



Operational Results of Coherent Jets at Birmingham Steel – Seattle Steel Division

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Introduction

Birmingham Steel – Seattle is a producer of SBQ grades serving the Pacific Northwest U.S. In the ever-present drive to lower production cost while increasing production tons, Seattle partnered with their oxygen supplier and installed Praxair's CoJet™ coherent jet technology on their 135-ton EAF in February, 1999.

Previous CoJet installations consistently showed improved production (tons/hr), better furnace operation (refractories, carbon removal efficiency, etc. ...) and improved safety (closed slag door throughout melt). With these incentives, Seattle chose to replace their four-year old burners and door lance with three fixed, sidewall oxygen and natural gas CoJet nozzles.

The results of using Coherent Jet Technology at Birmingham-Seattle have been outstanding. Seattle currently holds the Birmingham Steel corporate record for most tons produced in a day and most tons/hr.

History

Birmingham Steel was originally an integrated steel mill located on the shores of Elliot Bay in Seattle, WA. Started in 1904, the area "*across the bay*" was at the time compared with the Monongahela River near Pittsburgh, "*whose banks are black with the forests of chimneys that brought prosperity to the city at the Ohio's head, and made her a marvel of richness – her name a synonym for steel.*"

During the First World War, an open hearth furnace was added each year. By the end of the Second World War, Bethlehem-Pacific Coast Steel was operating five 50-ton open hearths.

In the late 1950's, the open hearth furnaces were replaced with electric arc furnaces (EAF's). Completed in 1958, the new mill consisted of two EAF's, soaking pits, a blooming mill, and a cross-country bar mill as well as a plate & structural mill. In the construction of the EAF shop, the infrastructure was erected to handle three EAF's. Only two were installed with a total design capacity of 400,000 TPY for a two-furnace operation, excepting a maximum of 450,000 TPY during the Vietnam War.

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In 1971, the Melt Shop was completely enclosed, with a bag house system evacuating off-gas from the enclosed building. In 1985 after a change in ownership to Seattle Steel, a continuous caster was installed followed by water-cooled walls and furnace roof (pipe-style) in 1988. Plant production remained at 400,000 TPY.

In late 1990, Birmingham Steel Corporation bought the plant from Seattle Steel and took control of assets in June of 1991. In 1995, Birmingham installed a new 135-ton Fuchs EAF, replacing the two Lectromelt 115-ton EAF's. The new one-furnace capacity is 848,000 TPY, although the plant has only reached 656,000 TPY due to market conditions. Given a five-day/week production schedule, the Seattle Melt Shop can produce nearly 700,000 tons. It is interesting to note that under Seattle Steel's ownership, the Seattle Melt Shop was producing roughly 400,000 TPY with some 300 Melt Shop personnel. Today, the Seattle Melt Shop produces in excess of 600,000 TPY with 115 employees!

Motivations for CoJet™ Technology

The Seattle Melt Shop came to recognize several inherent obstacles to higher productivity: a) turndown predictability, b) unplanned lance maintenance, c) poor delta life d) poor decarburization and e) extensive repairs to the furnace's breast area. In the words of Seattle's Maintenance Supt., Terry Johnsen, *"If we could take away the joy stick from the operators and replace that thing in the door with fixed side-wall lances, I would put it in tomorrow."*

After discussing CoJet technology benefits and its track record with Birmingham Steel's Corporate staff, an agreement was signed between Praxair and Birmingham Steel

licensing all of Birmingham's melting facilities to employ CoJet technology. Seattle would effectively be the proving ground within the Birmingham corporation: if it worked well in Seattle, it would work well anywhere within the corporation!

