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Automatic temperature set-point control strategies are most efficiently performed in a level 1 distributed control system of a reheat furnace that is not equipped with a supervisory computer. Furnace light up, purge and shutdown functions can be implemented by this system.

Use of level 1 controls for optimizing a reheat furnace

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MINIMAL requirements for a reheat furnace distributed control system (DCS) should include:

- Maintain operator-entered zone temperature set points and zone air/fuel ratios (recently, the double cross limited or lead-lag ratio control is commonly used).
- Control furnace common loops, ie, combustion air pressure.
- Incorporate all recuperator protection loops.

CRT screens should facilitate easy operator viewing of all furnace process values and changing of set points. Process alarms should be annunciated, printed and alarm status made available to the operator.

Automatic temperature set-point control

Due to financial constraints, particularly on a smaller or existing, older furnace, it may not be possible to implement full, level 2 supervisory control. A reduced version of the level 2 optimization can be implemented in the level 1 DCS. This can also be implemented on furnaces with supervisory control as a fall-back mode when supervisory mode is not available.

A series of look-up tables or production curves (depending on the standard software of the chosen DCS) are stored. These tables are based on off-line computer analysis of the furnace. The tables/curves are on a per zone basis for various material classifications. Material may be classified by size and/or metallurgical classification. Actual production rate is obtained, either through the PLC/DCS software communication link or a series of hardwired digital I/O. Italmimpianti normally uses a 2-min production rate cycle and smoothes the value over three cycles. Thus, the temperature set point of each zone is dynamically changing based on the current production rate and material classification in that zone.

In addition to this basic control, the following functions are part of the level 1 auto temperature set-point software: tracking; delay strategy; and control mode transition.

Limited tracking is included to handle situations with more than one product classification in the furnace at the same time. Screens are created to allow the operator to enter classifications and quantity for each charge group. Also, screens or push buttons are available to handle special production procedures such as recharging a piece back into the furnace so that the tracking stays on target.

The DCS will respond to operator input (via the delay CRT screen) regarding scheduled delays or anticipated duration of unscheduled delays. If the operator fails to input delay information, the system will automatically go into a delay mode based on zero production rate for a specified time.

Safe and efficient transition into and out of the auto set-point mode is provided.

Automatic temperature set-point control as performed at the level 1 vs supervisory level 2 has been discussed previously.¹

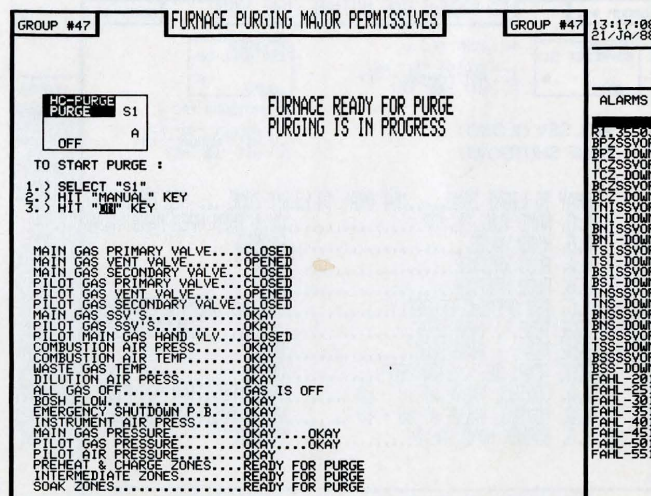
Furnace safety logic

Traditionally, the furnace purge, light up and shutdown logic has been performed in a separate safety logic control system, either relay based or PLC based, depending on overall requirements and level of automation. Advances in the discrete logic software capabilities of DCS systems have made it practical to implement this logic within the DCS. This results in two major advantages:

- Eliminates the need to interface (either hardwired I/O or communication link) between the DCS and safety logic systems or to install and wire directly to the safety logic system, separate additional field sensors, ie, high temperature T/C's or switches.
- Use of the DCS operator interface capabilities, especially custom graphics, facilitates the purge and light-up procedure including hot relight in case of momentary furnace shutdown.

