Modernization of Iscor's 56-In. Hot Strip Mill

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Two and one half years were required from release of the first order until full automation of the revamped mill was achieved. This was accomplished during numerous short down periods rather than one long downtime. The result is an extremely modern facility.

REVAMPING and modernizing a major mill facility is always difficult since it requires so many compromises not required for a new installation. Aside from the pure economics as to whether a revamp will produce a satisfactory return on the investment in terms of increased yield and quality, the most significant deterrent to embarking on a revamp of any key facility is the cost in lost production. The 56-in. hot strip mill at Iscor underwent a near total revamp of its drive equipment, and yet as a result of the planning, construction, installation and operational procedures used, there was little detrimental effect on mill production. Although every project has its own peculiar problems and requirements, it is felt that the manner in which this project was handled has possibilities of application in other similar situations.

SCOPE

As marketing requirements increased, it became necessary to determine the ultimate capacity of the hot strip mill complex. This required a careful study of all factors involved to reach an economic solution, capable of satisfying the complete range and volume of product demand in the South African market. Consideration had to be given to limitations in the steel production facility and slabbing mill with respect to mold and slab sizes. These then had to be aligned with crane handling, mill spacing and the mechanical limitations of the mill drives. Calculations were made to determine power, torque and speed requirements for the various slab sizes with respect to gages, qualities and widths to meet the metallurgical requirements. Finally, the potential capacity of the mill was calculated, based on a maximum throughput of 60 slabs per hr with 500-ton per hr heating capacity, as related to the permissible horsepower and order mix.

The investigations resulted in these conclusions:

1. Optimum PIW would be 600.
2. The horsepower and speed requirements had to be increased on the finishing mill.
3. The torque requirements for stands No. 1 and 2 necessitated the use of steel rolls restricted to a minimum diameter of 21½ in., instead of 21 in. previously.
4. A more powerful close-coupled roughing mill edger was needed.
5. The 100-in. roughing mill, formerly a plate mill, now had an entirely different demand necessitating a larger m-g set drive motor and additional generators for higher operating speeds.
6. The roughing mill should be decreased to 60 in. to reduce roll costs.
7. Replace the cluster roll coilers with two mandrel coilers to increase the PIW from 380 to 600.
8. Provide a new hot strip mill pulpit with operating controls designed to reduce manpower and fatigue.
9. Install automatic aids.
10. Add automatic gage control.
11. Improve runout table strip cooling.
12. Replace line shaft driven tables with individual motor driven rollers ahead of the finishing mill.

