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MACHINE SCARFING DEVELOPMENTS AND PROCESSES FOR THE MODERN STEEL INDUSTRY

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MACHINE SCARFING DEVELOPMENTS AND PROCESSES FOR THE MODERN STEEL INDUSTRY

By: Gary Klaybor

To better explain the benefits of more recent developments in scarfing, I would first like to review a bit of history. I believe this will point out that we, L-TEC, are continuously working to help the steel maker meet the ever more stringent quality requirements of the end-user.

L-TEC, a member of the ESAB GROUP, was formerly the Welding and Cutting Group of the LINDE DIVISION of UNION CARBIDE CORPORATION. L-TEC has been the leading supplier of scarfing machines to the steel industry for over 75 years.

The machine scarfing process was first developed about 1932. The original development, as was the case with many steel-making processes, was crude and somewhat inefficient but the intended results were achieved. It proved a viable process for removing defects from the surface of ingot rolled slabs and blooms to improve the finished product. As with any new process, refinements and improvements are always being made and before long hot scarfing was being done in-line at production speeds. Many of the improvements were, and still are, necessitated by ever improving steel-making methods.

Hot scarfing of ingot product was an accepted practice throughout the world. Then, with the advent of Continuous Casting, things changed. First, it was believed that the surface of cast steel would not need conditioning. When this theory did not hold true, a new challenge was posed for us in that the steel was no longer hot. In fact, in early practice, cast slabs were purposely cooled to virtually ambient temperature. Rising to the challenge, we developed the first cold scarfing unit in the late 1960's. Higher oxygen flow capability, better control of upper and lower block fuel gas, and a hotter preheat flame was necessary. Initially, pre-mixed gases were utilized to produce the hotter preheat, but, in later development this too was changed and the cold scarfing process now utilizes the safer post-mixed gas concept.

Thus the two basic scarfing processes "Hot" and "Cold" were developed and now steel is scarfed at temperatures ranging from ambient to 1100°C. Later, this temperature range was categorized further into three groupings with cold considered as ambient to 400°C, warm as 400°C to 850°C, and hot as 850°C to 1100°C.

Today's scarfing machines utilize the same basic thermo-chemical reaction as their predecessors, but the scarfing process has improved as different unit designs were developed for different applications. From the first "blow pipe" type nozzles came the;

<u>Continuous Slot Scarfing Unit</u> This unit provided a flatter, contiguous stream of oxygen, which caused a flatter scarfed surface.

<u>High Capacity Scarfing Unit</u> This unit enhanced metal removal capability.

<u>Shielded Preheat Scarfing Unit</u> This design shortened the preheat time on hot steel, offering fuel gas savings and increased production.

Cold Scarfing Unit   This design is capable of preheating ambient temperature steel.

Cold/Hot Scarfing Unit   This unit is designed to convert hot machines for scarfing cold cast slabs.

Spot and Band-Pass-Scarfing Units This unit is designed to minimize yield loss.

End-Start Scarfing Unit   This design offers full surface scarfing of all four sides simultaneously.

Smooth Surface Preheat Block   This preheat block design creates a very smooth scarfed surface. It can be retrofitted to any existing scarfing unit.

All these advancements have made the scarfing process and machine usage more flexible over the years. Later, I will explain several of these process developments in more detail.

To keep up with the demands of the industry, not only were process improvements necessary but process control methods needed to be improved, as well. The majority of modern scarfing machine installations today are intended to scarf continuous cast product. This is generally done in the cold or warm state. The scarfing process in this temperature range is considerably less forgiving than is hot scarfing, therefore, it is important to more precisely control process parameters. Today's scarfing machine has considerably different and refined control systems. Transducers have replaced pilot regulators and analog gauges, an Operator's Interface Terminal has been added, scarfing parameters have been integrated with data from mill computers and in several cases machine operation has been automated. Several of these improvements will also be explained later.

Continuous casting methods and metallurgical refinements have improved the quality of today's as-cast steel so that considerably less conditioning is done today than was twenty year ago. But, it has not advanced to the point of eliminating the need for conditioning. A survey made several years ago indicated that in today's market an average of 30% of the steel produced is scarfed. Most of this is used in critical applications in the automotive, appliance, can, bearing and special bar markets. This percentage seems to have increased somewhat in the last several years, as quality requirements of the end user become more and more stringent. In general, product such as, low carbon aluminum killed, ultra low carbon, high carbon or alloy steel and special bar quality product are normally machine scarfed.   In the latter case, product is scarfed warm as cast or hot after being reheated and rolled.

