SMALL STREAMS MAKE BIG RIVERS: INNOVATIVE DESIGN & OPERATION OF 2 STANDS REVERSING MILL EXPANDABLE TO PLTCM*

Johan PEERS[1]
François DUMORTIER[2]

Abstract
Today, solutions to optimize Capital Expenditure (CAPEX) & Operational Expenditure (OPEX) for small capacity Cold Rolling Mills (CRM) as well as for high capacity CRM are available, as extensively described by various Original Equipment Manufacturers (OEMs) & steel makers. A suitable solution for small capacity CRM is to start with a single stand reversing mill (up to 400 ktpy, depending on product mix), which can then be expanded into a twin stand mill (up to 900 ktpy, depending on product mix). The main drawbacks in conventional practice are the off-gauge length in single stand set-up and the long downtime of the mill during the erection of the second stand. For higher productions CRM, it is common practice to directly select a new Pickling Line Tandem Cold Mill (PLTCM), with a high CAPEX. Is there an in-between solution that would allow to start with limited output and CAPEX, without jeopardizing the ultimate expansion goal (1.2 to 2 mtpy), for which PLTCM is the best techno-economical choice? In the absence of a solution, JOHN COCKERILL developed an integrated solution that limits the CAPEX in the first phase of development, without crippling affecting future endeavors through an easy and economically sustainable expansion into a PLTCM, without long production downtime. The solution consists of first installing a twin stand mill, expandable into a tandem mill thanks to a smart design of the line. It is therefore possible to limit the production to 900 ktpy in the first phase of the project and then convert the mill into PLTCM in the second phase to increase the production from 1.2 to 2 mtpy, depending on the market trends and financial capabilities. In summary, JOHN COCKERILL has developed a smart new layout in reversing phase combined with a brand new rolling strategy to optimize productivity and limit off-gauge, compared to conventional solutions (patents pending). In addition the layout enables an easy conversion to tandem mill without high over investments, which is more sustainable financially than the initial purchase of a PLTCM. Long downtimes to allow for capacity extension, detrimental to this phase-by-phase approach, are also avoided. Technical and process description of the new layouts and rolling strategies, together with CAPEX & OPEX descriptions of the phases are detailed in this paper.
Keywords: Reversing Mill, Twin stand, Tandem Mill, PLTCM.

[1] *Mechanical engineer, Proposal engineer, John Cockerill Industry, Seraing, Belgium*
[2] *Mechanical engineer, Product Line Manager Pickling and Rolling, John Cockerill Industry, Seraing, Belgium*

** Technical contribution to the 11th International Rolling Conference, part of the ABM Week 2019, October 1st-3rd, 2019, São Paulo, SP, Brazil.*

1 INTRODUCTION

In recent years, while the global steel market has been showing both a decline and overcapacity, regional differences have been observed. Asia, and in particular South East Asia, is still an expanding market, with some countries showing considerable growth. Thus steel producers and equipment suppliers are not only faced with challenges in terms of quality, sustainability or digitalization, but also with an important need for flexibility.

In this context arises the question of upgrading mill equipment according to annual production trends. The most common reversing rolling mills are the single stand reversing mill (RCM) with an annual production typically lower than 400,000 t, the two stand reversing mill (also called “twin mill”) with an annual production typically lower than 900,000 t and the tandem mill (TCM) with an annual production greater than 1,000,000 t, as illustrated in figure 1.

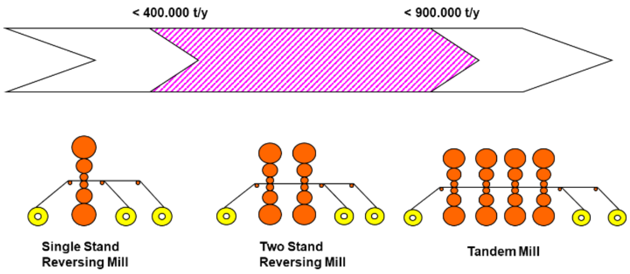

Figure 1. Available cold rolling solutions depending on yearly production

Generally, cold strip producers firstly invest in a single stand rolling mill. The growth of their market and subsequent need to increase production then leads them to invest in a second single stand rolling mill, despite the fact that two single stand rolling mills are less effective and more expensive than a twin stand mill.