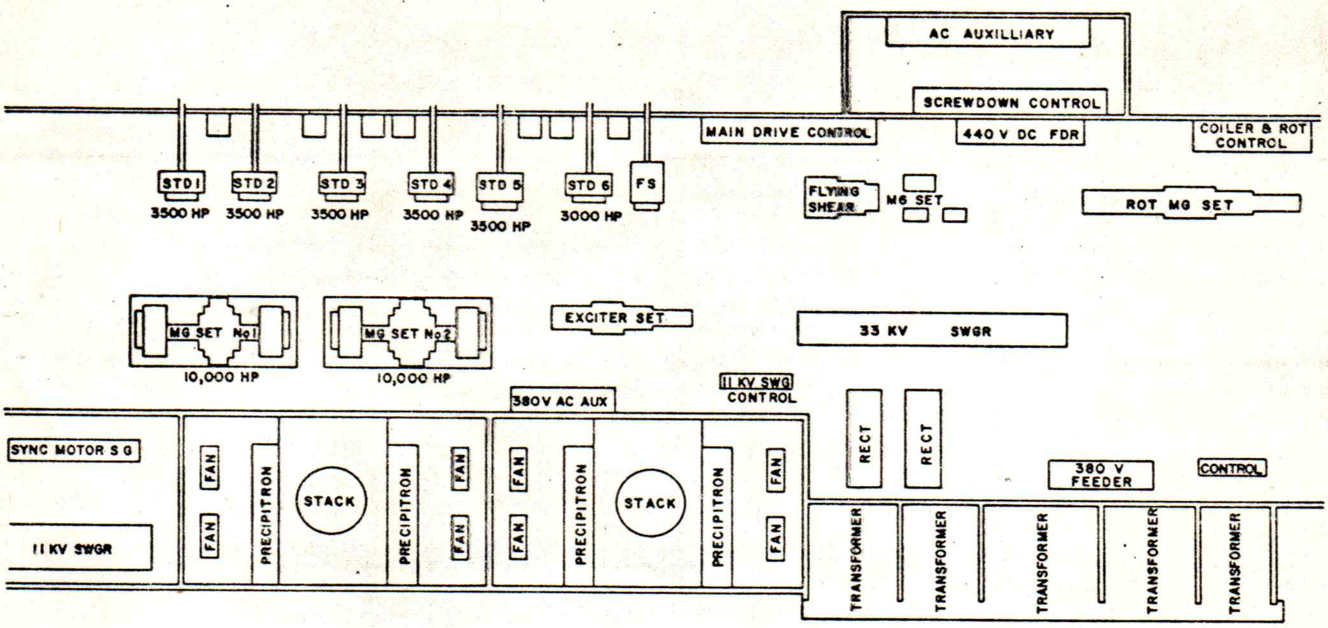


Figure 1 — Layout of the old 56-in. hot strip finishing mill motor room.

13. Install a system for rapid removal of crops from the finishing mill approach tables.
14. Provide furnaces to heat 130 tons per hr each with a hearth width of 22 ft-6 in. to heat 600 PIW slabs.
15. Install a new coil conveyor system compatible with the pickling line expansion program.

Figures 1 and 2 show some of the changes made.

MANAGEMENT OF WORK PROGRAMS

Even before the decision was made to proceed with the program, past experience with extensive construction work dictated that project management control of the activities involved was an absolute necessity. Accordingly, the first thing to be accomplished was the preparation of a PERT diagram. This served to provide a graphical interrelationship representation of the work details involved.

From a study of the requirements, it was evident that it would be impractical to accomplish the program in one long shutdown period, due to a number of factors, such as the time required to rebuild the existing drive motors and the lengthy preparatory work programs needed to allow work to be done on a broad scale. This dictated that the most advisable plan of action for the program would be accomplished by arranging for a number of short, three to four-day shutdowns spaced about one month apart with a final longer shutdown of about four weeks. The order position permitted such an arrangement.

It was especially important that work programs for all shutdowns be planned in minute detail so there would be no overrunning of the time allotment or failure to complete the work items.

To facilitate close follow-up of the work programs, extensive job lists were prepared with each item being assigned a number, the responsible department, a description of the work involved and an assigned time for its execution. These items were then plotted graphically on a bar chart serving as a display of the interrelationships.

Programs were developed in cooperation with all parties involved, and approximately one week prior to each shutdown period a general meeting was held with responsible representatives of each department. The job list was reviewed item by item and agreement reached so that each party would fulfill his specific obligation. The job list was most complete to be certain that no single detail would be lacking. By handling the shutdown in this manner, there were no unexpected situations, such as a truck not being available or cranes being tied up at critical periods.

Actually, the segmenting of the job into a number of small shutdowns permitted extensive preplanning. The amount of work scheduled for each shutdown was carefully regulated so that there was never any question that it could be accomplished in the time allowed; however, no time was wasted. The undertaking was a tremendous challenge, but this was answered with rare enthusiasm. These short monthly programs also provided excellent experience for planning the final major shutdown, and the same detailed procedures were applied more extensively.

CONSTRUCTION AND INSTALLATION

Remotoring and motor rebuilding—Repowering the mill called for the application of all the existing drive motors except stand No. 5. The old motors together with a new one of the same rating were rebuilt into three double-armature motors and reassigned to stands No. 2, 3 and 4. Stands No. 1, 5 and 6 were provided with completely new motors.

The rebuilding of the existing motors into double-armature motors was a difficult and exacting operation, particularly so because the motors were not returned to the factory where work as extensive as this would normally be done. Then, too, the existing motors were of a design in which the armature iron assembly and commutator assembly were independently attached to the armature shaft. The motors were rebuilt so that the commutators were attached to the armature spider rather than the shaft, thus preventing any angular displacement between the two.

The first motor to be rebuilt was stand No. 2. In doing this, a new motor, having a double shaft extension and the commutator attached to the armature spider, was purchased. The remotoring of this stand was accomplished by removing the old motor and replacing it with the new motor. Electrically, the two were exact, but mechanically some adjustments had to be accommodated. All work was easily accomplished in the four days allowed for the shutdown, and the mill started up and rolled without any detectable change in operation.