Steelmakers know that continuous casting of prime product requires equipment that is operating at peak efficiency. This requires a high degree of maintenance and in some cases might require expensive modifications to the caster. Time spent at the caster to achieve the required surface quality must be weighed against the cost to do so and the cost of alternative methods to meet the same quality requirement. In some cases, particularly for the grades used in the aforementioned critical applications, it has proven more cost effective to machine scarf. One mill has found it to be financially beneficial to use a less expensive mold powder during the casting operation and then machine scarf the steel to obtain the required end product results.

I would now like to review several of the control methods and processes currently used on all newly built scarfers. Many of these improvements can be retrofitted to machines in the field.

The use of the Programmable Logic Controller (PLC) has greatly enhanced the capabilities of the scarfing machine's control. Besides providing very precise logic control, it also allows the use of other state-of-the-art equipment as well as the possibility to interface with mill higher level computers. The computer communication link can be used to send steel tracking information, steel grade, product size, temperature, and any special conditioning requirements, to the scarfer PLC. Some of our customers use the scarfer PLC to calculate the amount of removal based on steel grade input by the mill computer, and temperature, input by a pyrometer at the scarfer. In this way, they insure an accurate metal removal rate based on the variables for the particular product being scarfed. The control of these variables insures accurate removal and precludes unnecessary yield loss.

Electronic Process Control is a feature whereby process pressures are energized and controlled by the PLC. This system replaces the pneumatically controlled pilot regulators, which normally require a great deal of maintenance and achieves precise process control. This is particularly important during the preheat period. Low-pressure slot oxygen, which is set at 0.02 Bar is critical to ensure a positive preheat . This in turn, eliminates the main cause of scarfing misses at the start of the cycle. According to maintenance personnel this low pressure is very difficult to set and maintain with the pneumatically controlled pilot regulators. With EPC low pressure slot oxygen can be set and controlled very accurately.

Figure 2 depicts a typical EPC system as an electronic control loop that utilizes pressure transducers controlled by the PLC. The software controls a 4 to 20 mA analog output signal to an E/P transducer, this transducer controls the main process regulator and the correct pressure is delivered to the scarfing machine. The return portion of the loop is from a P/E transducer that measures the actual pressure within the scarfing machine manifold and transforms this pressure signal back to the controlling PLC as an analog voltage signal. The "PI" (proportional-integral) control loop software analyzes this return signal and corrects for deviations from set point that may exist in the pressure measured at the scarfer. The pressure error is corrected very rapidly and is then maintained as a steady state pressure for as long as is required. This feature is a great upgrade for older scarfing machines to achieve accuracy of set pressure over the full length of the steel, exact repeatability of conditions, with a side benefit of reduced regulator maintenance due to the excellent compensation ability of the system.

