Roll shop design and equipment

Pomini Tenova designs complete roll shops as well as designing and manufacturing all the associated machinery. By working with only one supplier the customer has great technical advantages. From the beginning of the project, the layout of the plant is analysed and designed with new optimisation software tools. The machines are perfectly integrated into the plant and exchange data with a central roll shop management system, using the same servers, PCs, PLCs and CNCs, thus reducing the necessary skills for maintenance personnel and minimising spares. With great know-how and multi-disciplinary skills, Pomini Tenova offers several technical solutions to meet customer’s requirements, always keeping safety the highest priority.

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Historically, roll shops were often designed by steel manufacturers who bought equipment from individual suppliers and integrated them in the best way possible. Often this was not perfect or, at least, proved to be very difficult, due to the fact that strict co-ordination between several companies, though necessary, was not always achieved. Pomini saw steel manufacturers’ need for a better solution and, during the 1990s decided to move from the design and manufacture of roll grinders alone, to a turn-key solution including the design and manufacturing of all the main components of roll shops, as well as their integration.

THE COMPLETE ROLL SHOP: AN OVERVIEW

Automatic Loader System (ALS) An ALS creates a ‘cell’ inside the roll shop which can grind rolls and decide the grinding priorities without personnel supervision. The ultimate task of this cell is efficient production of rolls at a constant level of quality, allowing operators more time for other activities in the roll shop.

The ALS is basically a CNC-controlled crane (automatic loader) with gantry or semi-gantry layout and two or three controlled axes according to customer needs (see Figure 1), and which runs on rails in a dedicated automatic area, most of which is dedicated to roll storage. The operators fill the storage area with rolls to be ground and from this point onward, all the roll handling and grinding operations are performed automatically. The roll loader missions are optimised to achieve the best performance in terms of precision, accuracy and diagnostics. The roll is lifted or lowered by means of a special tong fitted to the loader’s hoist. The tong can be provided with a broad range of accessories and features to handle any kind of roll, with or without chocks; among them there is the possibility to adjust the distance between the grippers and to have two chock tilters which are able to rotate the chocks by 90° on board the loader. This operation is sometimes required before the grinding phase because of the particular shape of the chocks when grinding with chocks on.

Choking-dechocking machine Another machine of paramount importance in a roll shop is the chocking-dechocking machine, whose goal is to safely perform the extraction and insertion of chocks from and onto the rolls (see Figure 2). We can design and manufacture devices dedicated to work rolls, to back up rolls or to both of them in a single machine (combined chocking-dechocking machine), and for all types of mill.

The chocking-dechocking machine for work rolls usually comprises several stations, one next to the other, which
support the rolls when they are lowered from the main crane. Their number is decided by the customer’s production requirements after analysis by Pomini’s engineers. Two extractor carriages traverse each side of the stands and each carriage is provided with a top car, which can move perpendicularly to it, in order to approach the chock, grab it and perform extraction and insertion in the opposite way.

Due to the lower frequency of maintenance of back-up chocks compared to work rolls, the machine dedicated to back-up rolls usually comprises a single station. This central unit comprises four rollers on to which the roll is loaded with the main crane. Two extractor carriages on rails, one on the drive side and one on the operator side, are capable of clamping the chocks and perform the chocking and dechocking operation.

In the past, Pomini has also designed a combi machine that can extract and insert chocks of both the work rolls and the back-up rolls. The layout is similar to the one dedicated to work rolls, except that the last station is designed to support a larger back-up roll.

All functions are controlled through a Siemens PLC which communicates with the Roll Shop Management System (RSMS) and the WinLoader software. These two elements work together to schedule and keep track of roll movements in the roll shop, keeping updated information regarding the roll inventory, and providing useful statistics to help roll shop managers make better decisions.

The advantages of the risk analysis and design review, performed during design phase, significantly improve safety and ergonomics of the operation. As an example, the chocking-dechocking machine is controlled by handheld radio controllers in order to give the operators more freedom of movement and safety.