Rebuilding the old stand No. 2 motor required the removal of the old commutator and replacement with a new one, the boring of the armature spider, and the machining of numerous associated fits necessary to accommodate the new shaft and commutator. This work, including the general reconditioning of the motor, was accomplished during the four weeks following the mill shutdown. The rebuilt motor then became a duplicate of the new stand No. 2 motor which replaced it. With the motor ready, the mill was again shut down and the old stand No. 3 motor was removed, and the rebuilt stand No. 2 motor installed in its place. Stand No. 3 motor was then rebuilt, and in another four weeks the mill was again shut down for a similar replacement.

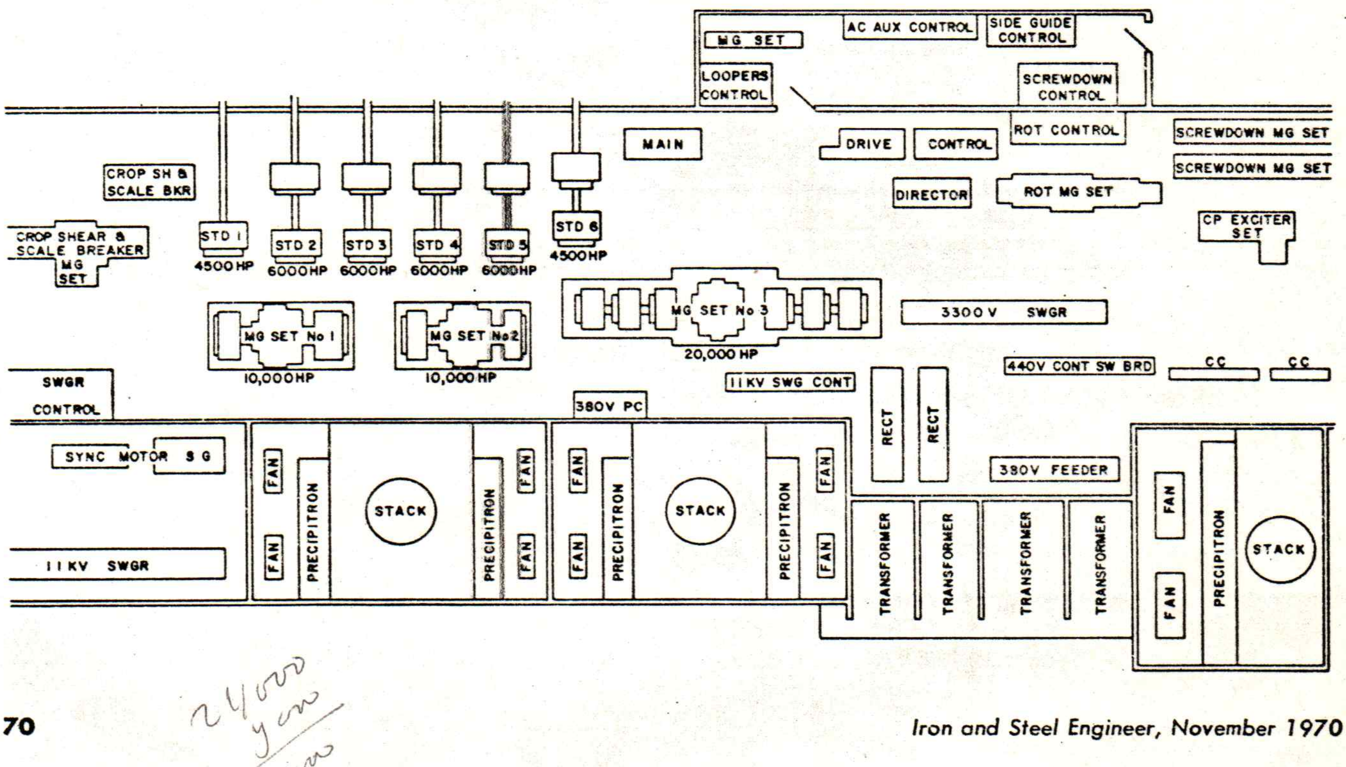
All front motors which were rebuilt were installed in their final positions, but were not electrically connected in the system. There was little point in connecting them into the circuit since there was no power available to drive them until the major shutdown, when the system would be converted from the common bus system to an individual generator system.