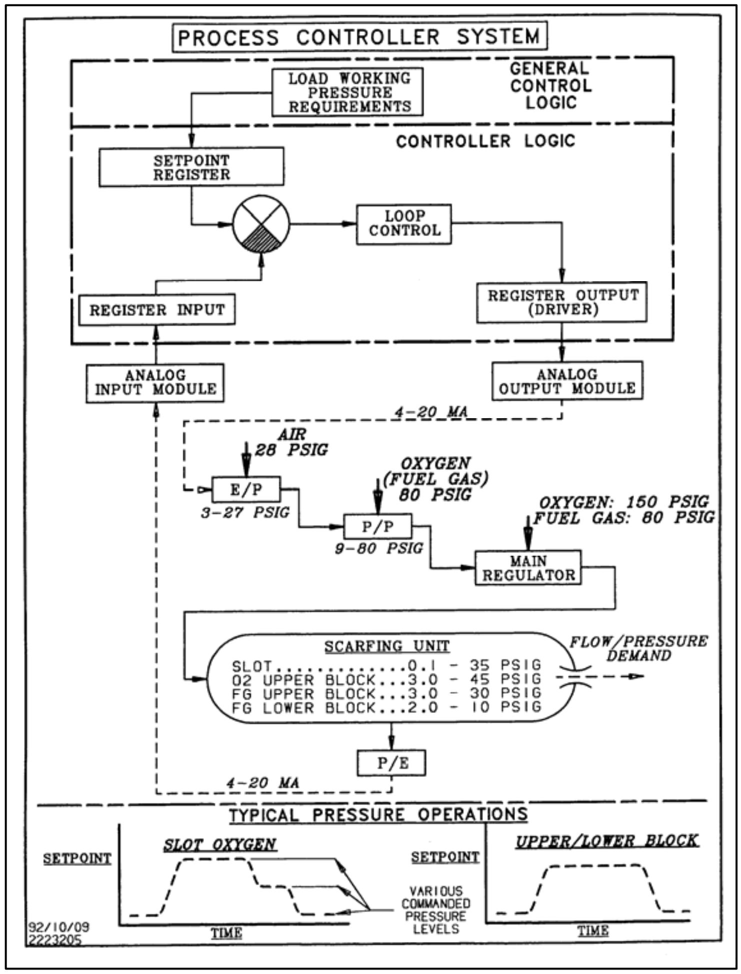


Figure 2

Scarfing installations that use the EPC system, usually incorporate an Operator Interface Terminal. This system consists of a PC, keyboard, program package and monitor, which allows the operator to communicate to the PLC. In this manner he can change process pressures, adjust timers or set new values into data registers. This interface allows the operator to control different items such as roll table speed and scarfing oxygen pressure, either of which controls depth of metal removal.

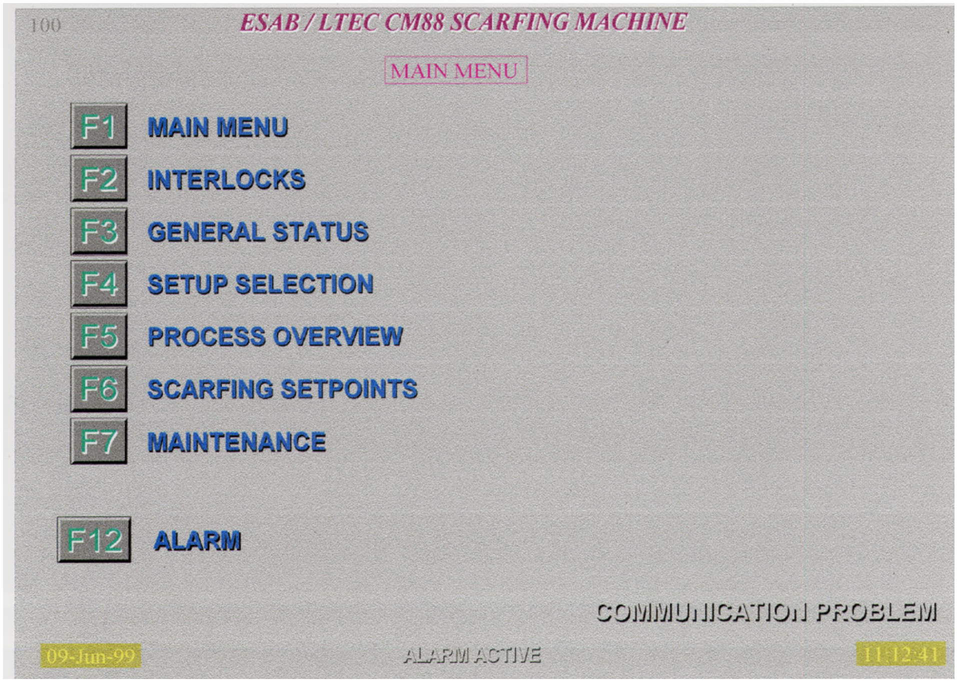


Figure 3

The OIT system serves as an informational display. All of the scarfing process pressures are displayed as digital and/or analog values on various screens.

