The roughing section of a structural mill has been replaced with a single-pass vertical stand and four, quick-change, multi-pass horizontal stands to permit the rolling of larger billet sizes and improve performance. Cobble rate has been reduced form 2 to 3% to 0.5%.

New roughing mill stands at the Co-Steel Lasco structural mill

D. Gordon Stewart, Senior Mechanical Engineer, **Robert P. Papazian**, Civil Engineer, Quad Engineering, Scarborough, Ont., Canada, and **David Leedy**, Manager—Structural Projects, Co-Steel Lasco, Whitby, Ont., Canada

IN the fall of 1993, Co-Steel Lasco initiated the design process for revamping the structural mill at the Whitby plant. The first phase of the revamp was to replace the roughing section of the mill with new mill stands, drives, electrics and controls. The new roughing mill stands were successfully started up in 1995.

Lake Ontario Steel (Lasco) started up the original cross-country merchant bar mill in 1964. In 1968, a straight-away section was added to roll structural sections up to 6 in. 1980 saw the removal of the cross-country section of the mill and the start-up of a continuous 17-stand bar mill. That gave Lasco the capability to roll 850,000 tons/year in one mill bay; 600,000 tons/year on the bar mill; and 250,000 tons/year on the old structural mill. The 10-stand structural mill consisted of:

- One 60-ton/hr reheat furnace.
- Four 20-in., fabric bearing, roughing stands driven by a-c motors.
- Six fabric bearing, 16 and 18-in. stands driven by d-c motors.
- A crop shear after No. 4 stand.
- One 130-ft drag-type cooling bed.
- Straightener, 8-roll.
- Cold shear, 700 ton.
- Bundling and stacking.

In 1989, the reheat furnace width was doubled to handle two rows of 17 ft-4 in. long, 5 x $7^3/_8$-in. sq billets at 115 tons/hr. This also allowed for full length 35-ft billets in the future. A new flying divide shear was installed at the finishing stand exit to allow for dividing the long billet in the future. These additions brought the capacity of the structural mill up to 400,000 tons/year. The product range on the mill was:

- Angles, $3^1/_2$ x $3^1/_2$ to 7 x 4 in.
- Channels, 5 to 10 in.
- Flats, 4 to 10 in.
- Grader blades, 6 and 8 in.

Design criteria

In the fall of 1993, a design team was assembled consisting of Lasco production and maintenance personnel, and Quad Engineering. The team developed the design and construction requirements for a new roughing section on the structural mill within eight weeks.

The mill layout was to consist of a single-pass vertical and four multi-pass horizontal stands (Fig. 1). Space for a free bar was required between No. 2 and 3 horizontal stand. The first three stands would be run at approximately 250 fpm to minimize temperature loss. The free bar space

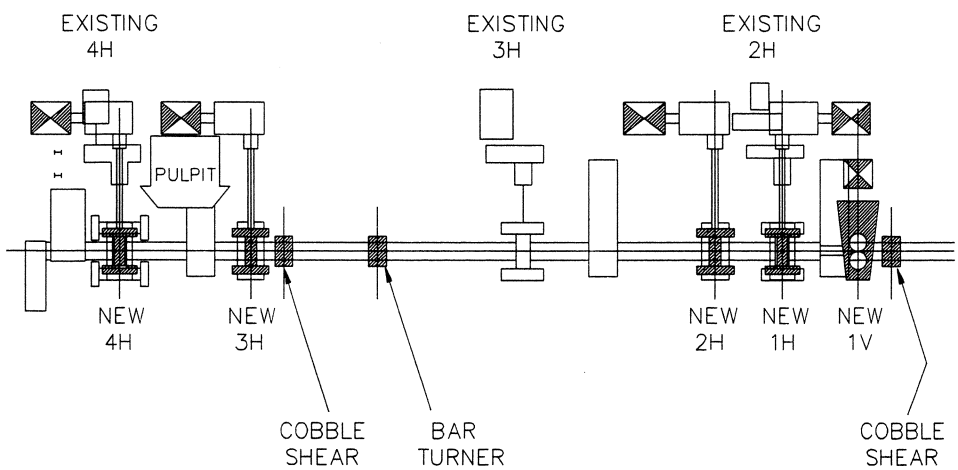

Fig. 1 — Roughing mill.

would also provide flexibility for pass design and bar turning. The first mill stand, No. 1 vertical, was located far enough from the furnace discharge so that a full length billet, 35 ft, could be side discharged into the mill. The billet size would be 5⅛ x 7⅜ in. x 17 ft-4 in. (future 35 ft) and the mill stands designed to run up to a 6 x 10-in. billet in the future.