SPECIAL TEMPORARY CONTROL ARRANGEMENTS---In installing the new stand No. 1 motor, it was necessary for the first time to make a change in the control. This became necessary because the new motor, although having the same speed range as the old one, was much larger and, as a result, the motor field requirements differed considerably from that of the old machine. This meant that the motor operated field rheostat and vernier rheostat were no longer suitable for the new motor. This problem was handled by the use of a small interposing exciter. The existing motor operated rheostat was modified to work into the field excitation system of the interposing exciter, and a small rheostat was added to the vernier rheostat in the pulpit to provide vernier control. The arrangement worked out quite satisfactorily.

The next stand to be worked on during the following shutdown was stand No. 6, which had a motor rated at 3000 hp, 175/350 rpm. The new motor for this stand is a double-armature motor having a rating of 2 × 2250 hp, 225/490 rpm. This created a special problem because the mill was being operated on a common bus, and the substitution of the motor would upset the speed cone of the mill. In reviewing the actual power requirements of stand No. 6, it was apparent that 2250 hp would be enough to operate the stand during the period prior to the major shutdown (Figure 3).

Since 2250 hp would power the stand adequately, it was possible to proceed and replace the existing stand motor with the new double-armature motor. This, however, required an unusual circuit arrangement. The arrangement was to connect both of the new armatures in series and set the motor field current so that the desired speed range would be obtained. The motors

Figure 2 — Layout of the finishing mill motor room after the modernization program was completed.



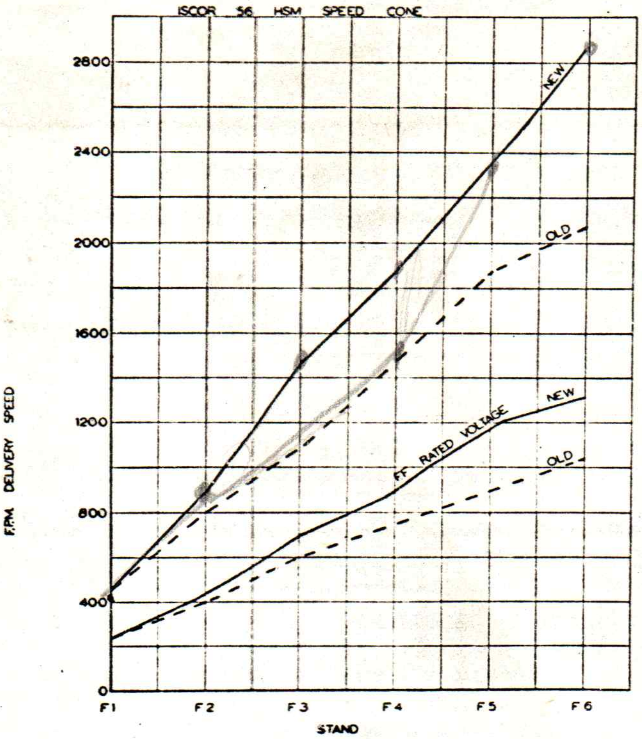
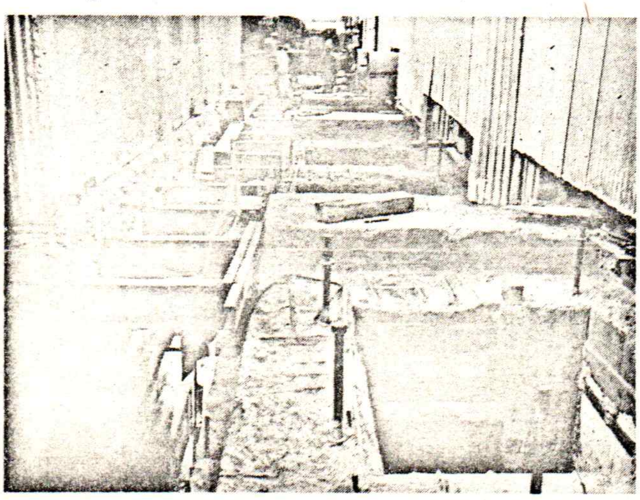


Figure 3 — Speed cone of previous and modernized mill.

operated in this manner had more droop than individually, but this proved to be an advantage with the mill operating on a common bus. The operation of the mill with this motor arrangement was entirely satisfactory and made it possible to rebuild stand No. 6 drive motor. When the motor was rebuilt, it was installed as the front motor on stand No. 4.

