# How iron ore pelletizing has recently gained new kiln efficiencies

More stable kilns, improved productivity and enhanced process control are delivering more for the industry than ever before.

Extract from a paper presented at the Torex International Academic and Practical Conference

**Given the significant impact a rotary kiln burner has on the costs and revenues of iron ore pelletizing, that burner had better do its job well.**

The capital cost of combustion equipment is negligible in comparison to the capital cost of the plant. Yet, combustion performance is a major determinant of the pellet quality and hence a major parameter on return on investment rate. This is why FCT's Gyro-Therm Precessing Jet Burner has made record sales in the iron ore processing and other industries worldwide, and is regularly being specified in new plants, expansions and upgrades. FCT's Gyro-Therm Precessing Jet Burner has been applied in a number of High Temperature Process (HTP) industries with remarkable results when burning natural gas in rotary kilns.

The burner uses the patented Precessing Jet technology to provide the mixing of the fuel and air in a way that improves the combustion process. The unique properties of the Gyro-Therm Precessing Jet Burner have resulted in:

- Up to 10% increase in kiln production
- Up to 10% reduction in specific fuel consumption
- 60% reduction in NOx emissions in different industries.

## A powerful type of jet diffusion burner, delivering a profound effect on fuel-air mixing.

The choice of burner influences the fuel consumption, production rate, product quality, refractory life and gaseous emissions for that plant. It is often surprising to understand the extent to which the return on investment of the whole plant can be affected by such a relatively minor and low cost item such as the kiln burner. Conventional turbulent jet diffusion burners for kilns use a combination of axial and swirl generated by the fuel and/or primary air jets to promote the fuel and air mixing.

FCT's Gyro-Therm Precessing Jet Burner brings a powerful method to the minerals processing industry. The new mechanism of combustion involves a new form of jet, known as the "precessing jet" which has been generated from a precisely engineered nozzle. The nozzle generates an ensuing jet with a stirring, or precessing, action. This precessing jet when employed in a kiln burner has a profound effect on the fuel-air mixing. Since the introduction of such technology to gas fired kilns, significant fuel savings, production increases, quality improvements and major NOx emission reductions have been reported. The technology has now been successfully deployed for solid fuel firing, and has been installed with remarkable results in iron ore, cement, nickel, lime and alumina industries.

## Improving the efficiency of iron ore pelletizing plants.

Modeling techniques have been applied by FCT Combustion in different industries including iron ore pelletizing in both traveling straight grate and rotary kilns. There are several case studies with industry verified results to demonstrate how FCT's modeling techniques have increased plant efficiency by fine tuning the affecting parameters. Physical modeling and CFD modeling have been used in most cases and the following parameters have proven to be of more importance in regards to combustion efficiency and product quality:
In pelletizing rotary kilns affecting parameters including but not limited to:

- Secondary air velocity profile
- Secondary air temperature profile
- Burner design (proper momentum and proportional axial and swirl air and/or fuel)
- Burner insertion distance
- Burner angle
- Ratio between different heat transfer mechanisms (i.e. radiation/convection ratio)
- The heat flux profile along the kiln

In traveling straight grate, affecting parameters including but not limited to:

- Downcomer design and hence air velocity profile
- Downcomer air temperature profile
- Burner design mechanism (well designed momentum and proportional swirl/axial air and fuel ratios)
- Burner insertion
- Burner angle
- Heat flux profile which is directly affecting flame length and width
- Burner tile profile/design

**Achieving large-scale fuel and air mixing without the need for moving parts.**

The Gyro-Therm Precessing Jet Burner technology has been shown to be mechanically very simple, but fluid-mechanically extremely complex. In its simplest form, the nozzle consists of a cylindrical chamber with a small, central hole at its inlet and a small, symmetric lip at its exit. When the dimensions of the chamber are chosen properly, a naturally occurring flow instability is stimulated within the chamber causing azimuthal movement of the jet as it leaves the chamber at a large angle to the chamber axis.