Compared to two single stands mills and tandem mill, the advantages of the twin stand mill are low investment costs (CAPEX) and low operative costs (OPEX), despite a lower overall production rate. The flexibility and the wide range of product mix also present an advantage.

There is therefore a strong need to be able to upgrade mill capacities in order to, for example, step up from a single stand rolling mill into a twin stand mill or from a twin stand mill into a tandem mill or PLTCM. Equipment flexibility is at the core of the concept. It allows to adapt to future market requirements, a criteria for investment.

On the market, there are well-documented solutions for the upgrade of single stand into twin stand mills. However, these alterations have the drawback to necessitate a shutdown time of 6 weeks, leading to a tremendous loss of production. The innovative concept developed by JOHN COCKERILL (patent pending) provides a flexible twin stand mill easily converted into a PLTCM or into a continuous tandem mill. The main advantages of this ingenious invention are the significant reduction of upgrade investment and shutdown time, compared to the prior state of art.

3 RESULTS AND DISCUSSION

3.1 Innovative layout

In order to avoid high investment cost and long shutdown time during the upgrade of the twin stand mill into continuous mill, the eventual revamping needs to be already thought-out during the initial stage.

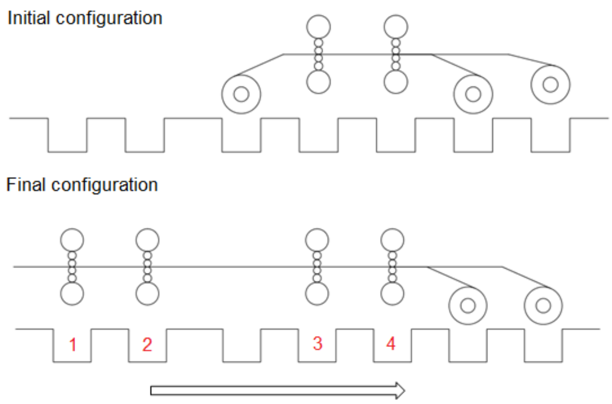

Figure 2. Schematic layout of the concept

Compared to a conventional twin stand mill layout, the JOHN COCKERILL concept's (see figure 2) main differences are:

- The civil work for stand #1 and #2 is already ready for a future extension. Appropriate space is kept between the foundation of stand #2 and the delivery tension reel of the twin stand.
- During the initial stage, the roll coolant tank is already designed for the capacity for four stands.

Thanks to this configuration, stands #1 and #2 can be fully erected in record time. This means that following items are already installed before the shutdown:

- Complete stands including all equipment inside the housings;
- All equipment between stands #1 and #2;
- Motor and gearbox of stand #1 and #2;
- Bridles, steerings and coupling looper for PLTCM operation;
- Additional hydraulic power unit and valve stands;
- Roll coolant instrumentations and pumps for stand #1 and #2;
- Additional lubrication for new gearboxes.

During shutdown, only the delivery tension reel of the initial reversing mode needs to be dismantled and a connecting table between stand #2 and #3 needs to be installed (as seen in figure 3). The automation system also needs to be modified for PLTCM operation. By following this erection procedure, the shutdown time and, thus, the loss of production is are drastically reduced.
Furthermore, the foundation used for the pay-off reel of the twin stand mill can be used again for another recoiler in order to reduce the exit T0.

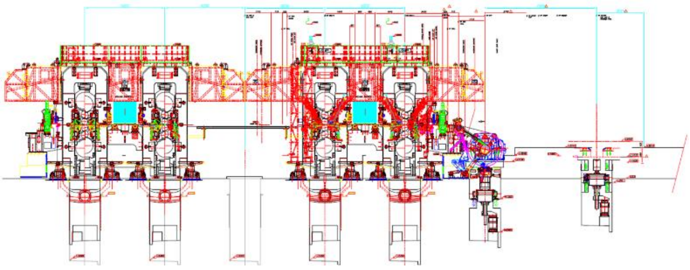

Figure 3. Final layout after conversion in PLTCM

3.2 Even pass strategy

This innovative concept for the conversion of a twin stand mill into PLTCM is closely linked with a new rolling strategy also developed by JOHN COCKERILL. Indeed, in conventional reversing twin stand mills, coils are either extracted from the delivery or from the entry tension reel. In other words, the pass schedule has even or odd numbers of passes depending on the incoming and final products. With the new JOHN COCKERILL rolling strategy, which consists of solely using even numbers of passes, the initial investment is reduced compared to standard twin stand mills, the yearly production is increased and the conversion to PLTCM, described previously, is faster and less costly.