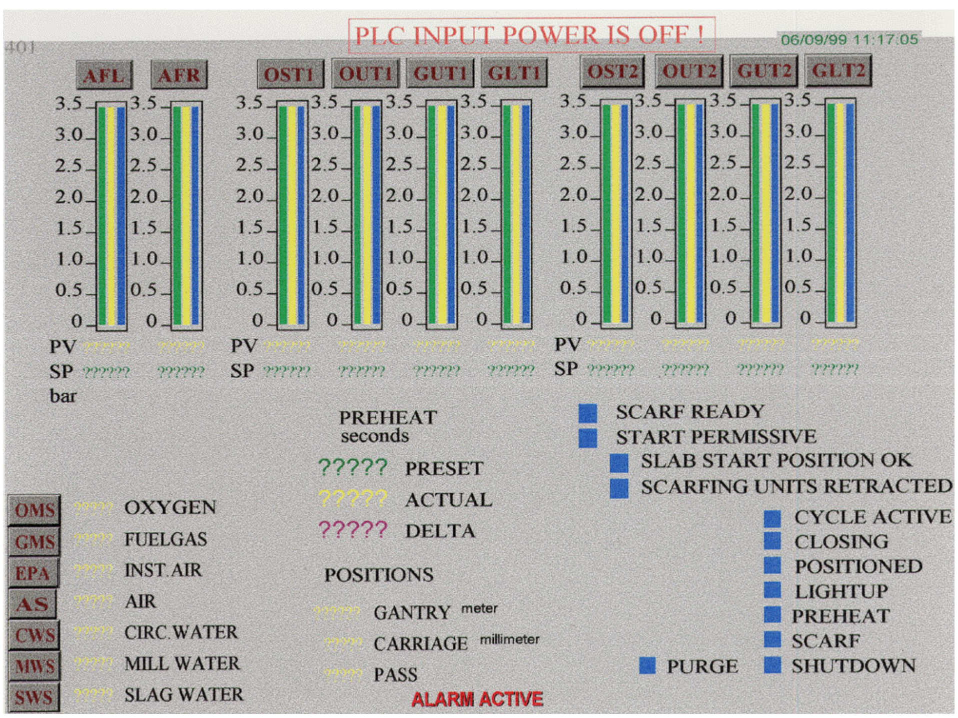


Figure 4

It can be designed as a steel tracking device, wherein the operator can verify and/or input specific data relating to a certain piece of steel. For example, he can record whether or not the steel was conditioned properly or if some error occurred that will require further conditioning. Such information is available for immediate use or can be archived for later review should a problem occur downstream. The OIT will also alert the operator to a specific equipment problem through programmed alarms. This alarm page helps as a trouble-shooting guide such as if the circulating water temperature is too high, or the oxygen supply pressure is below the minimum requirement, or that there is insufficient slag water pressure at the nozzles. Besides the standard screens provided for scarfer operation, screens specific to mill operation can be added.

Also available is specific control equipment and software to allow a totally automatic scarfing machine operation. In an automated installation the steel flow through the scarfer is controlled by devices such as hot metal detectors and distance monitoring transducers. The signals from this equipment are integrated into the scarfer software. Appropriate safeguards are provided to ensure that functions occur in sequence and to prevent damage to the scarfer should control equipment fail. Although there is no dedicated operator required strategically placed video cameras allow the passive monitoring of the operation in the rolling pulpit.

The above items have listed various methods for improved machine control. The following items are recent developments to the scarfing process that offer an improved scarfed surface.

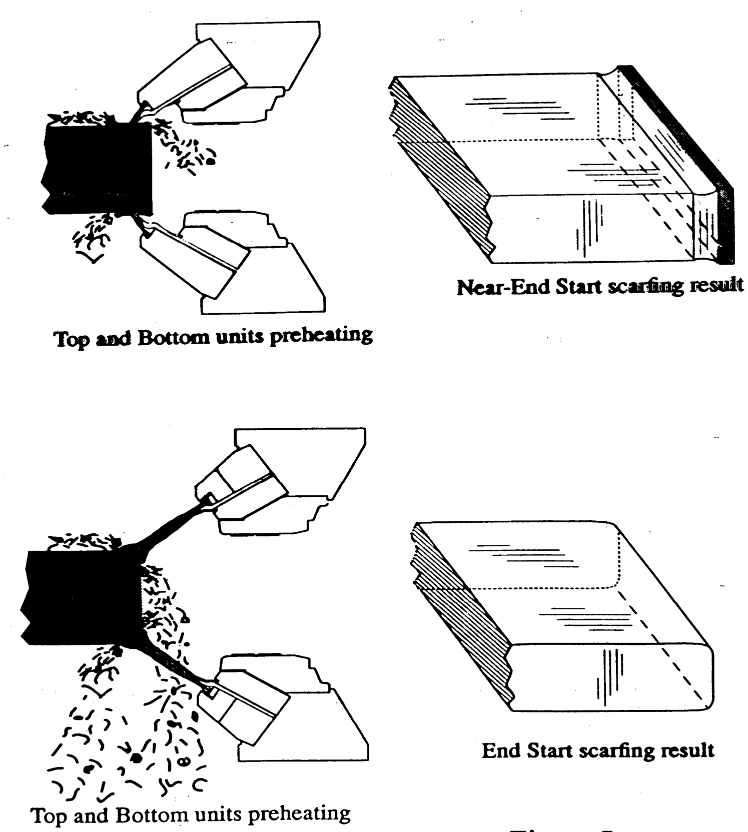


Figure 5

The End-Start process allows the simultaneous scarfing of all four sides of a slab or bloom along its complete length. Previously four-sided scarfing required near-end starts, which left an unscarfed band around the perimeter of the leading end of the steel. The recently patented End Start Scarfing Unit (ESSU) delivers a very substantial pre-heat flame, from a significant standoff distance. The standoff distance is required as protection for the scarfing unit from the potential splash of molten slag at the start of the scarfing reaction. Not only do these units start on the very end of the steel to completely scarf the entire surface they also offer a uniquely shallow starting gouge, when used for near end surface starts as is required with PMSU.