**Chock tilter** The chock tilter is a very useful auxiliary machine for chock maintenance. It performs a 90° rotation to the horizontal position which is necessary for bearing extraction. Thanks to this machine, the operator can avoid the dangerous operation of tilting the chock improperly using the main crane. The criteria that inspired the design of this machine includes a system of safety fences and interlocked gates to prevent the operator falling into the foundation pit.

**Shear blades** A grinder dedicated to the shear blades of the mill product cutting system is a new product in the portfolio. These grinders are capable of resurfacing straight blades up to 600kg and 5.5m long and comprise an electro-welded steel bed with a magnetic table on which the blade is positioned by magnetic clamping forces (see Figure 3).

A carriage with a grinding wheel traverses along the bed using an axis motor and linear roller guides which provide the necessary accuracy and stiffness. All the movements are CNC controlled to allow precision and repeatability.

**Auxiliaries** Pomini is able to supply other auxiliaries such as the washing machine for chocks and bearings for work rolls, the cleaning and preserving tanks, for the maintenance of Morgoil bearings, the cleaning cabin for washing the roll before the grinding phase, the cooling down station, whose goal is to lower the roll temperature when it enters in the roll shop prior to the grinding operation, the roll transfer car which transports the rolls from and to the mill, all the racks for the roll storage and jib cranes.

**ROLL SHOP LAYOUT**

The feature that probably most characterises the Pomini...
approach to roll shop design is the integration and location of the equipment in the shop to optimise logistics. The process to obtain an efficient shop involves several aspects. First, we have extensive experience and know-how to help the customer choose between several scenarios for the best production results even if the data are not all available.

Second, the use of roll shop simulation software (RSS). Even today, the common philosophy adopted for designing the layout of the roll shops is the static approach. Various pieces of information are analysed without considering the mutual influences of the machines on each other during roll shop operations. The approach has its limitations. First, it is not possible to rigorously monitor the consequences of a particular choice through time: e.g., assessing the effect, after some months or even years of running the roll shop, of decisions like installing a grinder in one location rather than another. Moreover, it is difficult to take into account the variability in mill and roll shop performances, which is always present, but requires a high level of experience and knowledge to be synthesised in useful indications.

In recent years, Pomini decided to move from the static approach to a dynamic one, thanks to RSS, developed jointly with the Politecnico di Milano (see Figure 4). The simulator software is able to drive the layout designers to the best solution from the several preliminary layouts. The roll shop machines are divided into three groups: grinders, transporters – which include roll handling devices such as automatic loader systems, transfer cars and cranes, and auxiliaries – and the machines required for maintenance, chocking dechocking machines, chock tilters, etc. The software associates each item belonging to the three groups with a database of management rules, defining their influence on the roll shop performance including, for example, the rate of arrival of rolls in the roll shop and the process time on both grinders and auxiliaries.

The simulator initially needs a preliminary configuration to be analysed. The number of machines for each group are initially assessed with the static approach, then the simulation is run and, within a few minutes, the results are displayed. With this software tool, several layout configurations can easily be tested, and the best chosen.

A good example of the usefulness of this tool is the design of the layout of the ATI ALC roll shop in 2010. The design was complicated due to the lack of space for the rolls and equipment to be installed. In these conditions, optimisation was necessary to obtain the required performance.

The initial idea was to place the automatic area and the related roll grinders as close as possible to the transfer cars of the finishing work rolls (see Figure 5). This choice appeared optimal, since they have to be ground eight times more often than the rougher work rolls and the back up rolls. In such a situation the back-up roll grinder was supposed to be installed at the south side of the roll shop, while the maintenance area for the back up rolls was at the north side. The automatic area for work rolls was going to be placed between them.

In fact, limited room prevented this arrangement as, although the flow of the finishing work rolls was extremely smooth most of the time, it was very inefficient when the

Fig 4 RSS schematic

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rougher work rolls and the back up rolls had to be ground at the same time as the finishing mill work rolls. In fact, the first main crane, which was dedicated to the finishing work rolls because of its lower load capacity, would have been continuously blocked by the second main crane, the only one capable of handling the back up rolls and rougher work rolls, whose mission would have been to transport them from the area at the south end of the roll shop to the one at north.