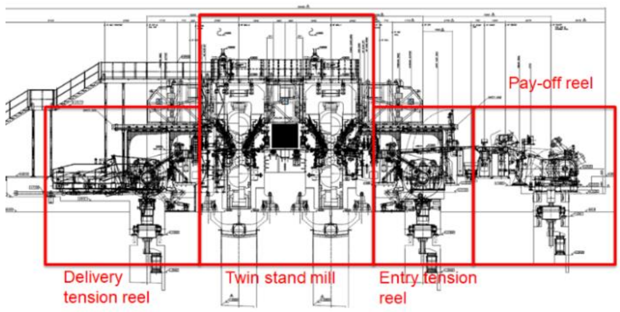

Figure 4. Conventional layout of twin stand mill

The advantage of the even pass rolling strategy in terms of CAPEX is obvious. The following items can be removed, compared to a conventional twin stand mill layout:

- Shapemeter between the delivery tension reel and the stand #2;
- Selective cooling at the delivery side of stand #2;

Exit equipment at the delivery tension reel.
This results in significant savings when supplying the line.

The benefits in terms of productivity with this rolling strategy are less obvious. Indeed, some coils previously produced in odd numbers of passes (1, 3 or 5) are now produced using an additional pass (2, 4 or 6). How is it then possible to reduce rolling time with this strategy? This can be explained by various parameters.

The first positive effect of the even pass strategy on productivity is linked to coil to coil time. When the coil is removed at the delivery tension reel, the head of the following coil has to wait until the mandrel is free and ready for the next coil (threading table and belt wrapper in place). In contrast, when the coil is removed at the entry tension reel, the extraction of the previous coil can be done is record time, and the delivery tension reel is left free to receive the next coil (see Figure 5).

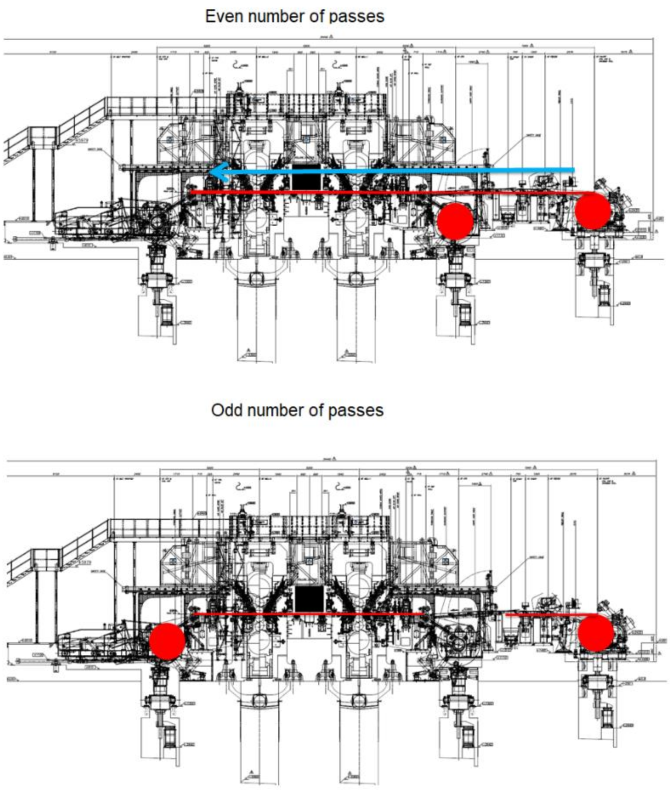

Figure 5. Coil to coil time comparison between conventional and even pass rolling strategy

Another important advantage of always extracting the coil on same side is that work roll roughness may be different on each stand: higher roughness at stand #1 for final roughness transfer at last pass and lower roughness at stand #2 for better reduction capability. Furthermore, oil concentration can also be adapted independently on each stand: low concentration on stand #1 in order to produce clean coils for batch annealing and high concentration on stand #2. Those two main assets lead to a lower friction coefficient in the roll bite of stand #2 which increase the reduction capability and reduce the required torque at the work rolls. This leads to increased productivity and lower energy consumption.

