INNOVATION IN HIGH SPEED ROD ROLLING MILLS[1]

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Abstract
Developments in technology for long product rolling mills in recent years has prepared the way to higher speeds and production rates, improved efficiency, better mill controls and higher product quality. These improvements can come about through proper use of this new technology such as the new MORSHOR® System and the Reducing/Sizing Mill®, enabling significant improvements in mill utilization while simultaneously enhancing the dimensional and metallurgical quality of the finished product.
Keywords: Rod; Rolling mills; Utilization; Productivity.

INOVAÇÃO EM LAMINADORES DE ALTA VELOCIDADE DE PRODUTOS LONGOS

Resumo
Desenvolvimentos tecnológicos para laminadores de produtos longos recentemente buscam melhorar os laminadores de alta velocidade em termos de capacidade, eficiência, melhor controle de processo e alta qualidade de produto. Estes desenvolvimentos veêm de encontro ao próprio uso desta nova tecnologia, o novo sistema MORSHOR® e o Reducing/Sizing Mill®, possibilitando significantes avanços na utilização dos laminadores enquanto que simultâneamente melhora a qualidade dimensional e metalúrgica do produto final.
Palavras-chave: Fio-máquina; Laminadores de produtos longos; Produtividade.

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INTRODUCTION

Most of the technology developments in the last two decades have been related to the finishing area of the rolling mill, where high speeds are so critical. The major product changing occurs in this location, involving roll, pass and guide changing. Maintenance is also related to speed, and complexity that is associated with speed is of great importance in the concept of mill efficiency. Morgan has placed high importance in this area of the rolling mill, and has developed the concept of single family rolling and the patented technology of the Reducing/Sizing Mill (RSM™) to enable its practical application in the mill and thus dramatically improve mill efficiency and utilization.

One of the most limiting factors in a rod mill is the production capacity when rolling small sizes – a constraint imposed by the maximum speed of the finishing end equipment. The production rate of a single strand rod mill, for example, is often only one-half that of its roughing and intermediate mill capacity when rolling the smallest sizes. A solution to this limitation has now been developed by Morgan in the form of the patented MORSHOR® System, which can transform a single strand mill with high production capacity on large sizes into a multiple-outlet facility with high production rates on all sizes.

THE MORSHOR SYSTEM

The MORSHOR® Maximizer System is designed to optimize the overall utilization and efficiency of the entire mill train by providing rolling capability up to that of the furnace capacity. With the MORSHOR system, a rod or bar mill can be upgraded so that the production rate of smaller sizes can be increased by up to 100 percent from a single strand feed roughing and intermediate mill. The system can be retrofitted into an existing mill or included as part of a new facility with benefits that can provide a fast return on investment.

When operating at furnace capacity, the speed of a round section from the intermediate mill is typically about two times the taking speed of a rod finishing mill for a 5.5mm diameter finished round product. Instead of reducing the speed of this section to feed a single rod finishing outlet, a switch is placed after the intermediate mill to direct alternating billets of the process section to two separate outlets, each proceeded by a MORSHOR unit. The MORSHOR is designed to accept the feed section at the high rolling rate and feed it, at a lower rolling rate, to the finishing end of the outlet for the small diameter products. For larger diameter products, an additional switch directs the feed section past the MORSHOR system at full mill capacity directly to the finishing stands. This concept of “Multiple-Outlet Mills” through the use of this new system is illustrated in Figure 1 below.

The MORSHOR System consists of a feeding mechanism, which takes the feedstock from the intermediate mill and distributes it onto a rotating drum, which is used to accumulate material being rolled a high rate. On the exit side of the MORSHOR, a payoff mechanism guides the accumulated material off the drum and into the downstream finishing end at the desired speed for the particular product size. Figure 2 below shows a computer-generated model of the MORSHOR System, with the key internal parts exposed.