The starting gouge from the PMSU process is caused by the focused preheat flame on the steel surface. The ESSU preheat process is projected approximately 8” to the steel surface causing the preheat area to be wider and therefore, shallower. This feature has been welcomed by steel producers who find the depth of the starting gouge left by the PMSU to be objectionable due to the extra yield loss and the need for secondary conditioning to clean up the unscarfed front end prior to subsequent rolling.

The wide preheat zone of the ESSU flame offers another benefit. With accurate positioning of the steel, the preheat flame impingement point can be located so that the preheated area will extend to the leading end. The result is a fully scarfed surface while minimizing the amount of slag that blows down the front end.

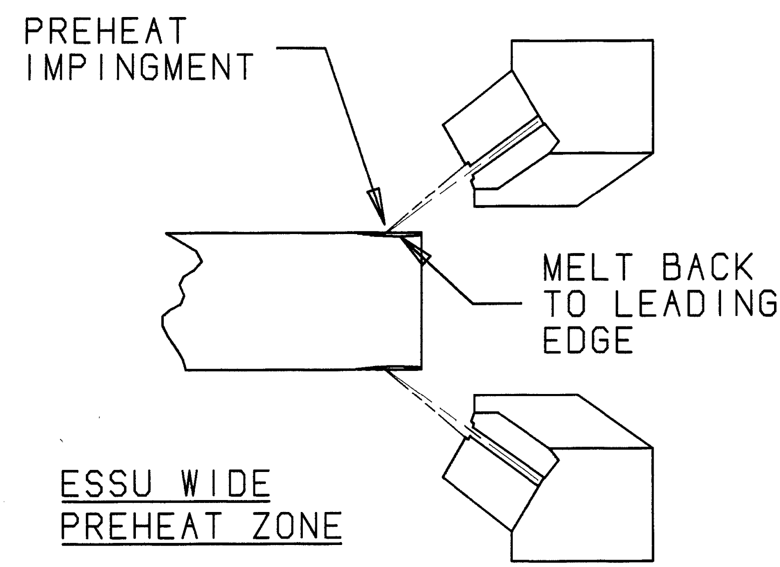


Figure 6

The ESSU can be retrofitted to any existing four-sided machine**.**

In an effort to improve scarfed surface quality, a newly patented lower preheat block has been developed to be used with any scarfing unit type. To better understand the smooth surface concept an explanation of the basics of the scarfing process may be helpful.