A typical custom graphic (in this case from a L&N MAX-I DCS) relating to furnace purge is shown in Fig. 1. Conditions required for furnace purge are listed. An item in proper condition for purge is displayed in green while a condition not in

Fig. 1 — Furnace purge graphic.



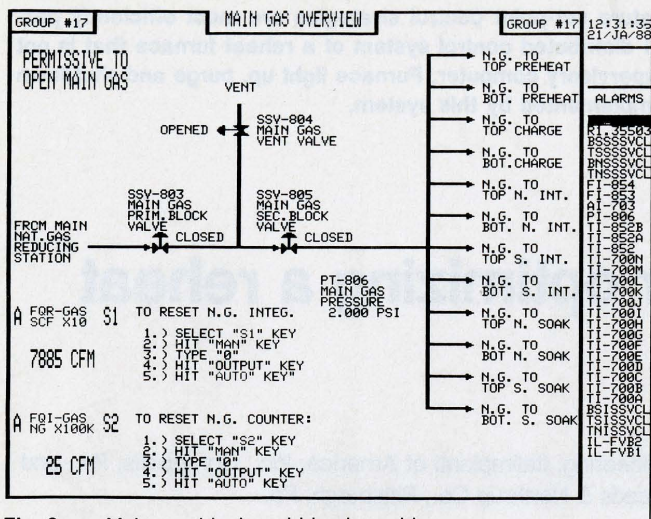


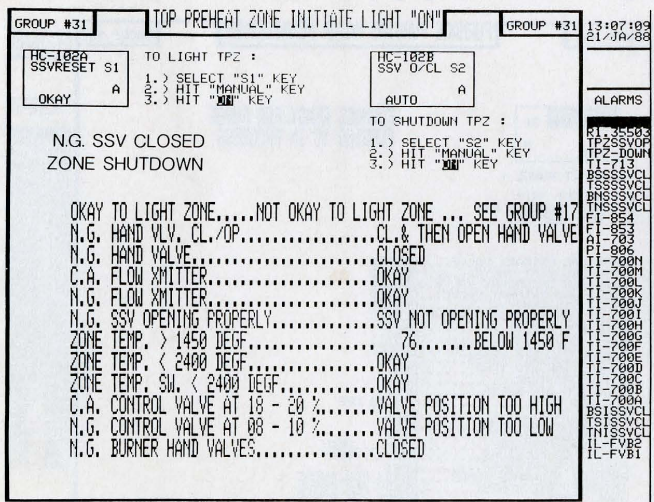
Fig. 2 — Main gas block and bleed graphic.

its proper state is shown in red. The message FURNACE READY FOR PURGE is displayed when all conditions are true. Instructions for actually starting the purge are listed. If any of the conditions fail to be true during purge, an alarm and message print out will be generated. PURGE IS IN PROGRESS is displayed during the purge period. At the end of a successful purge, PURGE COMPLETE is displayed and operator instructions for the next step in the light-up procedure are given. An added benefit of performing the purge logic in the DCS is that purge complete can be based on actual quantity of purge air through each zone, not just a purge timer.

The graphic shown in Fig. 2 guides the operator in opening the main gas block and bleed valves. All permissives (furnace purged, zone shut-off valves closed, etc) must be true before the PERMISSIVE TO OPEN MAIN GAS message is displayed. Following instructions, the operator first simultaneously opens the downstream block valve and closes the vent valve. Both these positions are proved via limit switches. Valve colors change on the CRT screen to reflect actual position. If everything remains OK, the operator proceeds to open the first (upstream) block valve.

A typical CRT screen associated with opening a zone safety shut-off valve is shown in Fig. 3. As before, the overall light-up sequence must be at the proper stage (furnace purged, main block and bleed valves in proper position, etc)

Fig. 3 — Typical zone light on (up) graphic.



and all individual permissives made (manual valve positions, transmitter signal limits, etc) before the permissive to open the zone safety shutoff valve will be allowed. In the Fig. 3 example, all conditions required for opening the safety shutoff valve are not present and the DCS will not respond to any operator command to open the valve.

The DCS is also programmed to handle the shutdown logic. This involves not only the safety shutoff valves but also making sure that control valves are driven open or closed depending on the cause of the shutdown. Italmimpianti has implemented level 1 DCS purge, light-up and shutdown logic on furnaces having both fully automatic and semiautomatic (Fig. 1, 2 and 3) purge and light-up logic and on furnaces with and without UV flame detection.