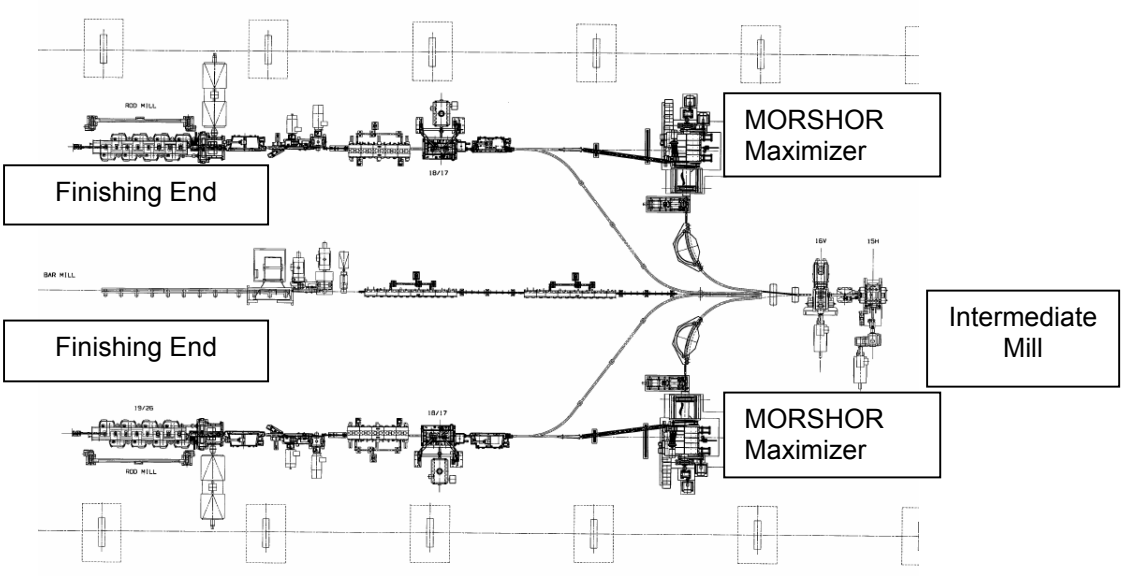

Figure 1 – Application of MORSHOR System

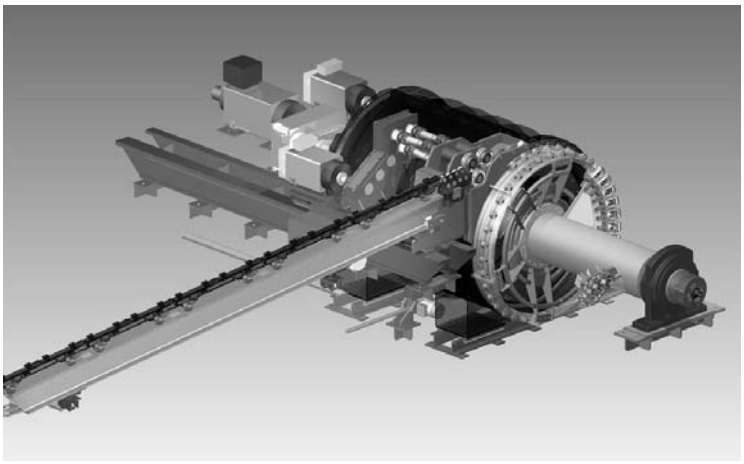

Figure 2 – Model of the MORSHOR System

To show the potential for improving mill production, the tons per hour for a range of product sizes can be compared with and without the system. See Figure 3 below.

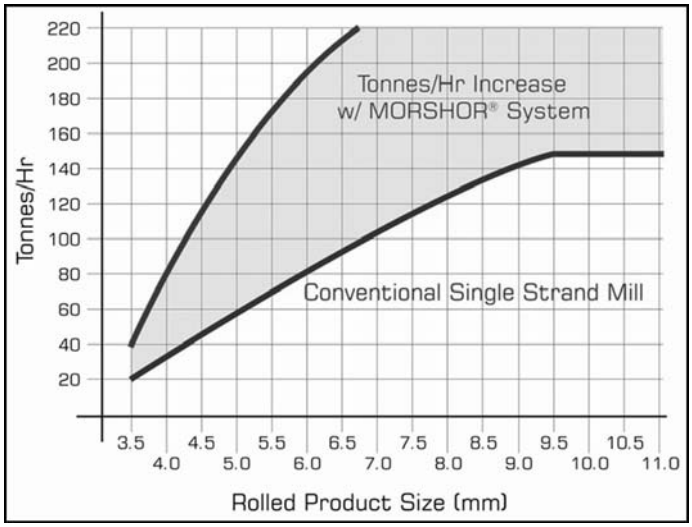

Figure 3 – Increased production capability of the MORSHOR System

The first MORSHOR Maximizer System installation is shown in Figure 4.