Melt Shop Background

After the 1995 Melt Shop revamp, production maxed out at 98 tons/hour by 1997. Later that year, the Seattle Melt shop installed Praxair's post-combustion technology on their existing door lance manipulator and increased productivity to 103 tons/hour while reducing power consumption by nearly 20 kWh/ton. The only negative was PC's effect on delta life. Due to several factors including the inconsistency of lance position varying from one crew to the next, delta life during 1998 decreased. It is important to note that CoJet systems have consistently demonstrated improved slag foaming capability and Seattle now enjoys an improved foamy slag practice. The proof is in the pudding: Seattle's delta life is now the best in its history even though Seattle is using double the amount of PC oxygen with its CoJet system as it used in its previous practice. **Conclusion: Improved foamy slag enhances the benefits of post-combustion and Coherent Jet lancing positively improves delta life by delivering lance oxygen to the melt in the form of fine bubbles.**

Installation

Piping, electrical, PLC, power, fuel and oxygen installation guidelines were shared with Seattle months before the installation. Since the Seattle melt shop furnace controls had been upgraded by AMI Meltshop, S.A.S. de C.V. (AMI) in 1995, it was the desire of the melt shop to integrate the CoJet system into existing control

hierarchy and PLC logic. Seattle has an outstanding array of touch-screen logic control screens that operate all furnace functions. It was decided to integrate the Seattle CoJet system into this control scheme for ease of installation, operator acceptance and long-term maintenance.

The Praxair team used an AB-SLC-504 PLC along with Seattle's AMI hierarchy for integrating the CoJet system control functions into Seattle's system.

After acceptance testing of the valve rack and software, the valve rack and injector hardware were shipped to Seattle. During weekly maintenance periods, the piping and electrical and PLC connections were made. During the week prior to start up, the old burners were removed and new CoJet nozzles were installed. Complete diagnostic testing of the valve rack, PLC and CoJet system software was also accomplished. The system was "ready" on schedule.

Operation

The Seattle CoJet system operates via touch-screen control. Prior to charging, the furnace operator enters the weight of the bucket being charged into the computer and initiates the CoJet system to "Charge" mode. Once the arc is "on", the CoJet software takes over. The Seattle control screens give melt shop personnel numerous burner and lance modes for each bucket. There is a traditional "Hold Fire" when the furnace is idling; "Charge Fire" when dumping scrap; several burner modes up to 6 MW in power; lance modes where the CoJet nozzles operate only as lances; and modes where the CoJet nozzles both lance, create foamy slag and post-combust simultaneously.

One control screen operates in the background on the computer totalizing oxygen and natural gas for each injector and PC location. This screen displays the current heat with the last ten heat's data for comparison and trending. Another operating screen displays safety interlock and alarms when a potentially disrupting situation exists, i.e. low gas flow on an injector. The CoJet system PLC tracks the nature of flow of each gas on each leg to the furnace. If one or more gases stray over pre-set limits, the Interlock Screen allows the furnace operator to work with the mechanical/electrical group to remedy the situation before an injector might become non-operational. In the first four months of operation, Seattle has experienced only one Mechanical delay attributable to the CoJet system: this was a 12-minute delay to unplug an injector nozzle on the spot. Had the injector simply been replaced (rather than cleaned in place), the repair is estimated to have taken five minutes.