Cascade burner control

At high turn down (low zone firing rate), it is possible to improve overall efficiency by staging off some of the zone burners so that the burners which remain on fire at a higher, more efficient rate. The following considerations apply to cascade burner control:

- Within a zone, burners are generally staged off and on in groups, typically three levels of burner shutoffs per a zone.
- Burner shutoffs are usually implemented on the pre-heat and first heating zones of the furnace since these zones typically exhibit a higher turn down than the second heating or soak zones.
- To prevent excessive cycling of burners, different turn-on, turn-off values are used. For example, if a given group of burners is turned off when the gas flow drops below 50%, it will not be turned back on until the flow reaches 55%.
- Gas or oil burner shutoff valves must, of course, be tight sealing valves. The air burner shutoff valves do not require a tight seal but air leakage must be limited to avoid affecting the air/fuel ratio at the firing burners.

Another type of burner shutoff also implemented in level 1 is short slab (or billet, etc) shutoff. Depending on the furnace charging pattern, it may be advantageous to shut off the end burners in the roof or longitudinally fired zones if material is not charged across a significant portion of the furnace. Similar to the demand-based cascade control, these burners may be staged on/off in groups (ie, short slab, short-short slab, etc). The signal or flag as to which group of burners to turn on/off usually comes from the level 2 supervisory computer since it maintains a more detailed furnace material map.

Fuel/air ratio curves

Even with good modern transmitters and control valves, it is difficult to precisely control fuel/air ratios at high turn down. This is due primarily to the low differentials across the orifice plates and nonlinear valve position vs flow relationship that exists at low flow rates. As a result, the amount of excess combustion air (above stoichiometric value) is frequently maintained higher than required to assure full combustion during this worst case situation. However, the excess combustion air results in decreased overall furnace efficiency during normal production.

To resolve this problem a fuel/air ratio set-point curve (or table) is set up for each zone in the level 1 DCS (Fig. 4). At low demand (flow), extra combustion air is requested to compensate for any of the previously mentioned inaccuracies but, as the flow increases, the excess air requirement quickly drops to just above stoichiometric value.

It is possible on furnaces with level 2 supervisory control to have the level 2 computer, during an extended holding period, analyze each zone at different ratios and for various firing rates (keeping the other zones at minimum) and use

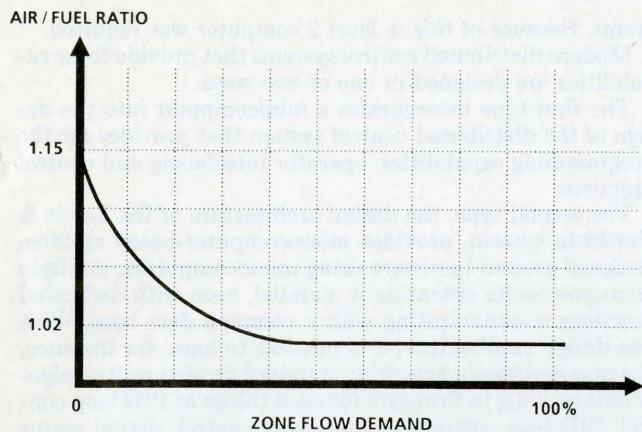


Fig. 4 — Air/fuel ratio curve.

this information to produce optimal ratio curves in the level 1 DCS.

Provision is made for operators to easily switch between the ratio curves and their own fixed fuel/air ratio.

Combustion air pressure curve

Generally, the combustion air pressure set point is chosen to provide good air distribution through the piping system for the worst case situation; ie, maximum air flow. At lower air flow rates, it has been demonstrated that the pressure could be lowered and still provide good air distribution. However, due to the fact that air flow can change quickly and that air flow in each of the furnace zones may differ greatly, it is not practical to expect the operator to continuously monitor and adjust the combustion air pressure set point.

The DCS can be configured to select the highest (in terms of percent of full flow) of each of the zone air flows. This value is used as the basis for a curve (or table) relating maximum percentage zone air flow to combustion air pressure set point (Fig. 5). Provision is made for the operator to easily switch from the curve to a fixed, operator-entered set point.