The last main important point, essential to understanding the reason why the even pass strategy gives a higher productivity than the conventional rolling strategy, is that increasing the number of passes also increases the rolling speed. Indeed, if the number of passes is increased, the reduction at each pass is cut down. As the torque is directly linked to the reduction, the rolling speed will be higher while using the same power.
For instance, if one product previously rolled in three passes with the conventional rolling strategy is now rolled in four with the even pass strategy, the rolling speed will be higher, as shown in figure 6.

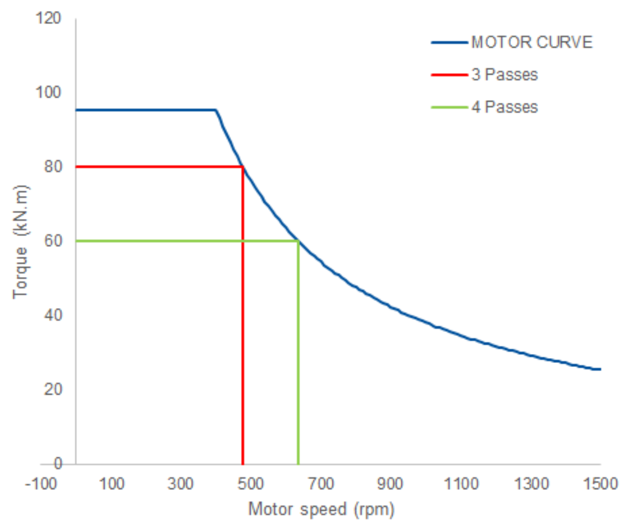

Figure 6. Rolling speed comparison between 3 and 4 passes

Due to this, even if some products are/ need to be rolled in an additional pass, compared to the conventional strategy, the small productivity loss (mainly due to the acceleration and deceleration time between two passes) is insignificant in contrast to the gains previously listed.

Many simulations and calculations have been conducted on different product mix coming from various steel makers. The conclusion reached is that the even pass strategy always allows for greater productivity than the conventional strategy (example shown in figure 7).

		NUMBER OF PASSES					TONNES PER HOUR
		1	2	3	4	TOTAL	
REGULAR STRATEGY	TONNES	2592	580003	17405	0	600000	91,0
	HOURS	38,4	6369,5	186,2	0,0	6594,1	
EVEN PASSES ONLY	TONNES		586464		13536	600000	92,5
	HOURS		6340,1		148,0	6488,1	

Figure 7. Comparison between old conventional and even pass strategy for Russian project

As previously mentioned, the even pass strategy is closely linked to the conversion of the twin stand into PLTCM. Indeed, if the even pass strategy is used in during the twin stand set-up, it will reduce the shutdown time of the mill and the investment cost of the upgrade. This is explained by:

- The difference in gearbox ratios. Since coils are always removed from the entry tension reel, the maximum speed of at stand #1 can be higher than at stand #2. Gearbox ratios are already selected according to their suitability to the PLTCM configuration/set-up. Thus, there is no need to modify the existing motorization when upgrading the mill.
- As explained above, oil concentration are is already different on stand #1 and on stand #2. There is therefore no need to install a new tank for an additional stand.
- The shape meter and selective cooling are already at the right location. As they have not been installed, those items in stand #2 do not need to be dismantled.
- The amount of exit equipment at the delivery tension reel is very limited (no belt wrapper, cradle rolls, etc.). This leads to a reduction in dismantling work for coupling in this area.

4 CONCLUSION

Thanks to those innovative concepts, JOHN COCKERILL's twin stand mill, easily expandable to PLTCM, is the best solution in terms of CAPEX, OPEX and flexibility for cold strip producers. The initial investment is lessened and, thanks to its smart layout, eventual upgrades to increase production are facilitated. Moreover, the even pass strategy increases the twin stand's productivity, and reduces the cost and the shutdown time necessary for the extension into PLTCM or a continuous rolling set-up.