Pomini proposed another solution (see Figure 5) by shifting the automatic area towards north side; in this way it was possible to concentrate all the machines dedicated to the back up and rougher work rolls at the south side, thus eliminating the inconvenience of having the two main cranes blocking each other. The disadvantage of this solution was the increased distance of the automatic area from the work roll transfer cars. However, with the aid of the roll shop simulator, we were able to demonstrate that, long-term, it was worth adopting the new layout since the cranes were managed in a better way and did not cause queues during the contemporary batch changes.

MACHINE DESIGN
After defining the plant layout, the next step is to have a precise idea of the layout of all the machines to be installed. Each is unique so the variety and flexibility of the solutions that Pomini can suggest is an advantage for the customer.

The ALS for the Thyssen Krupp Compass project in Calvert, Alabama is an example of flexibility combined with expertise. In the cold rolling mill roll shop the customer had asked for a loading system without a dedicated automatic area so as to have complete access for operators, transfer cars and forklifts in the zone. This required us to completely redesign the goal, mission and philosophy of the ALS such that the idea of an automatic area became a new concept, the ‘semi-automatic’ area. The fences with interlocked gates were removed so operators could remain in the surroundings of the loader during operation. We installed radar devices which would stop the loader operating if an obstacle (an object or a person) came too close to the working zone.

The loader was designed with a different philosophy: its mission was conceptually split into several steps, and each needed the permission of a dedicated operator (supervisor) to start (normally the supervisor just gave permission at the beginning of each mission). Once permission is given, the loader automatically handles the roll without supervisor input. To improve supervisors’ control and view, a pulpit was installed on board the lower head beam of the loader, from where they can safely monitor every operation.

This change in philosophy also influenced the design from a mechanical and structural point of view. The requirement of a semi-automatic area, crossable by operators and
machines like forklifts, required that the bottom rails of the loader had to be installed at the same level of floor, to produce the smoothest surface, without gaps or steps.

The standard Pomini layout of semi-gantry loaders uses guide rollers on the bottom head beam, to maintain good alignment of the crane along its travel, as well as discharging the relevant forces due to the bridge’s skewing. In this case, their presence would have required us to make a wide housing for the bottom rails in the concrete, preventing safe passage for the forklifts. Therefore, the engineers decided to install the guide rollers on the top head beam (see Figure 8), introducing at the same time a hinged connection between the girders and the leg beams (see Figure 7) of the loader, thus changing the static structural scheme of the loader. In fact, the installation of the guide rollers on the top head beam, while keeping a rigid joint on the leg beams and a lateral constraint on the bottom wheels (the lips on their edges), would have introduced a statically indeterminate scheme in the structure of the loader. This would be a disadvantage from the point of view of stress during the loader’s functioning, in particular with non-perfect alignment of the rails or with heat deformation.

**Integrated design** Pomini’s design philosophy helps in obtaining a set of machines that are perfectly integrated with each other and with the rolling mill. A good example of integrated design is, once again, the Thyssen Krupp Compass Project where the automatic loaders were given two special missions: the first was to assemble and disassemble the cold mill roll pairs in their cassettes, transporting a single roll with chocks to the chocking-dechocking machine, then transporting the roll to the grinder.

The second was similar, but dedicated to skin pass rolls and intermediate skin pass mill rolls. The rolls were taken on their racks, transported to the chocking-dechocking machine, and then to the grinders. In order to manage all these types of rolls, with and without chocks, a special tong with four grippers was designed for the automatic loader. This has the capability of handling rolls either on the shoulders or the ends, according to the particular configuration, in such a way as to perform safe lifting even from the cassettes designed by the customer, which were very narrow and offered limited space during the lifting. The two central grippers lift the SPM/ISPM rolls (with chocks) on their shoulder (see Figure 8), while the external ones lift the same rolls without chocks and the TCM rolls with and without chocks (see Figure 9). To horizontally adjust the external devices to the several configurations, the tong was equipped with two beams, which slide inside the central structure, thanks to special heavy duty bearings. For the vertical direction a degree of freedom was introduced on both sides, enabling the tong...
optimal distance between the supporting rollers is always achieved, without any overturning risk. The various positions of the rollers are connected with each roll type, so the operator, using the remote controller, controls the machine with discrete positions, which is the easiest and safest method.