The motion of the jet about the chamber axis is referred to as "precession", a term used to describe the gyration of the axis of one body (in this case, the jet) about an axis other than its own (the axis of the chamber) so as to describe a cone.

The precessing motion is generated without any moving parts within the Gyro-Therm nozzle. The precession creates a much larger scale of mixing than occurs in a conventional jet, as well as increased spreading of and entrainment by the jet. Refer to Figure 1 for a schematic representation of the precessing jet motion. The precession of a jet causes a dramatic change in the structure of the turbulent flow field that has a profound influence on the properties of a flame.

The flame itself does not precess. The effect is to produce large-scale mixing, via the stirring action of the jet, and a rapidly spreading flame. Precession increases the strain on the jet that emerges from the nozzle, resulting in rapid initial entrainment and growth, followed by the generation of very large turbulent structures.

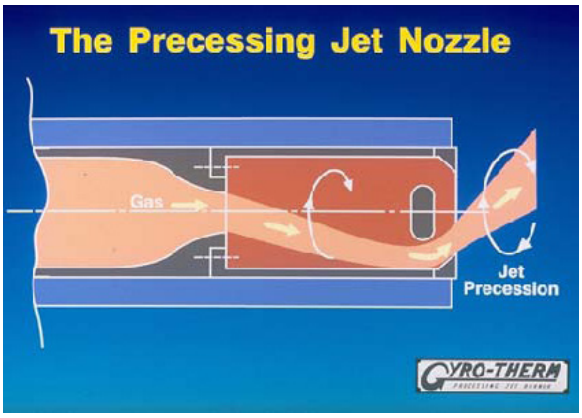



*Figure 1: Precessing jet mechanism*

**Reduced NOx emissions and combustion products means savings on the induced draft fan and better environmental credentials.**

When burning gas, this flow results in the stabilization of the flame close to the nozzle. The subsequent reduction of the strain in the jet is thought to promote soot formation, so increasing flame emissivity and radiant heat transfer. At the same time, the characteristic flame temperature is reduced, consistent with a reduction in NOx emissions in open flames when compared with a simple jet flame and in confined boiler type flames when compared with a swirling jet flame.

The highly luminous nature of the flame and the greatly reduced NOx emissions are a result of a naturally staged combustion process. The precessing jet engulfs air in such a way that stable combustion occurs close to the nozzle under fuel-rich conditions that produce soot. The soot increases the radiant heat transfer to the process, which in turn reduces the flame temperature. The soot is later burnt out in the more air rich sections at the extremities of the flame.

**Flame shaping for reliable product quality and longer refractory life.**

Although the flame spreads more than that from a conventional turbulent jet nozzle, the amount of spread can be controlled. This fact is important in rotary kilns where direct impingement of a flame on the product could produce instability or reducing conditions which would be detrimental to product quality or damage the refractory. There is strong evidence that uniform and high levels of flame radiation are responsible for increasing refractory life and positively influencing the product quality. A simple but extremely effective flame shaping technique is built into the burner. In gas firing, the technique for flame shape adjustment is based on a high momentum gas jet injected at a critical point into the precessing jet flow field.

This jet (termed the center body jet, CBJ) is expelled through the center body of the precessing jet nozzle, modifying the pressure fields within the vicinity of the burner in such a way that the flame is directed more toward the kiln axis.

As the proportion of gas is increased through the center body jet, the flame spread is reduced and the heat flux profile lengthened. An air channel is provided for burner cooling and for flame shaping during the warm-up phase. Refer to Figure 2 for a schematic representation of central body jet.