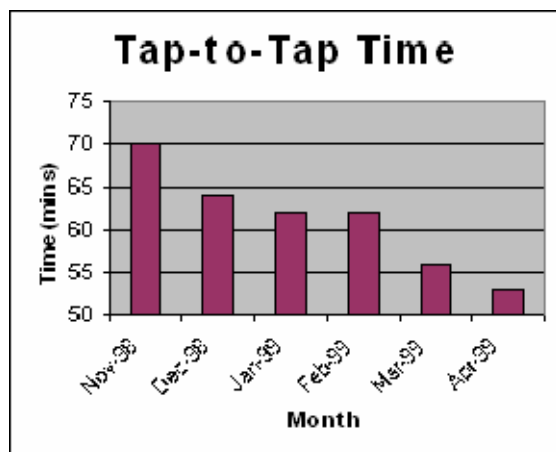
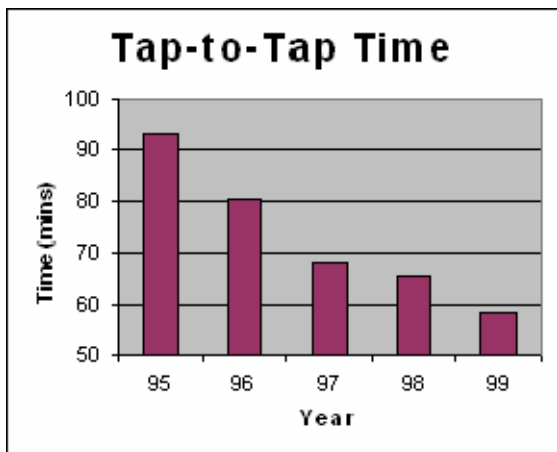
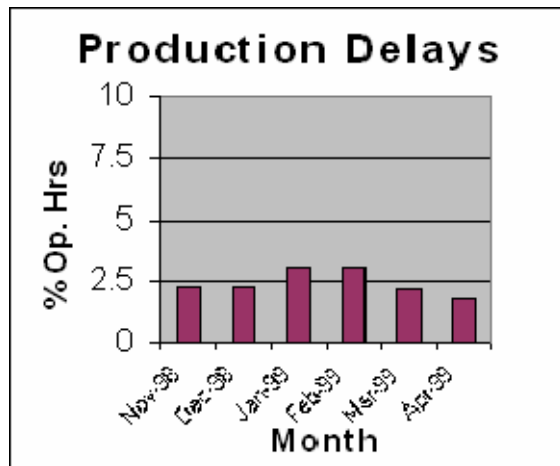
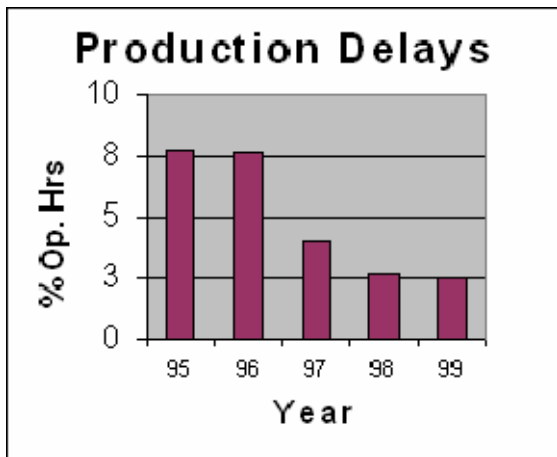
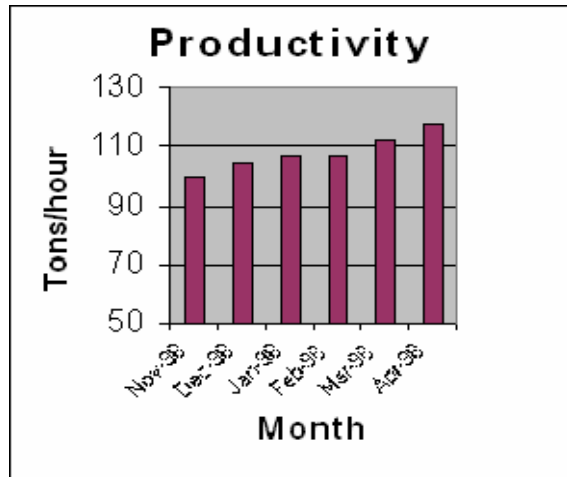
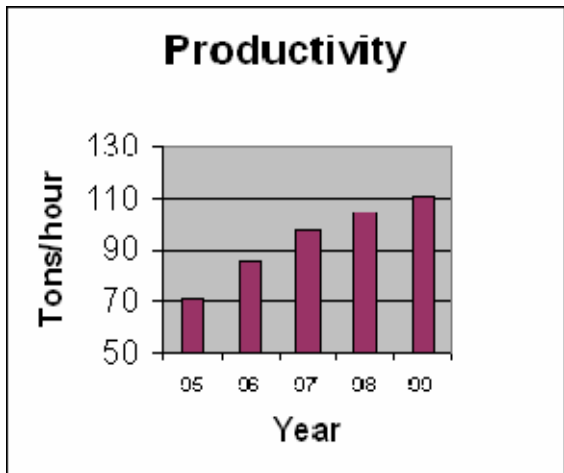
Seattle furnace operators and floor personnel much prefer to melt with the door closed and perform all lancing functions with the CoJet nozzles. Brick wear in the furnace breast area is down significantly since the CoJet system was started up in February.