The horizontal stands were required to be quick change, with the maximum crane lift not to exceed 20 tons. With the size of mill required this excluded exchange stands. Components in the chock assemblies, ie, bearings, seals, etc, were to be common in all locations and the same as the existing bar mill roughing components. Because of space restrictions in the motor room, all the reducers would have to be right-angle drives. The mill stand design had to be axially rigid for rolling structural sections. Since the existing mill had consistently recorded delays due to cobbles in the 2 to 3% range, the mill stands were also designed to reduce cobble delays. All drives would be d-c, with speed control in the close-coupled sections.

In addition, the existing mill was to operate throughout the construction period with shutdowns scheduled as follows:

- July 1994—Install foundations (two weeks).
- Dec. 1994—Install and commission No. 1 vertical and No. 1 and 2 horizontal stand (10 days).
- July 1995—Install and commission No. 3 and 4 horizontal stand (two weeks).

Mill design

Two mill stand designs were developed for the structural mill roughing section (Table I): vertical; and horizontal.

TABLE I Mill parameters

Mill stand	Roll dimensions, in. Barrel length	Diameter Max.	Diameter Min.	Motor hp	Motor rpm	Gear reduction ratio
1V	12.5	33	29	1000	500/1200	22.5:1
1H	48	25	21	1500	500/1200	15.0:1
2H	48	25	21	1500	500/1200	15.0:1
3H	48	25	21	1500	500/1200	15.0:1
4H	48	25	21	1500	500/1200	15.0:1

Vertical stand — The vertical mill stand is a single-pass mill, overdriven design (Fig. 2). The mill flumes are shallow in this area and the overdriven design was selected to minimize the amount of flume construction. Mill stand design features include:

- Closed-top housing mounted on a floor-mounted base plate.
- Hydraulic side shifting of housing for roll/chock cartridge removal.
- Two-row taper roll neck bearings with tapered bores.
- Manual screwdown.
- Entry and delivery restbars fixed on housing slabs.
- Telescopic universal spindles with hydraulic spindle lift for roll change.
- Double output speed reducer mounted on an oil reservoir tank, mounted on a steel tower.
- Horizontally mounted mill motor driving spiral bevel gear set in the reducer mounted on the steel tower.
- Air/oil lubrication of mill bearings and roller entry guide.
- Hydraulic snap shear at mill entry.

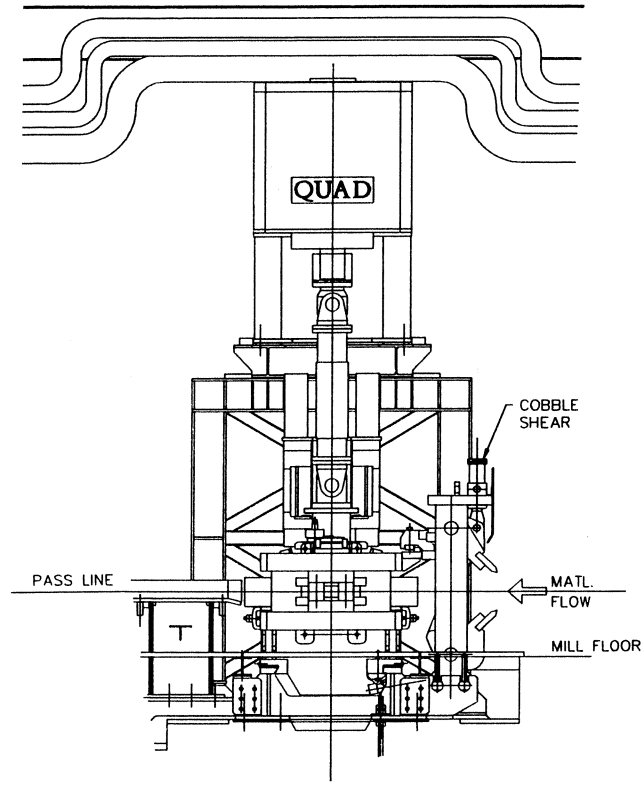

Fig. 2 — No. 1 vertical stand.

Horizontal stands — The horizontal mill stands required a unique design because of physical constraints and operational requirements. The rolls had to be multi-groove because of the number of structural products being rolled. A limit of 30 min was placed on roll change time. With a maximum crane lift in the mill of 20 tons (cranes were upgraded from 15 tons), an exchange stand design was not possible because of the weight restrictions. Thus, a quick-change cartridge was required.