With the installation of stand No. 6 drive motor being such a success, an investigation of stand No. 5 was undertaken. Stand No. 5 was driven by a 3500-hp motor with a speed range of 150/300 rpm, and the new motor is a double-armature machine rated 2 × 3000 hp, 200/400 rpm. Since the single-armature rating of 3000 hp was only 500 hp less than the original 3500-hp rating, this load loss was not significant. The greatest concern was over the possibility of the inherent machine load-speed characteristics causing operator problems.

Figure 4 — The foundations for the second armature of the double-armature motors are shown during the construction stage.



Calculated performance of the arrangement indicated it would be acceptable, so stand No. 5 motor was installed in a similar manner to stand No. 6 and was quite satisfactory in operation. These special arrangements permitted all stand drive motors to be installed prior to the major shutdown, resulting in a shorter major shutdown since this was a big item of work completed.

Relocation of existing equipment—The installation of the new 20,000-hp m-g set was a major task due to problems of clearing floor area and preparing foundations. Part of the area where the m-g set was to be located was occupied by 330-v switchgear which served various areas of the mill. In addition, the other part of the floor area was occupied by a 900-hp, 7-unit synchronous m-g set whose foundation served as a support for the floor beams in that area.

To be able to work in this area, it was necessary to relocate the m-g set. A temporary new foundation for the m-g set was cast on the motor room floor. With the foundation prepared, the m-g set was relocated over a period of just over three days. The transfer was accomplished without any serious problems.

In order to demolish the old foundation, columns were installed to support the floor beams using the foundation as their support. After completion, the difficult task of demolishing the old m-g set foundation was begun, a task which required many weeks to accomplish.

The other obstacle for the new 20,000-hp m-g set was the 3300-v switchgear. It was necessary to relocate about half the units to the opposite end of the line-up. This required considerable preparation so that the move could be made in a short time. Following this, the area for the new m-g set was cleared for construction purposes and the erection of the m-g set was able to proceed without any further interference with the operation of the mill (Figure 4).

All foundation work required for the motors and m-g set was accomplished while the mill was rolling or during normal down periods. The work area had to be completely cleared of all existing cable circuits which were provided to carry the relocated power and control. One very major problem was that of clearing the heavy copper d-c bus circuits and relocating the pedestal circuit breakers in the basement. This was the location to be used for the new motor foundations. Congestion was acute, and the necessary breakers were temporarily installed between the motors on the motor room floor level and in the pits under the generators.

Replacement of loopers—Another important phase in the revamp, which was accomplished during the monthly shutdown periods, was the installation of new loopers. To do this, it was necessary to remove the old looper drive system. The new looper system was a variable voltage type with regulators so that the strip tension would remain essentially constant. The change to the new loopers was quite orderly and was accomplished for all five loopers in two shutdown periods.

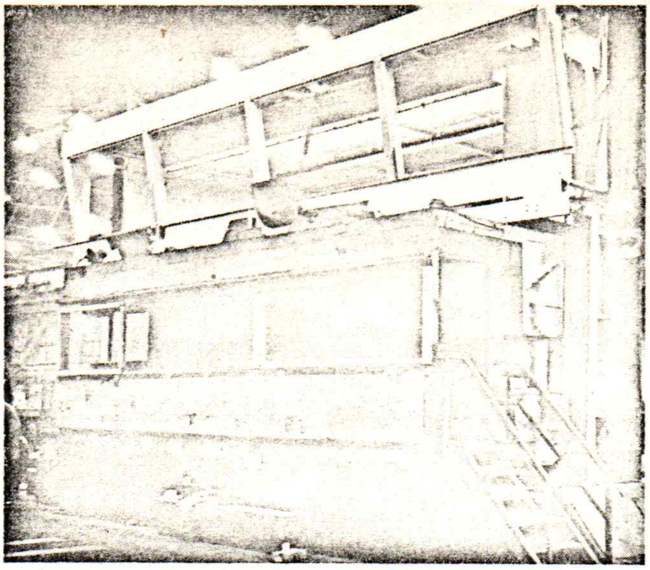


Figure 5 — The old mill pulpit was lowered and moved forward to provide sufficient space for the new pulpit to be installed.