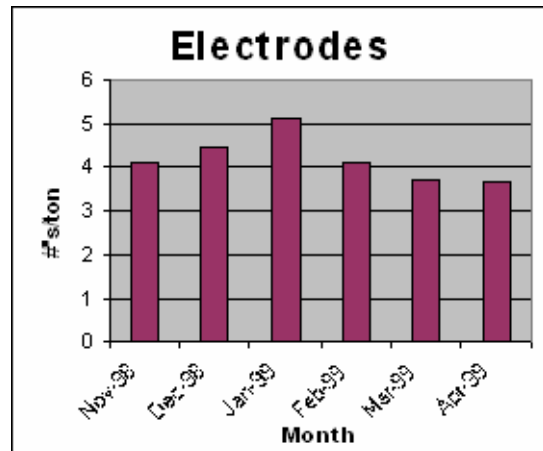
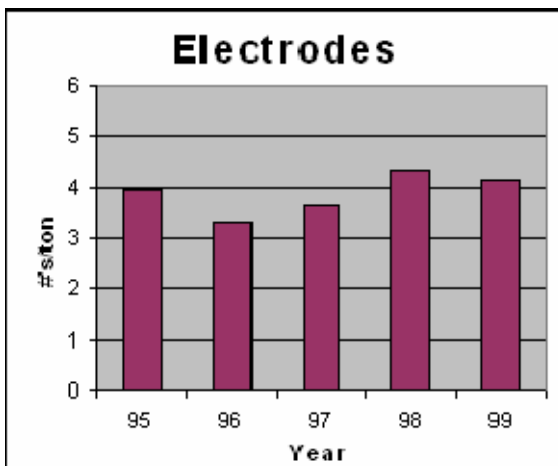
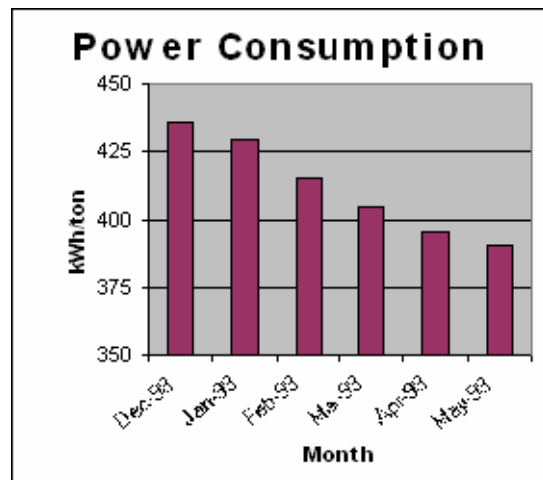
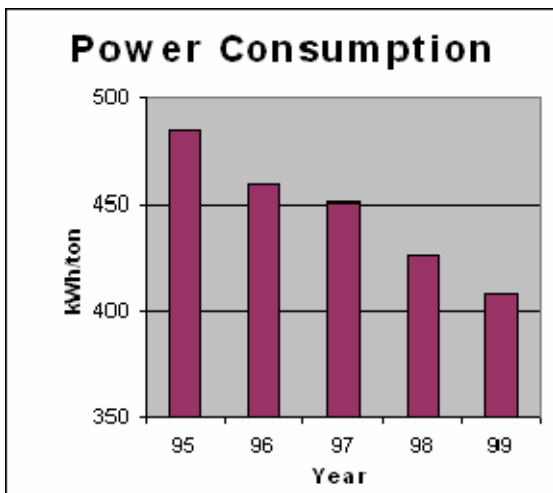
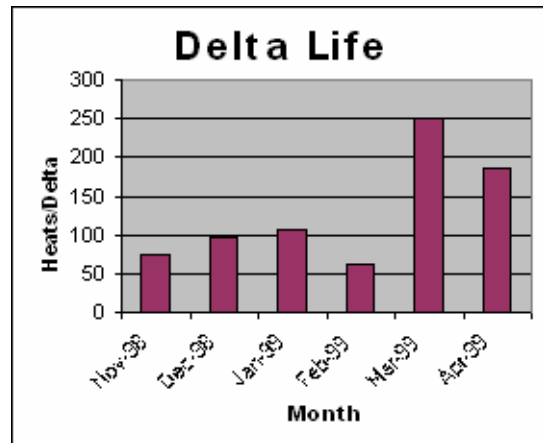
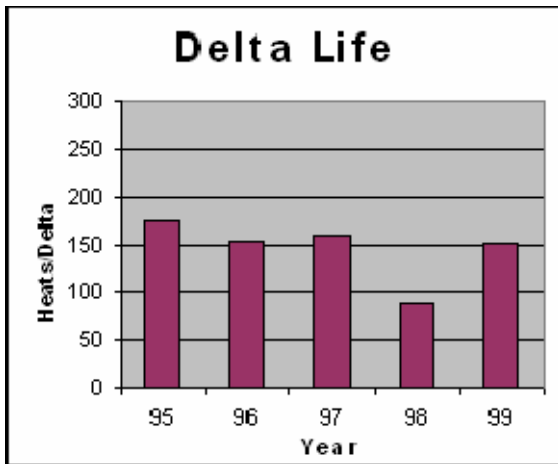
Decarburization