The main objective of this level 1 program is to reduce overall energy requirements. It is particularly beneficial in installations utilizing variable speed blower motors (VVVF or d-c drives) in place of inlet louver control.

Flue gas temperature cascade control

Excess temperature in the flue gas stack between the furnace and recuperator indicates inefficient heating. Too much

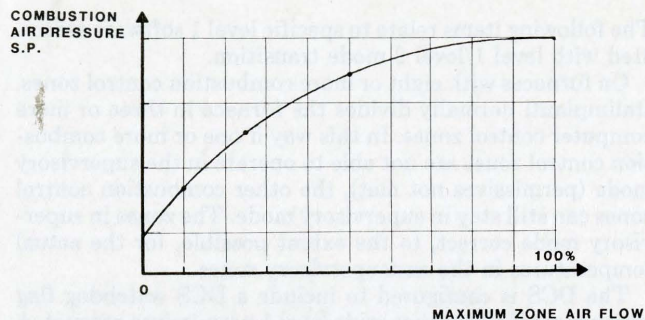


Fig. 5 — Combustion air pressure vs zone air flow.

heating is being done in the preheat and first heating zones, much of which is wasted up the stack. In addition to fuel inefficiencies, this practice could reduce stack life and, if excessive, could force into operation the hot air bleed or dilution air recuperator protection loops. This further reduces overall furnace efficiency and creates system instability.

Using off-line computer analysis, a relationship can be developed for any furnace relating the maximum acceptable flue gas temperature to the production rate. (The flue gas temperature will increase during higher production rates.) This information is entered and stored as a curve (or table) in the level 1 DCS. A cascade temperature controller (Fig. 6) is configured in the DCS. The controller is used to bias (lower) the operator entered temperature set points in the preheat and, depending on furnace design, sometimes the first heating zones. The cascade controller process variable is the measured flue gas temperature and its set point is obtained from the flue gas maximum temperature vs production rate curve noted earlier.

This control strategy is generally used only when the zone temperature set points are operator entered, not when level 1 or level 2 zone temperature optimization mode is in operation.

Level 1/level 2 mode transition

An important aspect of the level 1 DCS software is to provide a safe, efficient and smooth transition into and out of level 2 supervisory mode on those furnaces equipped with a supervisory computer. The level 1/level 2 interface is generally via a dedicated software link. Most DCS manufacturers can provide a hardware and software interface package between their system and the commonly used furnace supervisory computers; DEC micro VAX, DEC PDP series or IBM PC.

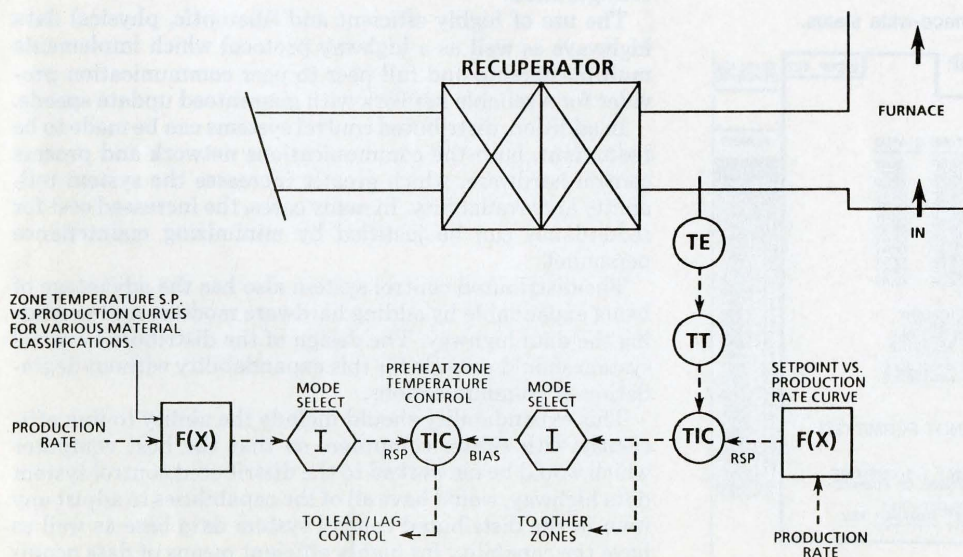


Fig. 6 — Waste gas temperature cascade loop.