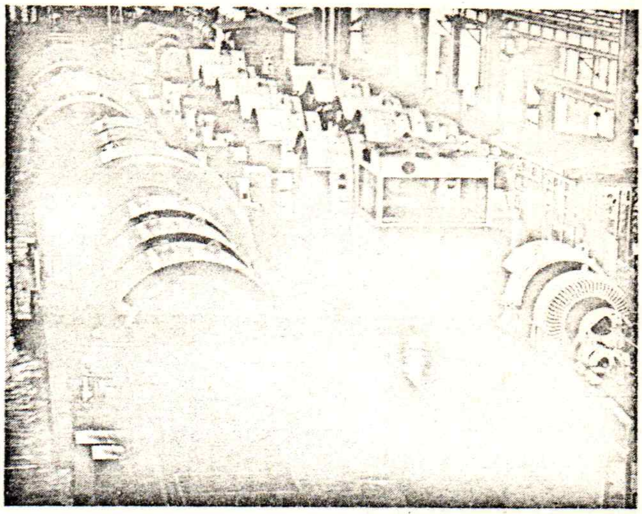


Figure 6 — View of the motor room after completion.

Replacement of screwdowns—The constant voltage screwdowns were changed to variable voltage systems during the regular monthly down periods. This was accomplished in several down periods without serious problems. The horsepower of the new screwdowns was increased because of the gage control requirements, but the frame size of the new and old motors were the same, which reduced the mechanical problems of the change. This was because the old motors were of the old line of the mill motors and the new ones were of the 600 line mill motors.

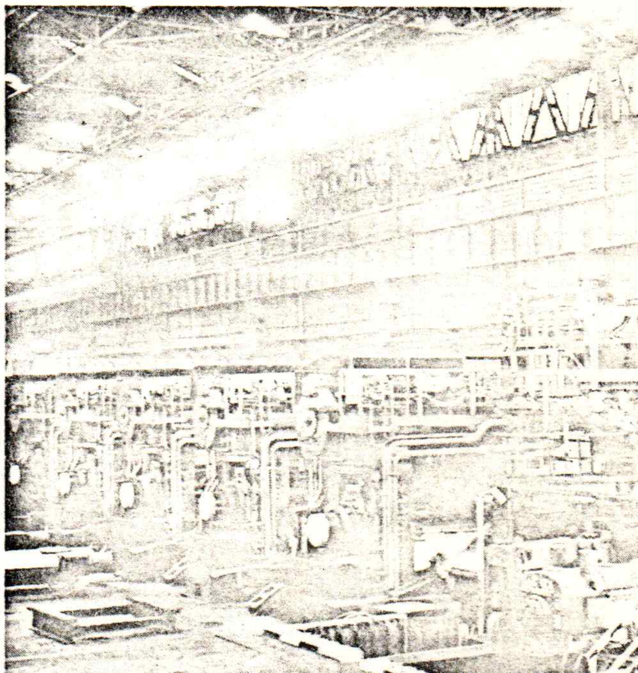
Load cell installation—Load cells were installed below the bottom backup rolls, therefore, it was necessary to machine the mill housing to accommodate them. A milling machine was designed so that the work could be done with the housings in place; thus, it was possible to have nearly all the stands machined before the major shutdown.

New pulpit and control room—One new addition to the mill which required acute planning was that of the new pulpit and control room located below it. They were completely built and wired while the old pulpit was still in service. To accomplish this, it was necessary to make room for it as the new pulpit was to be located at the old pulpit's location. To make room, the old pulpit (Figure 5) was lowered so that it was only about 2 ft above the mill floor. It was also moved toward the mill as far as possible while still permitting changing of mill rolls. In addition, the back of the old pulpit was cut off to make it shallower. This arrangement permitted sufficient room so that the new pulpit could be built with the control room below it. Strangely enough, the operators had no significant problems operating the mill from this low level and record tonnages were rolled.

Major shutdown—On January 17, 1966, the mill went down for a scheduled 30-day period. The job list included 212 separate items for the hot strip finishing mill, but major work was also included for the entire hot strip mill complex. Apart from all the electrical construction and testing work on the finishing train outside and inside the motor room, the individual runout table motors were to be remounted approximately 2 ft further away, a new laminar flow runout table strip cooling system had to be erected, the machining of the stand housings had to be completed for the load cells, the cells had to be installed and operable, a new crop shear with foundations and a crop pit had to be completed, a new drive motor for the reversing rougher m-g set had to be installed, and a new roll cooling system on the finishing train had to be installed. (Figures 6 and 7.)

The mill started to roll on February 13 after a total

Figure 7 — Majority of the revamp work was accomplished in numerous short shutdowns. Shown is the finishing train.