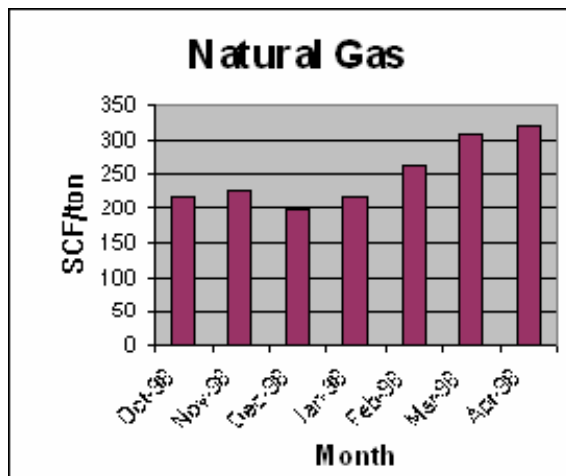
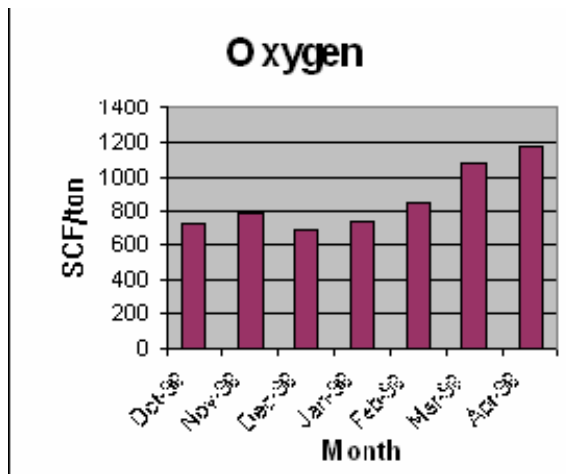
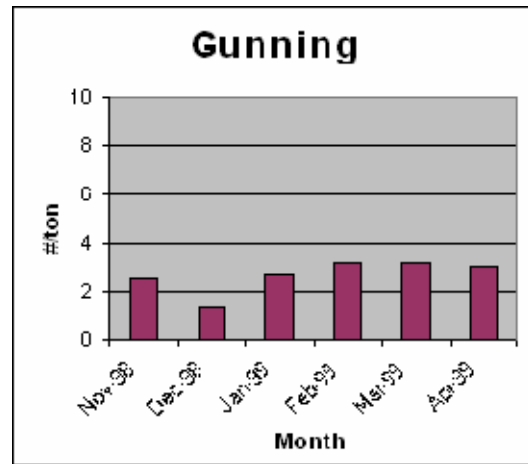
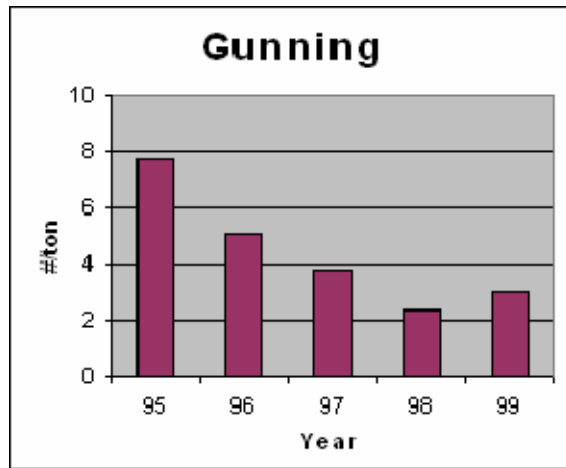
The former lancing operation in Seattle left something to be desired with regards to decarburization: i.e., if a heat turned down high in carbon late in the melt, a hand lance had to be inserted into the door of the furnace in addition to the lance manipulator to achieve the aim carbon. Since the CoJet nozzles have been installed, decarburization has been completely accomplished with the Coherent Jet system.