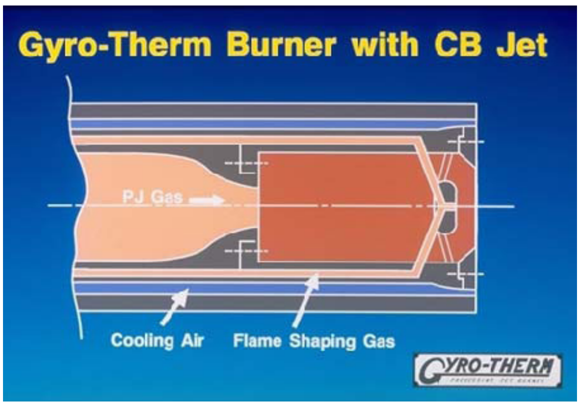



*Figure 2: Gyro-Therm with central body jet for flame shaping*

**Less need for the primary air fan, plus increased thermodynamic efficiency.**

The mixing generated by the precessing jet nozzle is produced directly by the gas stream, utilizing the potential energy available in the high pressure gas supply rather than using a high momentum primary air stream.
Consequently, the primary air fan can be reduced in size and effectively becomes a cooling fan.
In most rotary kiln applications a Gyro-Therm Precessing Jet Burner would only use a small quantity of air, about 1-3% of the total air for cooling (in the event of a kiln stoppage) and flame shaping during warm up.

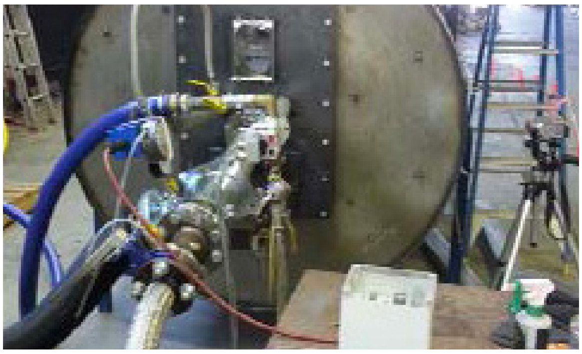
Reducing the air has two advantages:

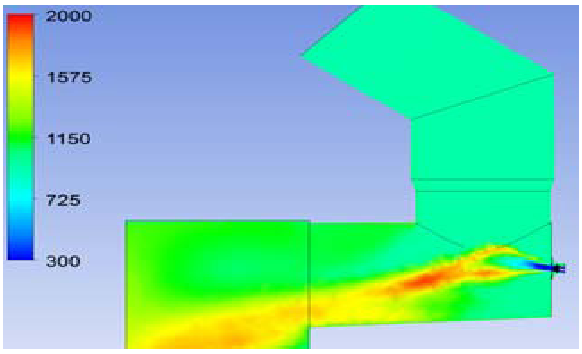
- Reduced operating and maintenance costs of the primary air fan
- Increased thermodynamic efficiency.

The efficiency gains result when the volume of hot secondary air from the product cooler increases due to the reduction of cold primary air.

**Compatible with gas or solid fuels, including slow burners and coarse grinds.**

In solid fuel firing, clean primary air is introduced through the precessing jet nozzle to generate the stirring action that gives the unique fuel/air mixing regime. Flame shaping is achieved again by simple adjustment of air supply between the precessing jet channel and the axial jet channel. This applies to either direct or indirect firing of solid fuel. One of the advantages with solid fuel firing is that the axial velocity of the fuel jet can be slowed, as the precessing jet provides mixing energy also, so that good mixing is not reliant only on axial jet momentum. This is particularly advantageous for slow burning fuels like petcoke, but also can allow a coarser coal grind to be burned.





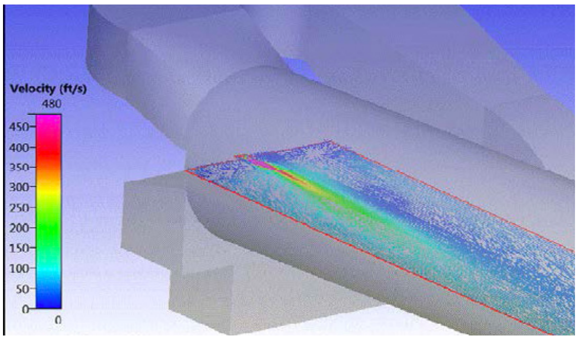

*Figures above: FCT's traveling straight grate test facility in Australia. Full scale modeling of a straight grate pelletizing burner compared with numerical simulation performed by customized ANSYS®. One could see very good agreement in regards to flame shape, flame burn out rate and temperature profile in both cases.*