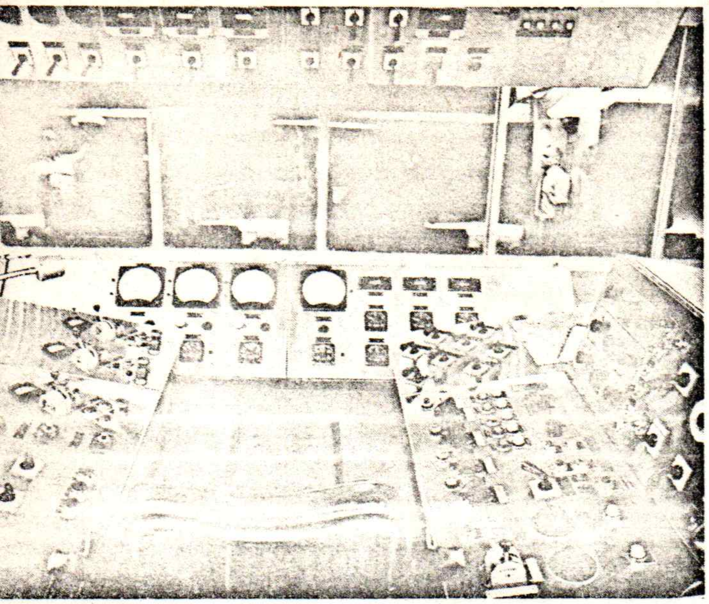


Figure 8 — The new pulpit is arranged with the controls on both sides of the operator.

downtime of only 27 days, three days less than scheduled. However, in starting up the mill with the new systems, it was not the intention of putting the automatic systems in operation since it was felt that the operators had enough to cope with in operating from a new pulpit, having an entirely different operating arrangement. In the past, the screw movements and side guides were controlled from the mill floor at the stands. Now they were in the pulpit. In addition, the pulpit (Figure 8) was arranged so that the operators were seated with the controls on either side of them; previously, they stood up with the controls in front of them. The meters and various other controls were all different, with the meters being in front of them at floor level and various setup controls overhead in front of them. With all the drastic changes which the operators had to face, they very quickly became accustomed to the new facilities.

NEW FEATURES AND THEIR PERFORMANCE

AUTOMATIC CROP SHEAR—In starting up the mill, it was desirable to include the automatic crop shear, since it would then be possible to eliminate the entry desk on the mill floor. Since the shear was new, as well as the drive system, everyone was mentally prepared for a certain amount of break-in problems before attaining a satisfactory operating level. To everyone's delight, the problems were insignificant, and the shear and the automatic feature worked very efficiently.

Any difficulties experienced nearly always related to the hot metal detectors. They were mounted on an overhead structure whose main function was to support a width gage, just in front of the shear. This structure was also close to the crop pit. The location was such that the structure was bumped frequently while servicing the pit, causing misalignment of the hot metal detectors whose focus was critical. Since it was found that the accuracy of cutting with the hot metal detectors was so satisfactory that no improvement could be made through the width gage, it was decided to remove the structure and relocate the hot metal detectors in a less vulnerable site.

AUTOMATIC SIDE GUIDES—As the operators became more accustomed to the mill, the procedure was to add automatic features. Among the first systems to be added were the preset side guides. This was an important automatic feature to add due to the manner in which the side guides are operated. It has been the practice to short stroke the individual side guides "in" immediately after each stand is threaded, and short stroke them "out" as the strip leaves each stand. This was an ideal automation application, as quite a few men were involved in accomplishing the function manually.

Performance of the system has been good, although it was found that due to the short stroke feature, the use of a constant voltage controller with armature shunt circuit has definite limitations over a variable voltage scheme. The high operating rate causes greater maintenance, and the setting of the armature shunt resistance is quite critical, being related to the friction torque which can vary widely depending on lubrication. The position sensing selsyns were subject to water spray, especially on the early stands, and required some mounting changes to provide greater protection.

PRESET SCREWDOWNS—The next automatic system to be added to the mill was the preset screwdowns. These were also digital systems. These systems work with the variable voltage screw-down systems, and they proved to be very effective in time saving. There were no significant problems encountered with the system.

PRESET SPEEDS—The preset speed feature is an analog system and a function associated with the speed regulator. The system worked quite well, but not without some effort as it is a low-energy system which is susceptible to noise pick-up. This problem was complicated by some unfortunate bad cable runs from the noise pick-up standpoint.