The following items relate to specific level 1 software associated with level 1/level 2 mode transition.

On furnaces with eight or more combustion control zones, Italimpianti normally divides the furnace in three or more computer control zones. In this way if one or more combustion control zones are not able to operate in the supervisory mode (permissives not met), the other combustion control zones can still stay in supervisory mode. The zones in supervisory mode correct, to the extent possible, for the actual temperatures in the nonsupervisory zones.

The DCS is configured to include a DCS watchdog flag which is set if all furnace-wide level 1 permissives are met. A supervisory watchdog flag is set up in the level 2 computer. A watchdog timer is established. If the bit status for this timer is not continuously and alternately reset by both the DCS and supervisory systems, it will time out and the furnace will drop out of supervisory mode. A furnace-wide DCS CRT status screen is shown in Fig. 7. A similar screen will exist for each of the computer zones, listing the zone level 1 permissives.

The furnace (or portion thereof) may drop out of supervisory mode due to loss of permissive(s), the watchdog timer timing out or operator initiated switch out of supervisory mode. Regardless of the cause, each combustion zone temperature controller will be configured to respond as follows when no longer in supervisory mode: revert to automatic mode; initial output matches the output (demand) from the supervisory computer (output initialization); and the set point for the zone becomes the actual zone temperature at the time of mode transition (set-point tracking).

The operator may then change any of the zone temperature set points as required.

DCS hardware considerations

To implement the functions described previously without the use of a level 2 computer, the distributed control system must be designed to contain standard control system function blocks (control algorithms) that are hard-coded in firmware to provide both reliability and speed, and also must contain adequate memory and processing power to implement programmed level 2 functions to work concurrently with the control algorithms.

Until recently, distributed control systems were not designed to have both of these capabilities. Most commonly, the earlier designed distributed control systems contained the control system function blocks, but did not provide the memory capability or processing power to implement pro-

grams. Because of this, a level 2 computer was required.

Modern distributed control systems that provide these capabilities are designed in one of two ways.

The first type incorporates a minicomputer into the design of the distributed control system that provides for the programming capabilities, operator interfacing and control functions.

The second type, the design architecture of the Leeds & Northrup system, provides microcomputer-based systems designed around hardware using microcomputers, multiple microprocessors operating in parallel, each with dedicated functions communicating with a common data base. With this design architecture, it is possible to have, for instance, one microprocessor executing standard process control algorithms residing in firmware for such things as PID loop control, PID host computer supervisory control, digital status and alarm capabilities, etc. Another microprocessor provides for the programmability functions executing programs written in a compiled language running at real-time speeds to work concurrently with the process control algorithm. Since the system components can be physically distributed, these microcomputer functions can reside in multiple location nodes or drops from the data highway. This physical and functional distribution allows for both paralleling of control and operator functions, and high reliability associated with minimum impact on the system in the event of a hardware failure.

As mentioned previously, the distributed control system must provide for a highly efficient and flexible operator interface to allow the operator to be alarmed after the failure of communication, hardware or process changes and must provide for efficient interactive graphics which emulate the process and can be presented to the operator in a form which complies to this particular operating practice. In addition, it must have the capabilities of presenting screens to enable the operator to enter interactive data to execute the functions described. Also, the operator interface can have the ability to collect, average and compress historical data for use in the optimization program and for historical retrieval of data for quality tracking in the furnace.

The same microcomputer multimicroprocessor design can be used to implement all of these functions in the operator interface station. Microprocessors with onboard memory can be dedicated to specific functions and be made to operate in parallel and communicate to a common data base. A highly efficient, functional and reliable operator interface results.

There is an additional advantage to having the distributed control system contain level 2 functions: increased reliability because of fewer devices required and a simpler hardware configuration.