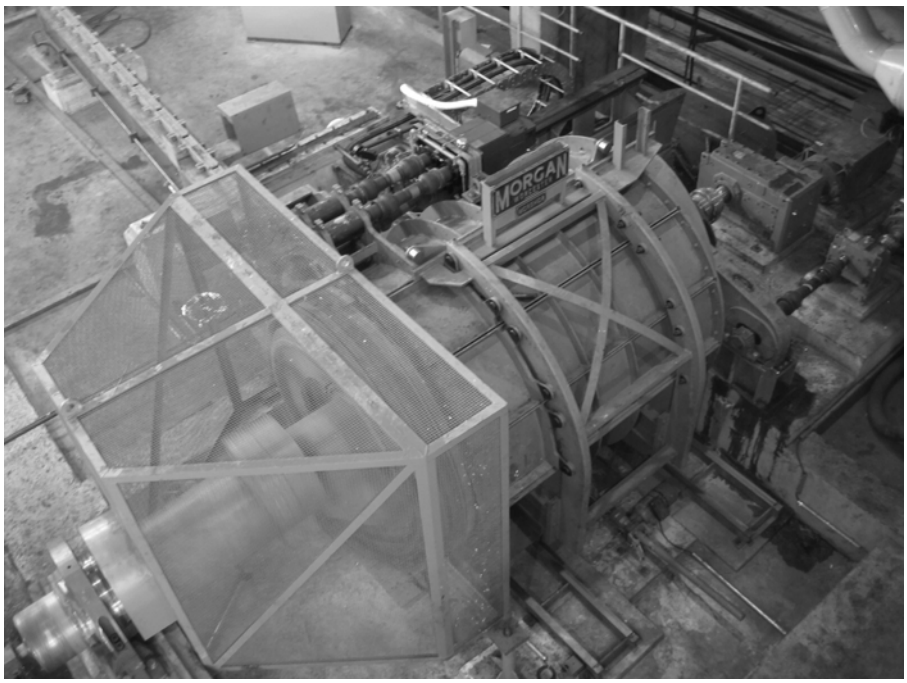

Figure 4 – MORSHOR Installation

SINGLE FAMILY ROLLING

Single family rolling is based on the mill line having only one set up from number one stand through many stands of the mill, with size changes accomplished by changing only a last series of stands in the mill and dummying selected stands prior to the finishing block in order to provide the proper feed section size. Single family rolling, along with variable fine tolerance of the finished projects is the focus of the Morgan patented technology. Shown in Figures 5 and 6 are examples of a conventional pass design and a single family pass design, respectively.

Most rod mills produce a variety of sizes and qualities, many times rolling on a supply and demand basis to meet the market demand for shorter deliveries, plus satisfy customer special requests and make quality products to their needs. To meet the shorter deliveries, many producers are now rolling products and holding them in storage until the customer requests the delivery - this practice increases the mills product storage, and as we all know this is dead money. With better equipment technology and choice of mill layout, this costly practice can be avoided, and the mill can increase utilization and productivity.

In mills taking advantage of this technology, size change can be done in a minimum time frame of between 5 to 15 min. depending upon the complexity of the change. The entire equipment from the pre-finishing mill through the finishing blocks, as described below, can be readily moved on and off line. The RSM itself has the flexibility to have constant feed sections for products from 5.0mm through 25.0mm wire rods, and on a bar mill with a bar RSM a single family for all products up to 90mm rounds. In addition, roll partings can be adjusted under load.