FEEDBACK TENSION LOOPERS—Iscor had been accustomed to the operation of their loopers in an elevated position, so there was nothing new to this system. However, they were never operated in a system where they would raise and lower automatically or feed back control signals which changed the speed of the mill drive motors. The new loopers were also different in that they operated with very low tensions and had an entirely different feel. They required exacting adjustment of the mill systems as a whole, since with a feedback control system it is very easy to have interaction between systems and unstable operation. In particular, the amount of speed corrective signal fed back to the stands behind had to be adjusted with respect to the drafting pattern of the mill. If an average signal were used, it was only valid for one drafting pattern, and other patterns resulted in an under or overcorrection in the stand speeds. This required the looper associated with that stand to further correct. In the extreme case of stand No. 1, the amount of correction required sometimes resulted in the loopers going out of range due to the errors fed back from other loopers. By adjusting the feedback signal with respect to drafting pattern, the loopers did not run out of range and the mill settled down quickly on threading.

MILL ACCELERATION—Slow acceleration was used soon after the commissioning of the new mill, but the fast acceleration could only be tried when the old cluster roll driven coilers had been replaced by the new mandrel driven coilers, more than a full year later. The fast acceleration has two possible rates: 75 fpm per sec or 150 fpm per sec, the former being the only one used so far. To date, the mill has been accelerated up to its top speed of 2850 fpm on the thinner gages, such as 16 and 18, without any great problems in gage or shape control.

The AGC system is efficient in counteracting the tendency for the gage to decrease. It would appear that there is a slight overcorrection. The tuning of this aspect of the AGC has to cover the gage range from 0.050 to 0.110 in. over which fast acceleration is used.

Automatic gage control—The subject of gage control can be long and involved, so no attempt will be made to discuss the system in detail. The system is on all stands and uses the gagemeter principle as well as x-ray gage feedback. In addition, a slave operation is used whereby the load cell on one stand controls the screws on the following stand in an open-loop system. Also, skid marks are detected by means of hot metal detectors which apply a superimposed signal on the screwdowns to help correct for the skid marks. The mill setup is also readjusted just prior to bar entry by comparing the temperature of the incoming bar with that of the previous bar. Correction for gage deviation as a result of temperature rundown has been effectively controlled by the use of a slow acceleration speed which is manually selected by the operator to values determined by experience and observation. The effect of the slow acceleration has been to reduce the demands on the gage control equipment in correcting for rundown errors, and thereby make it more effective. This rather complex system has proved itself in the results obtained over the very wide range of product rolled.

Considering the variations in gage pattern obtained on different grades of steel and different gages, the heavier the gage, the greater are the gage swings, and the harder the steel, the greater are the swings. A continuous succession of bars have been rolled with no difficulty staying within a 1-mil tolerance.

SUMMARY

A great deal was learned from this project and considerable satisfaction was gained when looking at the completed facilities. In looking over the achievement, a number of points come to mind which would apply in any such undertaking:

1. Cooperation between all parties is most essential, and they should be represented at meetings where the important decisions are made pertaining to the work program. When the operating department understands the problems, it can contribute to the speed of the project by arranging special operating programs. Many times they will inaugurate programs no one else would dream of suggesting, resulting in the saving of countless construction manhours, or even months, in the overall schedule.
2. Certain compromises are necessary in any revamp and must be weighed carefully so that an acceptable result will be the outcome. In this case, the major compromise was the decision to use reduced horsepower on stand No. 1. It proved to be a good one. If this compromise were not made, then a new mill stand would have had to be added, and the complications this would have created (the need for new foundations) in the mill area probably would have caused the project to be abandoned.
3. Great stress should be given to the avoidance of foundation work and, in particular, in the mill area where the operation of the mill may be adversely affected. All alternatives should be fully explored before committing work of this nature in the mill area
4. An amazingly high mill operating performance can be maintained under very adverse construction conditions, if the mill is operable. Record tonnages were rolled on the mill during periods when the motor room looked like a bombed-out shell.
5. This revamp proved that there is great merit in accomplishing the majority of the work by numerous short shutdowns rather than trying to do all the work in one long shutdown.

The result of the many modifications and additions to this mill was the conversion of a typically old mill to one having the features and performance ability of the most modern mills in the world today. It does not have a computer, although this feature has been planned. Performance has been rewarding, and the venture must be considered a dramatic success having been accomplished in record time by any standards—less than two years from the release of the order until it was repowered, and two and a half years with full automation in satisfactory operation. ▲