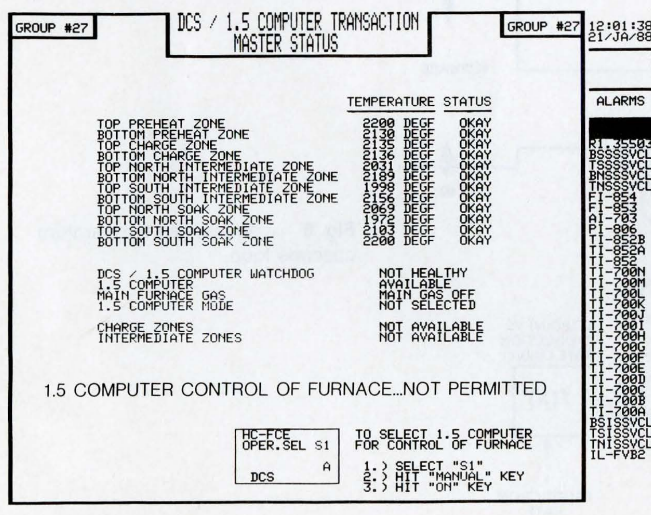
The use of highly efficient and fiberoptic, physical data highways as well as a highway protocol which implements multimastering and full peer to peer communication provides for a reliable network with guaranteed update speeds.

In addition, distributed control systems can be made to be redundant, both the communications network and process control hardware, which greatly increases the system reliability and availability. In many cases, the increased cost for redundancy can be justified by minimizing maintenance personnel.

The distributed control system also has the advantage of being expandable by adding hardware modules and extending the data highway. The design of the distributed control system should provide for this expandability without degradation of communications.

This expandability should include the ability to link efficiently with future computers so that the host computer which would be networked to the distributed control system data highway, would have all of the capabilities to adjust any item in the distributed control system data base as well as have the capability for highly efficient means of data acqui-

Fig. 7 — DCS/supervisory computer furnace-wide status.



sition without any degradation of overall system performance.

The design of distributed control systems is headed in this direction. The authors consider that as time goes on, more and more of the level 2 functions will be contained in the level 1 distributed control system.

Summary

Automatic temperature set-point control and other control strategies are most efficiently performed in a level 1 distrib-

uted control system of a reheat furnace that is not equipped with a supervisory computer.

Furnace light-up, purge and shutdown functions can be implemented by the distributed control system.

REFERENCE

1. Schurko, R. J., et al, "Computer Control of Reheat Furnaces: A Comparison of Strategies and Applications," *AISE Year Book*, 1987, pp. 219-224. ▲

Bethlehem Chairman Seeking VRA Extension

The chairman of Bethlehem Steel Corp., Walter F. Williams, said that while the U.S. system of Voluntary Restraint Agreements on steel imports has not stamped out unfair trade in steel, it has at least contained it, and called for a 5-year extension of VRA's beyond their 1989 expiration.

The VRA program, negotiated by the Reagan Administration with 20 exporting nations, has proven effective in reducing the market share for imports of finished steel from nearly 26% in 1984 to approximately 20% last year.

That reduction meant an additional 5.3 million tons of shipments for domestic producers last year alone.

When the existing VRAs expire in Sept. 1989, the world steel industry will still be plagued by excess capacity, and heavy subsidization. And the U.S. industry will still be in the process of modernization and recovery from its five years of heavy financial losses between 1982 and 1986.

The obvious answer is to extend existing VRAs for another five years, until conditions return that support fair and open steel trade throughout the world. Unless America firmly presses for its rights in trade, the rest of the world will continue to take advantage. And the longer that happens, the greater the danger that their exports will eventually become extremely expensive.

The chief executive also noted that since the institution of VRAs, Bethlehem Steel and the rest of the integrated domestic steel industry have made numerous advances in technology, reduced costs and increased productivity and yield.

He emphasized that the American steel industry still has plenty left to do in further modernizing facilities and driving down costs while improving quality and service.

The steel industry is not a rusty old relic, nor has it relaxed within the comfort of an established 5-year recovery program. U.S. companies hit the ground running, knowing what needed to be accomplished and have been working relentlessly at those goals ever since, despite heavy financial losses which extended through 1986.

He emphasized that the issue is not whether American steel producers can be price competitive against foreign producers, but how the foreign producers can be price competitive in the U.S. market, considering current foreign exchange rates and the fact it costs another \$70 or so a ton to ship steel to U.S. markets.