**MANUFACTURE AND ASSEMBLY**

The manufacture and assembly of the machines are steps Pomini follows with great care as we know their importance. For example, on the beds of the grinders, which constitute the base of the machine, strict dimensional control is required. In particular, the hydrostatic guides and the carriage guides which slide on the bed are machined with extreme care. However, the interface check between the carriage and the bed is still directly performed by workshop personnel who carefully verify the surfaces to obtain the desired hydrostatic performance and stiffness.

The same philosophy is adopted for spindles. Each part is dimensionally checked and then assembled by well experienced members of our spindle team. The set-up of this critical component involves several steps. First, the spindle is measured without oil pressure; then the hydrostatic bearings are activated and new measurements are recorded, to check geometry, gaps of journal bearings, and the pressure drop on restrictors. Provided that values are within the desired tolerances, the spindle can be tested with rotational movement. In this case, measurements of flow, temperature and pressure are taken to monitor that the mutual influences of these values were under control. The spindle is then ready to be tested with load during a grinding session after a careful calibration of the wheel.

Another example of strict care in assembly is the bed of the new machine MW479, dedicated to cluster mill rolls. The bed is made of a particular polymeric granite, in a single unit, on which the front and back parts of the machine are mounted (see Figure 11). This material combines stiffness with damping, but requires accurate analysis of its geometrical features, which depend on the state of polymerisation of the granite itself. The bed to handle rolls on grinders, chocking dechocking machine, cassettes for the cold mill and racks for ISPM/SPM.

**Safety**

The approach of integrated roll shops is strongly linked with the engineering of safety, since every technical decision is taken together with Pomini’s safety team. An example of this interaction is the chocking-dechocking machine for back up rolls for the ATI ALC project. The customer required the chocking-dechocking operation on all the back up rolls, included those of an existing cold rolling mill. These rolls had a much shorter barrel (1,400mm) compared with the new HSM, up to the point that a very narrow station was necessary to support them.

On the other hand, this narrow station would have been extremely slender for the roughing rolls of the new mill, which has a barrel 1.5 times longer. The risk analysis identified a risk of overturning these rolls during removal of the first chock as the weight of the roll, together with the weight of the remaining chock, would have been enough to cause the instability of the whole assembly.

To design a safe machine, we used a central station with movable supporting rollers and, thanks to hydraulic cylinders and heavy duty sliding pads, the central frame is capable of adjusting the distance of the rollers in the direction of the roll axis (see Figure 10). In this way, the
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can be machined once this stage has been completed. A high level of precision is required, particularly on the wheel carriage guides, since there is no chance of later adjustment, the bed being a single block. Thus, compliance to the strict tolerances in their planarity and linearity is of critical importance in having a smooth wheel movement and an even load on the wheel.

The same approach is taken with auxiliaries for roll shops. Our workshop is equipped for the assembly of such machines even though, to achieve a virtually infinite production capability, Pomini has established a network of specialised and qualified sub-suppliers.

CONCLUSIONS
Since the 1990s Pomini has been a leader in the design and manufacturing of complete roll shops. Our portfolio of machines includes grinders, automatic loader systems, and several auxiliaries for the maintenance of rolls and chocks. We have the experience and know-how and a new software tool to help our customers achieve maximum efficiency in the roll shop from the early phases of the project in which the layout is designed.

Our machines are the result of the flexibility towards the customer’s needs and multi-discipline skills, together with the engineering of safety, elements which let us choose between several technical and innovative solutions. Pomini’s high quality machines are also built on the mutual interaction between the design department and our workshop, which applies the strict specifications during the manufacturing and assembly phase. This synergy, together with an attitude that is always open to new challenges, has been key to Pomini’s success in the world market, and is the basis for future achievements. *MS*

ACKNOWLEDGEMENTS
We would like to thank Giovanni Bavestrelli, Guido Matarazzo, Rick McWhirter, Filippo Negrini, Silvia Soldati and Emanuele Vanini who contributed to the paper.

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