The design developed is called a wide-window stand (Fig. 3). It has two different sized mill housing windows. The drive side window is a standard closed top slab with the operator side window opening wide enough to accept roll, chock, restbar and guide assemblies. The roll chock assembly, including restbars and guides, are mounted on

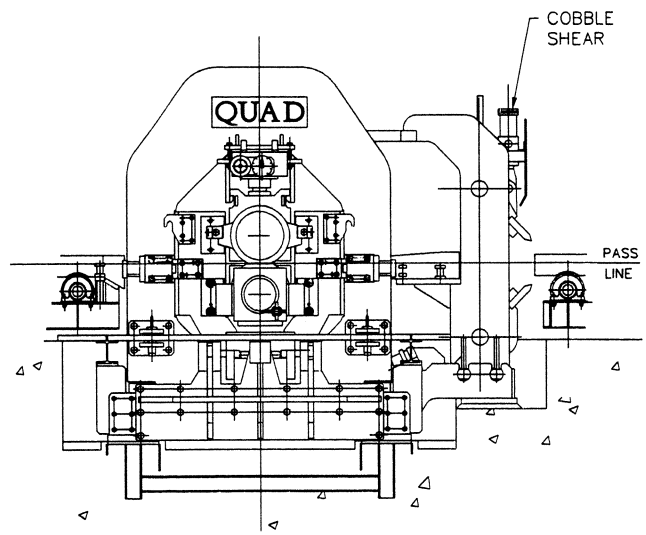

Fig. 3 — No. 3 horizontal stand.

a carrier which is side shifted hydraulically out of the wide window housing for roll change. The carrier assembly weighs 17 tons.

During a roll change, the old assembly is moved to the set-up shop and a prebuilt assembly installed. There is no setting or aligning of guides required on the mill. In the set-up shop, the used chock sub-assembly is removed from the carrier and a hydraulic chocking machine removes the chocks in pairs off the rolls. The chock and bearing assemblies are then hydraulically pressed onto new rolls and the roll chock sub-assembly placed in the carrier. New guides are placed and aligned on the restbars. The carrier assembly is then ready to go back into service. Mill stand features include:

- Closed-top housing mounted on a floor-mounted base plate.
- Hydraulic stand shift for passline alignment and roll carrier exchange.
- Overhead hydraulic roll balance.
- Hydraulic carrier clamps, holding carrier assembly rigidly in the housing.
- Bottom roll axial roll adjust mechanism.
- Hydraulic stand clamp.
- Overhead cartridge-type manual screwdown.
- Two-row taper roll neck bearings with tapered bores.
- Entry and delivery restbars and guides mounted on roll carrier.
- Telescopic universal spindles with hydraulic spindle lift for roll change.
- Double output speed reducer with a right angle drive, driven by a 1500-hp d-c motor.
- Air/oil lubrication of mill bearings, roller entry guides, axial adjust and screwdown.
- Hydraulic snap shear at No. 3 horizontal stand entry.

Because of space restrictions in the motor room, all reducers are right-angle drives and, to minimize spares, all reducers are identical with 15:1 gear ratios.

The air/oil lubrication and hydraulics for all five stands are fed from a central hydraulic room located in the motor room.

Wide window mill housing stiffness

The design of a mill stand with two different size mill windows could cause problems with different mill housing stretch or stiffness. The wide window slab had to be designed so that it closely matched the stiffness of the narrow window slab.

A theoretical analysis was done during design with physical testing after the mill was up and running. Using finite element analysis, the two housing slabs were checked for comparative rigidity. The theoretical mill constants are: wide side, 4465 tons/in.; and narrow side, 5050 tons/in.

Physical measurement of the mill housing stretch was done in Aug. 1995. Low profile hydraulic jacks were placed between the mill chocks and, as the jacks were incrementally loaded to 8000 psi, a machinist's magnetic dial gage provided readings of displacement between the top and bottom chocks. The total displacements measured during five tests are shown in Table II, with the mill housing displacement, after compensation for shims, chocks, cylinder, etc, shown in Table III. The measured mill housing constants are: wide side, 4800 tons/in.; and narrow side, 5195 tons/in.

The theoretical and measured constants are within 10% of each other, with the narrow window and wide window constants also within 10% of each other. The housing designs are acceptable for the structural mill application.