He explained that the world's largest steel exporting countries all have excess steelmaking capacity, but because those industries provide well paying jobs in the home country, they allow the continued operation of their overbuilt steel facilities.

Government subsidization of steel is common practice abroad, noting that between 1980 and 1985, the European Community provided more than \$40 billion in subsidies to help its steel industry. And Brazil has written off \$12 billion in debt for its government-owned steel operations, while announcing plans to double the country's steelmaking capacity by the year 2000.

Even next door in Canada, several hundred million dollars of public funds are currently being spent for a rail mill that no one needs—certainly not Canada, where the new facility will add capacity to a product already in oversupply.

He said estimates are that over a million dollars will be spent for every single job created by the new Canadian mill.

Canada is not among those countries that signed Voluntary Restraint Agreements with the U.S.

"To let America's competitiveness erode by allowing foreign countries to continue to dismantle our industries is a one-way ticket to long-term mediocrity for the U.S. We just cannot let that happen, because the alternative is second class status among the world's powers.

Meanwhile, America will have to keep working to improve its productivity and we must demand equal treatment and fair trade from our trading partners.

We simply cannot maintain a first-rate manufacturing base if we remain everyone's dumping ground for excess manufactured goods.

To prevent that, America should do the following:

- Improve all manufacturing operations through further cost reductions, productivity gains and quality improvements.
- Get our macroeconomic house in order by reducing federal budget deficits. This is the single most important step government can take to make the U.S. more competitive.
- Keep a close watch on international economic policies and demand that our government take prompt corrective actions whenever unfair and illegal developments occur.
- Amend our newly legislated tax system to encourage investment and discourage overconsumption.
- Convince Congress to stop shooting our country in the foot with actions that clearly harm our ability to compete, such as legislation dictating unrealistic plant layoff notification procedures.
- Continually educate all segments of our society on the need to maintain an industrial base and enhance its competitiveness.

We have a pervasive trade problem. It is serious and it needs fixing now. American businesses are being had by the market-grabbing mercantilism of our trading partners. ▲

Bethlehem's Shape and Rail Products Div. striving for long-term viability

THE structural and foundry operations of Bethlehem Steel Corp.'s Shape and Rail Products Div., located in Bethlehem, Pa., enjoyed a better level of business in 1987, and posted a modest profit for the year. The division's Bethlehem plant is the largest producer of structural shapes in the U.S. and a major producer of foundry products.

However, despite the past year's profitability, efforts are being intensified to insure long-term viability of the operations in the face of stiff competition, both in the U.S. and abroad.

The division, which includes the Steelton plant near Harrisburg, will be facing some stiff domestic competition from a major new 600,000-ton capacity mini-mill operation.

Some industry analysts have predicted that the entrance into the mar-

ket by a low-cost structural steel producer most likely will result in an integrated producer being forced out of the structural business.

The important matter of cost cutting will be aided this year with completion of the \$50 million modernization of the plant's 48-in. mill. The project involves installation of a 59-in. roughing stand.

The modernized mill will enable the plant to produce wide flange structurals at a lower cost and with improved quality.

Last year started out with a healthy level of business, primarily because of a work stoppage at the structural operations of a major competitor, then fell off mid-year, but rebounded in the third and fourth quarters.

Looking at the operations individually, fully 50% of the plant's coke pro-

duction is now being sold to sister plants; the foundry, which added slag pots to its list of products last year, made notable gains in cost reduction; the blast furnace operation's tonnage increased in 1987; the steelmaking department began shipping ingots to Bethlehem's Burns Harbor plant; and, in the second half of the year, the rolling mills recorded healthy gains in yield.

In addition to this year's modernization of the 48-in. mill, the plant has also earmarked substantial expenditures for the improvement and maintenance of equipment to keep pace with the demands of the market.

The plant will continue its efforts in the area of new product development. New structural sections are being developed for the combination mill. ▲

Steelmaking at Bethlehem's Shape and Rail Products Div. is accomplished in modern basic oxygen furnaces. Here, one of the furnaces is in the turndown position, permitting an analysis sample to be taken of the molten steel bath.



Structural steel beams are loaded for shipment at the Bethlehem plant, the largest producer of structural shapes in the U.S.