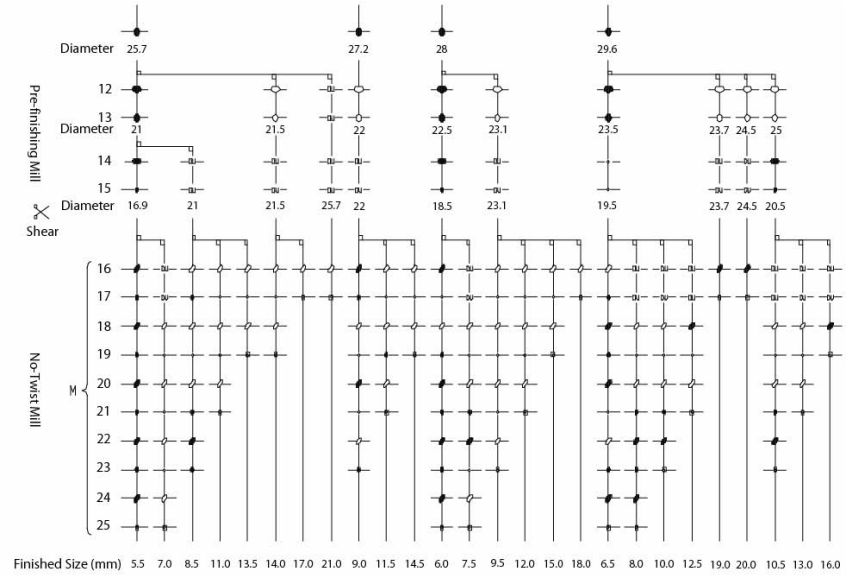

Figure 5 – Conventional Pass Design

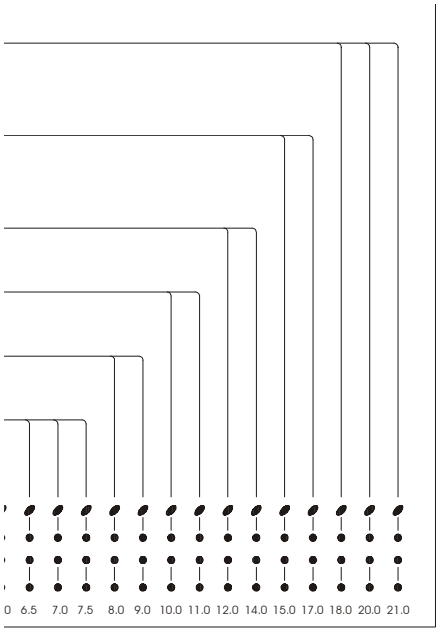

Figure 6 – Single Family Pass Design

The basis of single family rolling is that the pass design throughout the mill maintains the same rolling sequence for all sizes, which makes the operational control more simple. Speed control only varies depending upon the tons per hour due to speed limitations of the smaller sizes, such as 5.5mm at 110 met/sec. The pass design is constant, and thereby guide equipment is also constant, so for the rolling staff, set up time in and off line is greatly reduced compared to a conventional mill.

THE MODULAR NO-TWIST® MILL

The No-Twist® Mill (NTM) arrangement shown in Figure 7 is that of a Morgan modular mill with the possibility to change each pair of stands in five minutes and thus be ready to roll a new size. The arrangement is such that the drive to the

patented modular mill is so designed that when progressively producing larger sizes the stands that are not used are disconnected from the mill, namely the higher rotational speed stands. It is well known that with higher rotational speeds the wear rate on equipment such as bearings and seals exponentially increases with increasing speed. Another advantage of this unique design arrangement is much of the equipment can be maintained without stopping the mill rolling. Even at times of unforeseen breakdowns, the down time can be minimized with a mill using this concept by rolling some product size that does not need the section of the block involved in the breakdown, provided that the material in the furnace is compatible.