FCT also offers process optimization using physical modeling and CFD. FCT employs physical modeling and Computational Fluid Dynamics (CFD) as effective tools to simulate the physical phenomena such as turbulence, chemical reactions and heat transfer. The physical modeling and numerical simulation combined, gives an insight into detailed flow patterns, velocity profile, temperature distribution, flame shape, heat flux profile and species concentration at any given time or given condition inside the kiln, cooler and pre-heater.

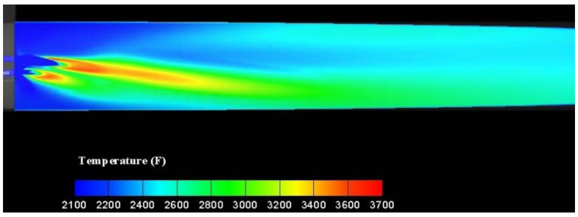
The process investigations and combustion modeling studies are designed to provide a custom designed and totally optimized kiln burner system resulting in superior plant performance and reduced commissioning times (as the burner has been optimized through modeling). The cost to the plant is negligible and payback through increased production, reduced fuel consumption or product quality is very attractive.

With a scientific history of 30 years in rotary kilns and 10 years in traveling straight grate pelletizing plants, FCT has well proven that the burner design cannot be satisfactory unless furnace design (geometry, aerodynamics), operation philosophy and all other relevant parameters have been considered accordingly. In many cases, feedback from pyro-process shop could also help with improving the functionality of other sections of the furnace.

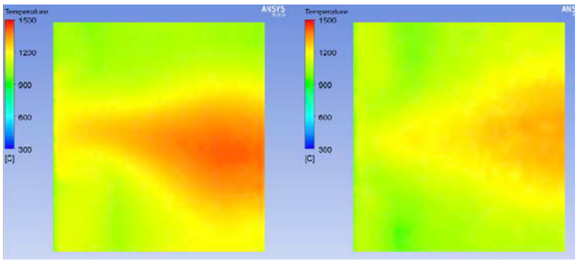
*Below are a few selected examples of Computational Fluid Dynamics cases performed by FCT Combustion in the pelletizing industry.*



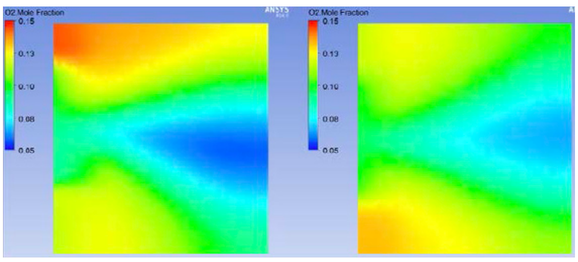

*Study of secondary air velocity profile affecting by fuel/air jet from the burner – kiln horizontal centerline. Gas Firing.*




*Temperature profile – kiln horizontal centerline. Gas & Coal Co-Firing.*



*Traveling straight grate pelletizing plant, gas temperature right above pellet bed, burner angled up by 10 (left), burner horizontal (right).*



*Traveling straight grate pelletizing plant, oxygen molar concentration right above pellet bed, burner angled up by 10 (left), burner horizontal (right).*

**Overview of the benefits of the Gyro-Therm Precessing Jet.**

The Gyro-Therm Precessing Jet increases the large scale mixing and reduces the fine scale mixing to yield localized fuel-rich combustion. This in turn:

- Increases luminosity
- Reduces specific fuel consumption
- Increases kiln output
- Increases refractory life time
- Saves on the ID fan with less combustion products generated
- Reduces electrical consumption of primary air fan
- Reduces NOx emissions
- Improves product quality as a result of better heat flux profiles
- Greatly reduces primary air volume for gas firing
- Improves flame turndown and stability

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