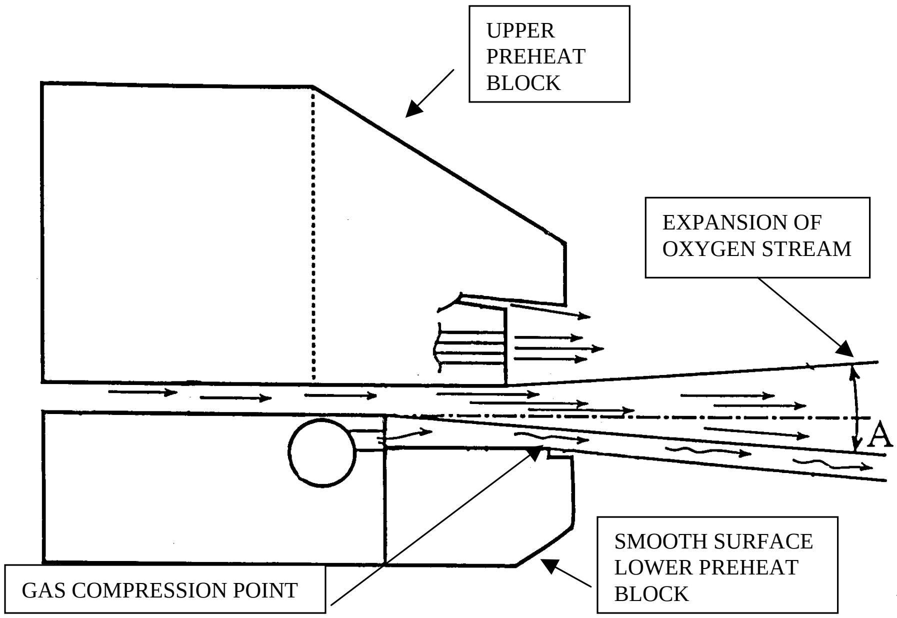


Figure 7

Consider the process as a sandwich of gases, upper block oxygen, upper block fuel gas, slot oxygen in the middle, and lower block fuel gas. Each has its specific effect on the obtainable results. The slot oxygen, or scarfing oxygen, stream provides the metal removal capability and must be uniform across its width. Any variation in uniformity will show as a variation in the metal removed. The upper block provides preheat to initialize the scarfing reaction. The oxygen shields the fuel gas to intensify the heating capability. The upper block fuel gas, in turn, shields the scarfing oxygen stream as the scarfing reaction occurs. Because it shields the upper surface of the scarfing oxygen stream it has little effect on the surface finish. The lower block fuel gas shields the lower surface of the scarfing oxygen stream as it impinges on the steel surface, and is therefore critical to surface quality. Any discontinuities in the lower block fuel gas stream cause a disruption in the scarfing oxygen stream which in turn causes ridges or surface irregularities. Flow and pressure requirements are the same for both the standard lower block and the smooth surface lower block. The advantage of the new design is that the fuel gas first flows into a “chamber” formed by the upper surface of the baffle and the oxygen stream. As the oxygen stream flows toward the steel surface it “pulls” the fuel gas along and expands towards the baffle surface. The fuel gas is compressed between the baffle surface and the oxygen stream. This smoothes out the irregularities in the fuel gas flow, which may have been caused by tip plugging or other irregularities in the fuel gas ports.

The initial field tests performed on a CM-90 were dramatic. The results are illustrated in the following pictures as taken at the test site. Figure 8 shows the scarfed surface using the standard PMSU lower preheat block. Figures 9 & 10 show the scarfed surface using the smooth surface lower preheat block.

Figure 8 (SLABS SCARFED WITH STANDARD "PMSU")

Figure 9 (SLABS SCARFED WITH SMOOTH SURFACE UNIT)

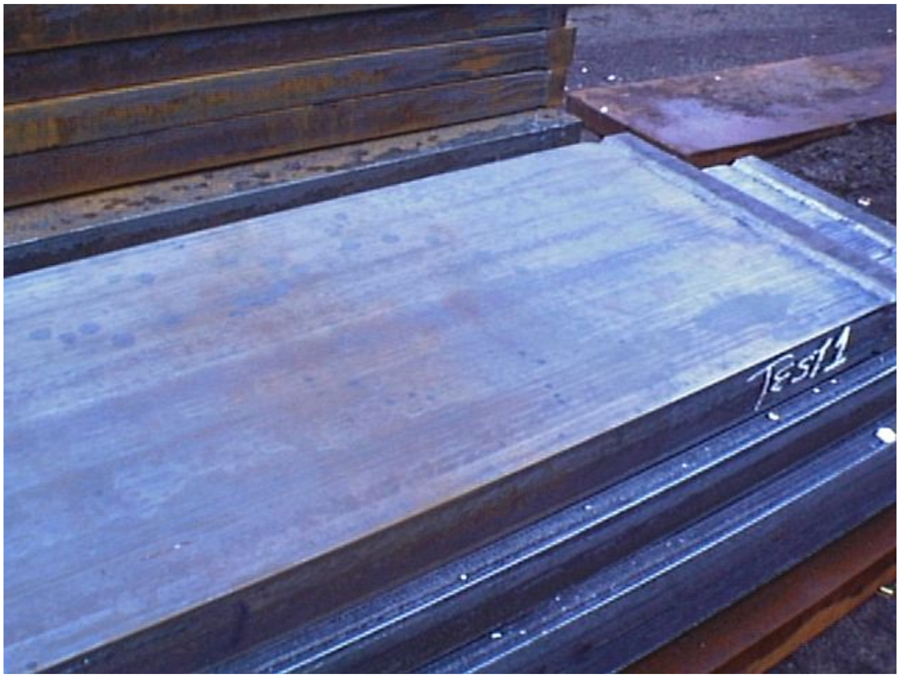


Figure 10 (SLABS SCARFED WITH SMOOTH SURFACE UNIT)

This patented lower block is available as a retrofit to any existing model of scarfing unit. If purchased as a retrofit it is advisable that all of the lower blocks are exchanged en masse, otherwise a mixed steel surface smoothness will result.

Another improvement requested by various customers is the ability to remove more metal from the top and bottom “corner” surfaces of cast slabs. The width of this longitudinal defected area is 6” – 10”. There are certain grades of steel that produce severe cracking problems along these surfaces, whereas, the middle of the slab contains fewer or less severe defects. If the metal removal is set to remove the deeper corner surface cracks there is an unnecessary yield loss from the remaining surface. To accommodate this request a segmented manifold was needed. A solution was simple for the fixed corners but to accommodate the floating corners required a more unique approach.

