise configuration and the time requirement must be calculated case by case, depending on mill configuration, production mix, etc.
In the paper, a 16 stands mill for bar and rebar different production rates were simulated to achieve an indication of the area of application of a combined machine just as a first guideline that must be confirmed by a specific feasibility study.