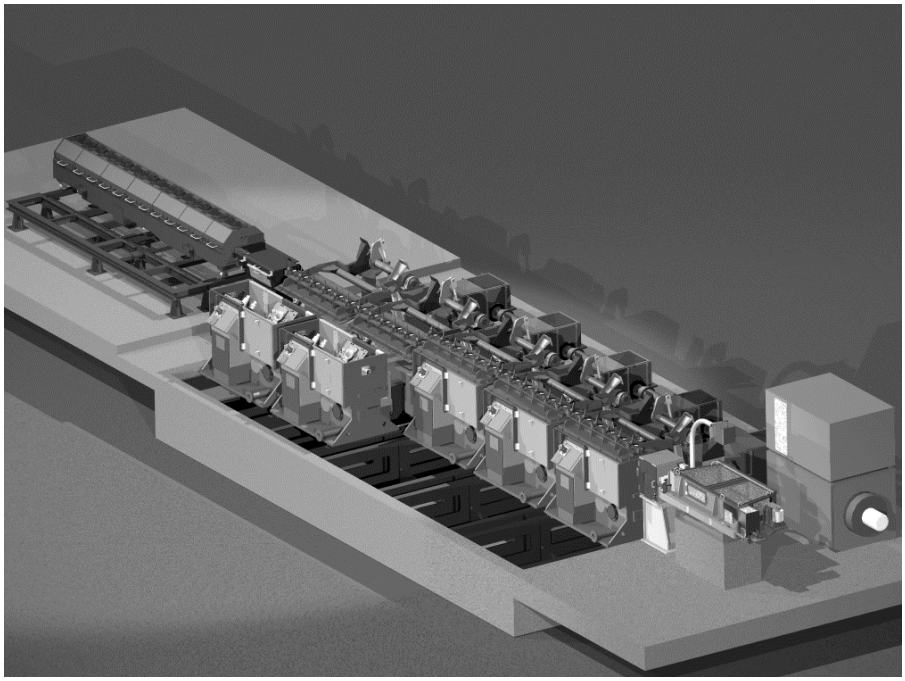

Figure 7 – The Morgan Modular NTM

In the concept of a NTM of modular design the same units can be used as pre-finishing mini blocks, as well as in the NTM, making spares more common. On all of these units it is possible to have the design such that power screw down on the material under load is possible. This allows the product to be modified for tolerance or small size changes to suit individual requirements and produce to the many rod gauges on the market today.
NTMs are now available in 4, 6, 8 and 10 stand configurations. The roll stand sizes can also be changed to suit rolling loads as needed, presently 140, 150, 160, 212, 230 and 250mm stands have been made. The high load capacity of the larger heavy duty stands also enables thermo-mechanical rolling of certain qualities, depending on size, provided that the entry temperature is reduced and when rolling with a NTM mill of this design.

THE REDUCING/SIZING MILL (RSM)

The Reducing/Sizing Mill is a vital part of the highly efficient mill, enabling the rolling machinery to achieve single family rolling, precise tolerances and thermo-mechanical rolled products.
A basic aspect of the patented Reducing/Sizing Mill technology is the rolling sequence of oval-round-round-round The mill is designed to be able to change the

reductions between stands to give the single family requirements, which is accomplished by a well designed gearbox driven by a single AC motor and, of course, the correct pass shapes. Figure 8 shows a gearbox for the RSM.

Figure 8 – RSM Gearbox

The mentioned pass design has the added advantage that with three rounds making the finished product the groove life is much longer; in some cases double that of the NTM style of rolling using only the oval round sequence. Also, the last stand that holds the oval is running at least ten percent slower for the same finishing speed in a NTM.

Tolerances of ± 0.1mm and ovality of 0.12mm can be achieved on 5.5mm, this enables the wire drawing industry to save on the number of drawing passes, wire drawing die wear, material losses in bolt making, etc. Surface scale is also superior due to the fact that there is no visible parting.

Thermo-mechanical rolling is a more controlled process with the RSM, especially on smaller sizes. On a high speed NTM the temperature increases significantly through the stands of the block, since there is no opportunity to cool the stock. With the use of the RSM, the last few reductions are located downstream of water boxes, so that the stock can be cooled and sufficiently equalized before the last critical reductions. In addition, the reductions in the RSM are limited, such that temperature rise is controlled, but with sufficient deformation to prevent abnormal grain growth which can occur with low reductions. Other competing mill arrangements using four stands of oval-round sequence have higher deformations and deformation rates, thus increasing the temperature build-up in the stock. See Figure 9 for an example of an RSM installation.

Figure 9 – Reducing/Sizing Mill and Water Box Installation

PINCH ROLLS AND LAYING HEADS

The ever increasing rolling speeds and increase in range of product sizes in rod mill have driven the development of pinch roll and laying head technologies to accommodate these higher speeds.