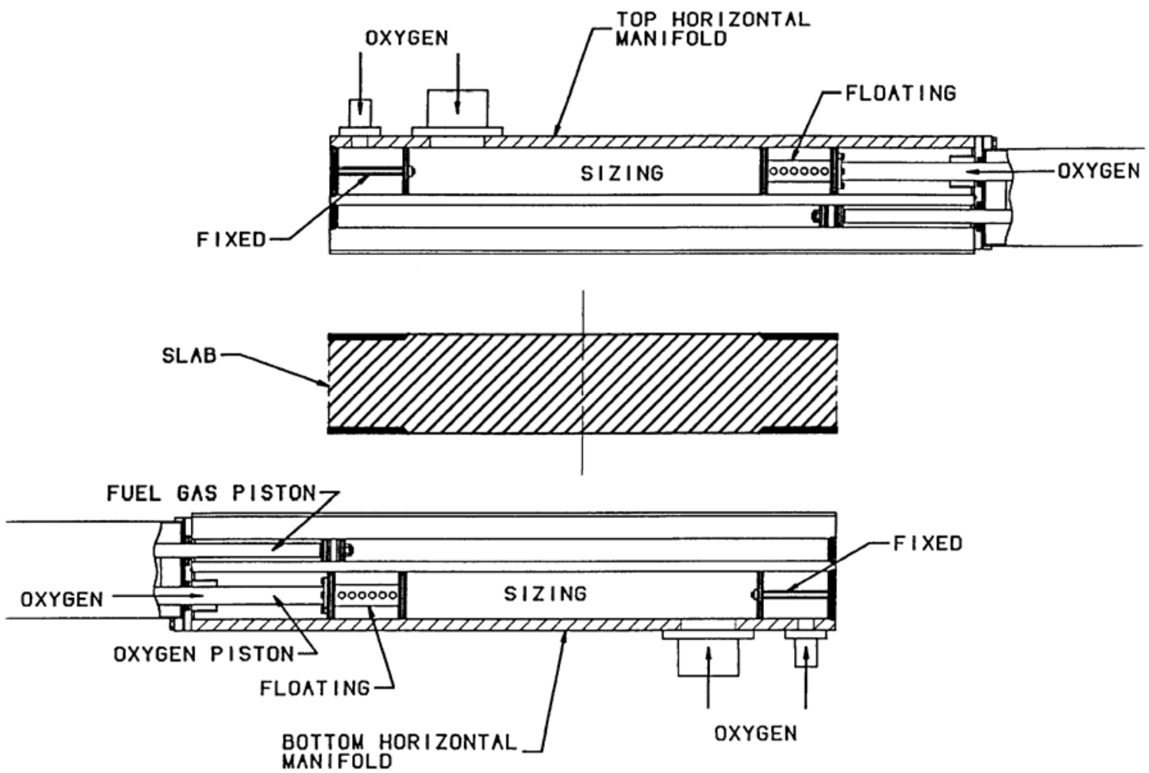


Figure 11

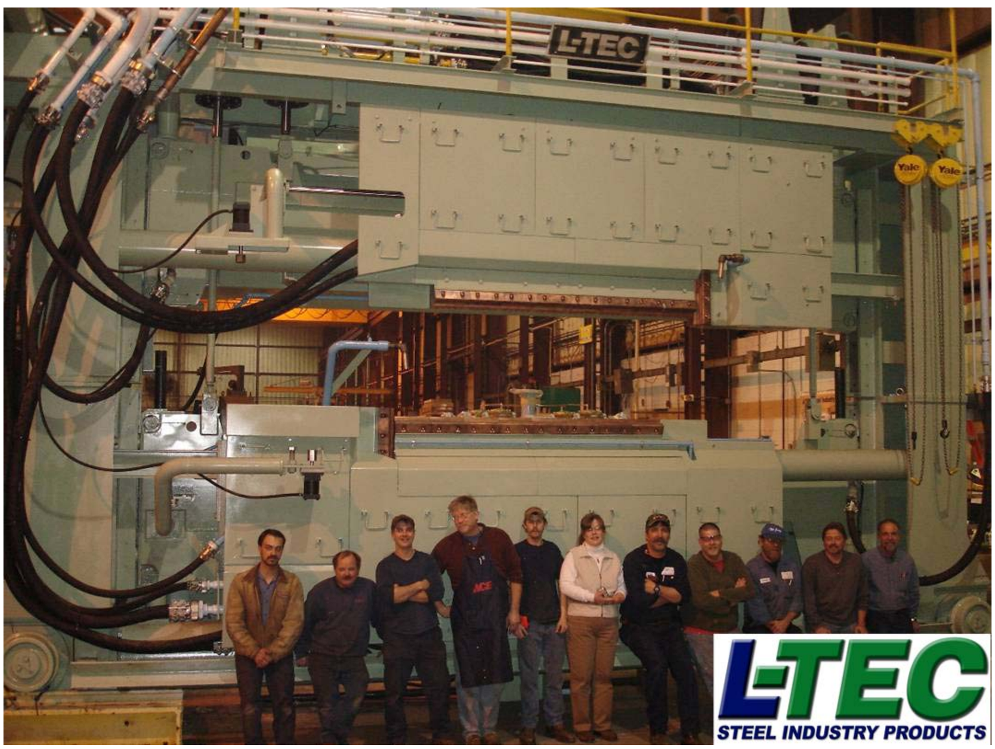
As a solution to the problem a segmented manifold was designed to allow separate oxygen control to the corner surfaces. A spool section placed in the blind end of the manifold readily accommodates the fixed corners of the slab. The unique feature of the invention is the spooled piston that allows the same differential removal on the floating corners.