**Apples-to Apples:
Furnace Operating Statistics**

In order to give a fair and complete comparison of the furnace operation before and after installation of the CoJet system, the following annual and semi-annual statistics are presented.







Records Broken/Records Set

Steelmakers with more than one melt shop compete internally with their sister melt shops for best operating statistics, and the Birmingham Steel Corporation is no exception.

Since the installation of CoJet™ in February 1999, every melting record for the shop has been broken and several have been broken again several times since. The melting statistics for these records (day, shift, etc.) are shown below to reveal the enhanced melting power and efficiencies of the Seattle furnace. These are: Seattle's Best Shift (12-hour); Seattle's Best Day; Seattle's Best Week; Seattle's Best Month; the Birmingham Corporate Daily Tonnage Record and the Birmingham Corporate Best Day – Tons per Hour.

Seattle's Best Shift (12-hour)

Date: 4.26.99
Crew: A
Number of Heats: 14
Tons Produced: 1610.77
Tons per Hour 134.23
kWh/good billet ton 370.07

Seattle's Best Day

Date: 4.19.99
Crew: C/B
Number of Heats: 28
Tons Produced: 3043.59
Tons per Hour 126.82
kWh/good billet ton 375.98

Seattle's Best Week

Week of: 3.30.97
Tons Produced: 15,468.48
Week of: 4.25.99
Tons per Hour 124.27

Seattle's Best Month

Tons Produced: March '98 = 62,607.65
Tons per Hour: April '99 = 117.87
kWh/good billet ton: May '99 = 395.44

Birmingham Corporate Best Day

Day: 4.19.99
Tons Produced: 3043.59
Tons per Hour 126.82

Conclusions

A significant improvement in the operating performance of Birmingham Steel's EAF located in Seattle, WA has resulted from the installation of a Praxair CoJet system. Power consumption is down (20-30 kWh/good billet ton); electrode consumption is down (0.4-0.5 #/ton); delta life has improved (60 to 160 heats/delta average); refractory consumption, especially in the breast area of the furnace, has decreased dramatically; oxygen consumption increased (~900 to 1125 scf/ton) and natural gas consumption increased (214.5 to 315 scf/ton); carbon and gunning are up slightly; production tons per hour have been impacted in a huge way: a 15% increase in tons/hour (104 to 117 TPH); turndown carbon is predictable and repeatable; maintenance downtime on the furnace is down, especially eliminating lance related repairs; foamy slag practice is improved; and bath temperature is more homogeneous with lancing in three as opposed to one positions.

Acknowledgements

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