Pinch rolls have in the past been a piece of equipment that has required precise setting of the roll parting, having pressure transmitted via an air cylinder using a solenoid valve for the closing and functional operations, with a good electrical timing process via a hot metal detector. The control of this operation becomes a significant problem with higher speeds. To resolve this problem, Morgan has developed an intelligent pinch roll, which is controlled entirely by electrical motors. The arrangement of this patented Pinch Roll technology is shown in Figure 10. By controlling the pinching force via a servo motor, the roll parting can be set digitally and the main drive motor torque can be precisely balanced, thereby preventing slipping or marking of the rod. The speed of movement is much faster and more consistent than with an air cylinder, and the displacement or rate of displacement can be digitally applied, in conjunction with the main drive torque.

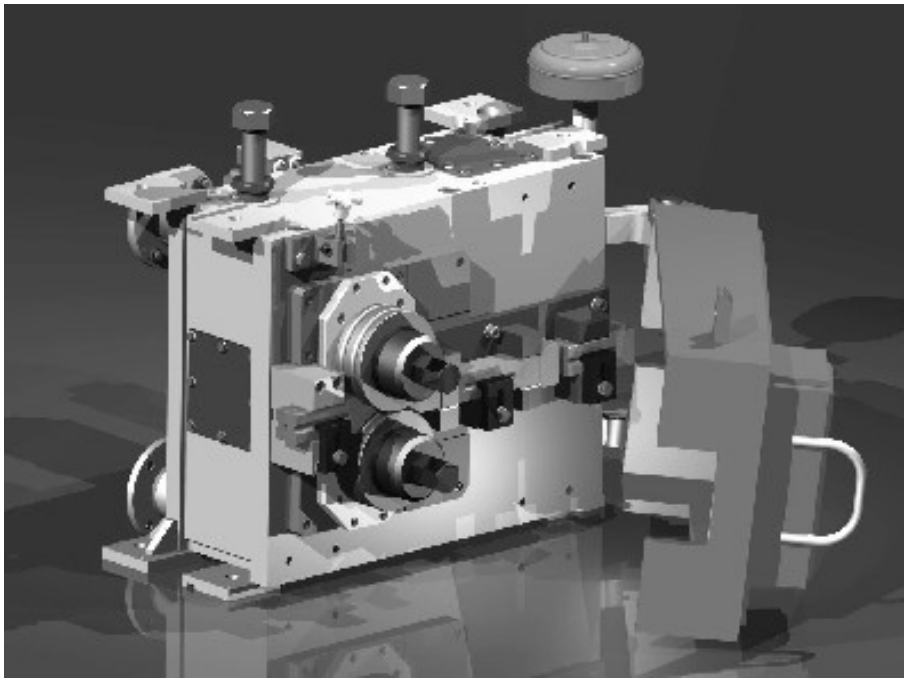

Figure 10 – Intelligent Pinch Roll

At higher speeds the tail end of the rod exiting the laying head becomes wild due to the centrifugal forces accelerating the rod on leaving the pinch roll. To reduce this phenomenon Morgan has developed a Tail End Control system, which is an extension of the laying head path in the form of a guide trough. This trough has its outer surface covered with a stationary skirt which prevents the full expansion of the rod, and the badly shaped ring. The trough has an additional benefit in that on larger sizes the guide path forms the first ring into a better shape. See Figure 11 for an example of this patented 2nd Generation Tail End Control arrangement. Other design modifications were made to compensate for the extra weight at the extremity of the laying head. To accommodate higher speeds and lower temperature products the inclination of the laying head is now usually chosen to be set at an angle of 20 degrees. Figure 12 shows a typical laying head installation.