This patented three-segment manifold allows separate scarfing oxygen pressures to be set in the specified areas which allow differential metal removal for a preset speed. The width of the corner bands is mechanically preset according to the customer's requirements. The benefits derived are either heavier metal removal along the corners or simply equalization of metal removal across the full surface to compensate for temperature differences between the corners and the middle of the slab.

The use of this "segmented" manifold is for machines with piston sizing. Retrofitting packages for existing machines are available.

We have also made other, not so obvious changes, that has improved the operational life of the copper preheat blocks and shoes. A new copper alloy that inhibits cracking due to grain growth caused by thermal cycling is now being used. This has been well received by maintenance departments in so much as the service life of the original blocks are much longer and welding repairs can be performed more often. Thermal cracking of the copper block is no longer a problem.

Although refinements in the steel making process may be considered the ultimate solution to today's quality requirements, in many cases, machine scarfing is still the most economical method to produce the necessary results. A number of conditioning options are available from our standard line of machines and processes. Only a few have been discussed in this article. In our development laboratory, we constantly search to expand those options. In today's customized market, customized solutions are required. We are ready to work with you to provide those solutions.



L-TEC CM-90-8-2 LH Scarfing Machine

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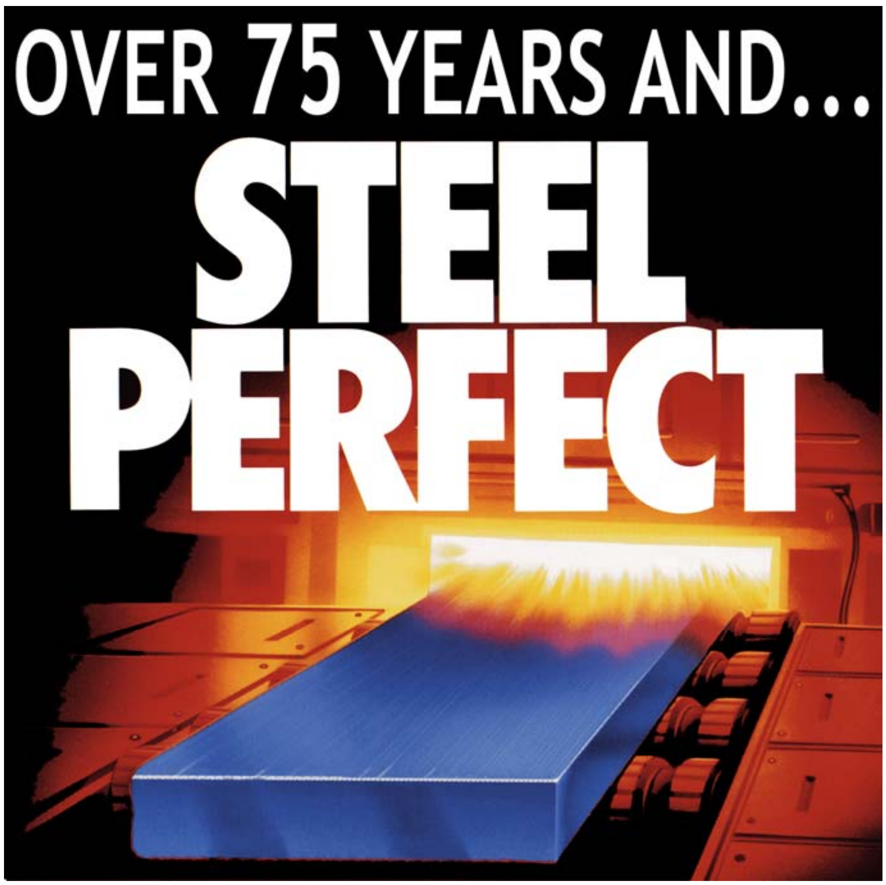

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