TABLE II Total mill slab displacement

Hydraulic pressure, psi	Total load, lb	Displacement, in. x 10^{-3}				
		Wide window		Narrow window		
		Test 1	Test 2	Test 3	Test 4	Test 5
1000	19,242	5.8	4.1	2.1	2.1	2.5
2000	38,484	8.5	6.9	4.9	4.2	4.6
3000	57,726	11.4	9.9	8.1	6.6	6.8
4000	76,968	14.5	12.4	11.2	9.1	9.8
5000	96,210	17.3	15.0	14.0	12.0	12.1
6000	115,452	19.8	17.4	16.6	14.2	14.5
7000	134,694	22.5	19.7	19.0	16.5	16.5
8000	153,936	24.9	22.0	21.2	18.5	18.9

TABLE III Mill stand housing post displacement

Displacement, in. x 10^{-3}				
Wide window		Narrow window		
Test 1	Test 2	Test 3	Test 4	Test 5
5.15	3.45	1.45	1.45	1.85
7.21	5.61	3.61	2.91	3.31
9.46	7.96	6.16	4.66	4.86
11.91	9.81	8.61	6.51	7.21
14.07	11.77	10.77	8.77	8.87
15.92	13.52	12.72	10.32	10.62
17.97	15.17	14.47	11.97	11.97
19.73	16.83	16.03	13.33	13.73

Construction and installation

Serious site restrictions dictated how and when the construction and installation of the new mill stands could proceed. A construction team consisting of local contractors familiar with the Lasco equipment, site and systems was put together in early 1994.

No unscheduled disruptions to production were allowed and none occurred during the 15 months of construction. Through most of the construction period, the structural mill ran 15 turns, allowing considerable work to be done during the weekends. However, the bar mill in the same building was running on 20 turns.

Construction began in the spring of 1994 in preparation for the 2-week summer maintenance outage. All of the mill base rail and flume areas on the operators side of the mill were installed. A new drive room was installed in the existing motor room. All prewiring and prepiping were done inside the motor room. The hydraulic unit and air/oil lubrication units were installed. Rerouting of existing services was done in the area where the vertical stand would come through the mill wall.

During the July 1994 summer shutdown, the existing No. 1 through 4 mill stands, interstand conveyors and two bar turners were temporarily removed. The new foundations and base rails for all five new stands were installed. Temporary filler plates were installed on top of the new bases and the existing equipment re-installed on top of the new base rails. The mill was restarted on schedule.

From July to Dec. 1994, preparations were made for the installation and start-up of No. 1 vertical, and No. 1 and 2 horizontal stands. A new pulpit was installed, prewired and tested. The pulpit would start-up after the Christmas 1994 shutdown controlling the complete mill line. All of the programming and controls commissioning was done prior to the shutdown. The reducer and motor bases for No. 1 and 2 horizontal stands were installed. The tower for No. 1 vertical stand was installed while the mill was running. Just prior to the shutdown, the reducers and motors for No. 1 and 2 horizontal stands were installed. During the outage, the reducer and motor were installed for No. 1 vertical stand. This required a mobile crane to be brought into the mill bay on a short turnaround, because the bar

mill was only down for a few days during Christmas. The spindles and mill stands were installed for No. 1 vertical, and No. 1 and 2 horizontal stands. In early January, the three new stands were successfully commissioned and started up.

In the spring of 1995, preparations were made for installation of No. 3 and 4 horizontal stands in the 1995 summer shutdown. The reducer base for No. 3 horizontal stand and the motor bases for No. 3 and 4 horizontal stands were installed under the bar mill main pulpit. The two motors and No. 3 horizontal stand reducer were installed prior to the shutdown. The new roll chocking machine and a new roll storage area were constructed. All prewiring and prepiping for the two mill stands were completed. During the July shutdown, the base for No. 4 horizontal stand reducer was installed, new No. 3 and 4 horizontal mill stands installed and new conveyors installed between No. 2 and 3 horizontal stands, and No. 3 and 4 horizontal stands. At the end of the 2-week outage, the new equipment was successfully commissioned and started up.

Installation of the new roughing section took 21 months from the start of the design to the completion of start up, with no interruption to regular mill operations.

Summary

Co-Steel Lasco successfully installed and started up six new mill stands in both the bar mill and structural mill in 1994-1995.

Early in 1995, a new vertical and two new wide-window horizontal stands were installed in the structural mill to replace old horizontal stands. Two additional horizontal stands were installed in May 1995. At the completion of this phase the old roughing had been replaced, new electrics installed and a new main mill pulpit commissioned.

The requirements for the wide-window stands, including the capability to preset rolls and guides off line, and change rolls and guides quickly without the need to exchange complete mill stands have been discussed. The construction and installation phase of the project are achieved in a congested area without requiring any unscheduled production outages.

To enable larger, common billet sizes to be used in both the bar mill and structural mill, new vertical stands were installed at the beginning of both mills. Overdriven, straddle-mounted bearings type of stand were selected. Cobble rate has been reduced to 0.5%. ▲