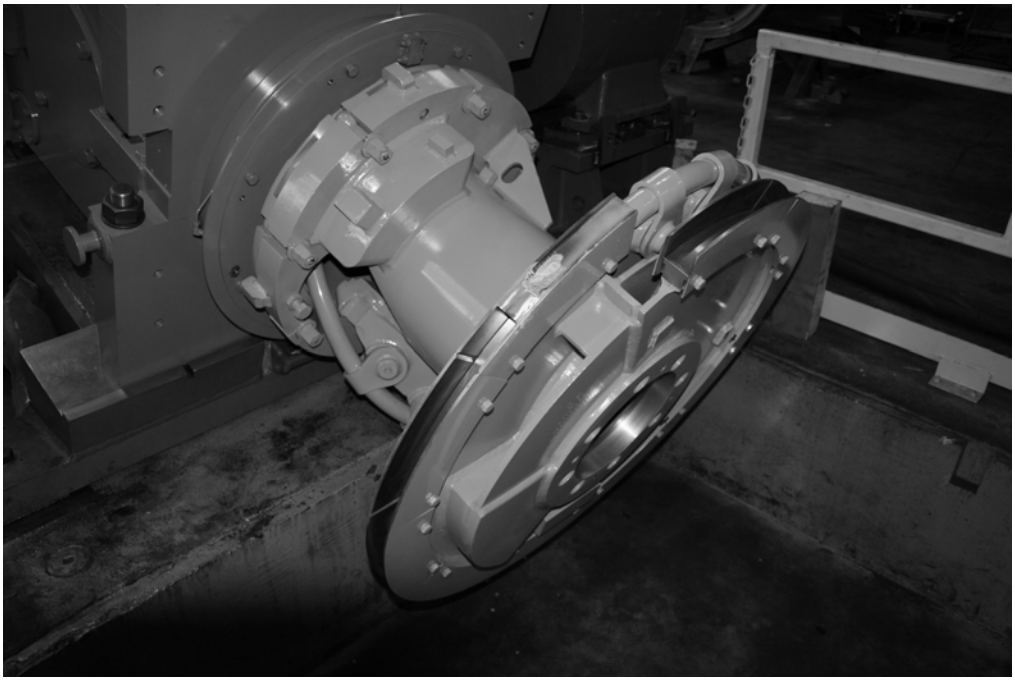

Figure 11 – Laying Head Tail End Control Arrangement

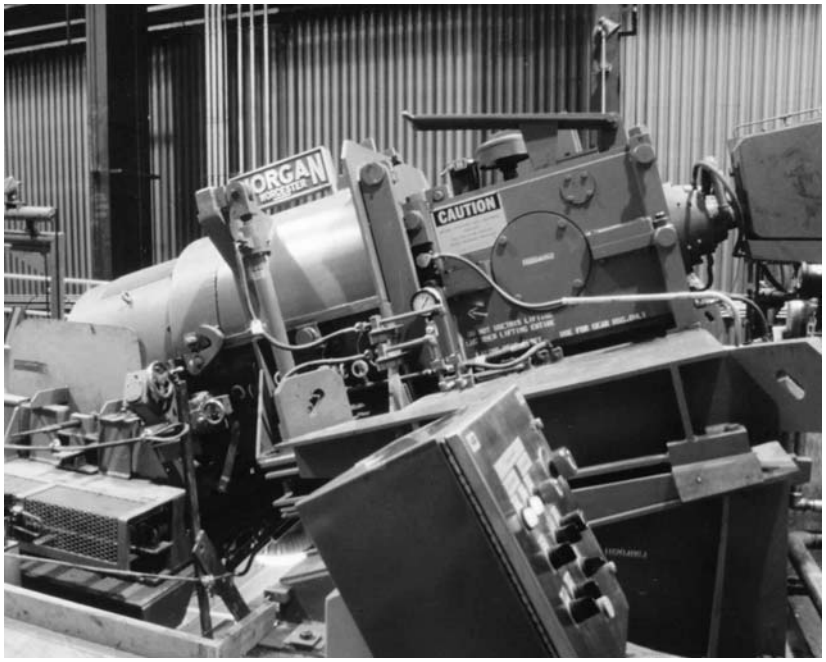

Figure 12 – Typical Laying Head Installation

SUMMARY

Developments in rolling mill equipment and processing technology have enabled improvements in finishing speed, mill utilization and product quality in new mill installations as well as in mill upgrades. When implemented in the proper combination, these developments can dramatically increase the productivity of the rod mill and therefore heighten the chances for success. In particular, the new MORSHOR System offers significant improvement potential for many mills and is therefore expected to play an important role in the next generation or long products mills.