# MODELLING THE EFFECT OF THE SRI SWIRL SPREADER BAGASSE COMBUSTION SYSTEM ON FURNACE OPERATION

By

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**KEYWORDS: Boilers, Bagasse, Furnace, Combustion, Swirl.**

## Abstract

CONVENTIONAL pneumatic bagasse spreader systems with a plane air jet to feed bagasse into sugar mill boilers have been widely used for over forty years. Being relatively simple and reliable, conventional spreaders have served the cane sugar industry well. However, they do have some significant deficiencies. Firstly, at high bagasse moisture contents, there is usually a significant build up of fuel on the grate which limits steam output and can cause combustion instability. The pressure excursions arising from combustion instability can cause significant damage to the boiler. Secondly, by inspecting the flame in the furnace through any small ports available, it is clear that the flame produced is concentrated towards the back part of the furnace. A significant portion of the furnace volume is underutilised. The swirl spreader addresses the issue of an underutilised furnace volume by spinning the bagasse as it enters the boiler, achieving a better spread of fuel over the furnace grate and reduced deposition of unburnt material. Current swirl spreader installations have made it possible to increase boiler steam output by up to 10% and make the boilers more tolerant of high moisture content bagasse. Further improvements in performance are possible through the use of hot air at the swirl spreader. The Computational Fluid Dynamics (CFD) code FURNACE was used to compare swirl spreaders to conventional spreaders, both cases using hot air, based on modelling the effect on furnace operation. The modelling predicted that the swirl spreaders achieve a more uniform temperature profile in the furnace, with smaller hotter and colder regions, and with the flame located closer to the grate. Lower peak and average gas temperatures and velocities at the furnace exit and convention bank tube inlet were predicted with swirl spreader operation due to the predicted increase in furnace heat absorption.

## Introduction

Conventional pneumatic bagasse spreader systems (Dixon and Jorgensen, 1988) with a plane air jet to feed bagasse into sugar mill boilers have been widely used for over forty years. Being relatively simple and reliable, the conventional spreaders have served the cane sugar industry well. However, they do have some significant deficiencies. Firstly, at high bagasse moisture contents, there is usually a significant build up of fuel on the grate which limits steam output and can cause combustion instability. The pressure excursions arising from combustion instability can cause significant damage to the boiler. Secondly, by inspecting the flame in the furnace through any small ports available, it is clear that the flame produced is concentrated towards the back part of the furnace. A significant portion of the furnace volume is underutilised. Previous computer modelling has supported this observation and predicted that a significant increase in heat transfer would occur if the volume in the furnace was better utilised (Dixon and Plaza, 1995). Improved heat transfer in the furnace will result in improved overall boiler steam output and boiler efficiency and, in the longer term, the development of a smaller, cheaper boiler station.

The swirl spreader addresses the issue of an underutilised furnace volume by spinning the bagasse as it enters the boiler, achieving a better spread of fuel over the furnace grate and reduced deposition of unburnt material. Mann *et al.* (2004) described the history of its development, including the operation of a large sugar mill boiler (MCR 200 t/h) at Proserpine Mill using swirl spreaders of Mark III design. Since that time, relatively small modifications by Proserpine Mill staff have resolved a wear problem, resulting in the current Mark IV design. Observations from boilers where swirl spreaders have been retrofitted have shown that swirl spreaders (using cold air) can increase boiler steam output by up to 10% and make boilers more tolerant of high moisture content bagasse.

It is believed that the use of swirl spreaders with hot air will result in further improvements in boiler performance. Such measurements are not available. Computer modelling can be used to gain some insight into the operation of a furnace with such an installation. Previous work (Woodfield *et al.*, 1997, 1998; Mann *et al.*, 2004) demonstrated that the Computational Fluid Dynamics (CFD) code FURNACE (Boyd and Kent, 1986) successfully predicts general trends and patterns in a furnace, including gas temperature and velocity distributions. This poster paper uses FURNACE to compare the gas temperature and velocity predictions for the Proserpine No. 4 boiler furnace operating with conventional spreaders and with swirl spreaders.

## Predicted results for furnace operation

The Proserpine No. 4 boiler was modelled with conventional spreaders and with swirl spreaders. Both types of spreaders were positioned on the same centre line. The simulated swirl spreader air temperature was 230°C. In order to compare only the swirl spreader to the conventional spreader, all air for both alternatives was simulated to enter the furnace at this temperature, with the total amount of bagasse and air entering the furnace being identical for both alternatives. The modelling was carried out for operation at a high steam load (210 t/h). A description of the furnace locations referred to in the discussion of the predictions is shown in Figure 1. The results of the simulations are shown in Figure 2, Figure 3 and Figure 4, which respectively show a gas temperature side view near the middle of the furnace, a gas temperature plan view halfway up between the grate and the bottom of the furnace exit baffle, and a gas velocity side view near the middle of the furnace.

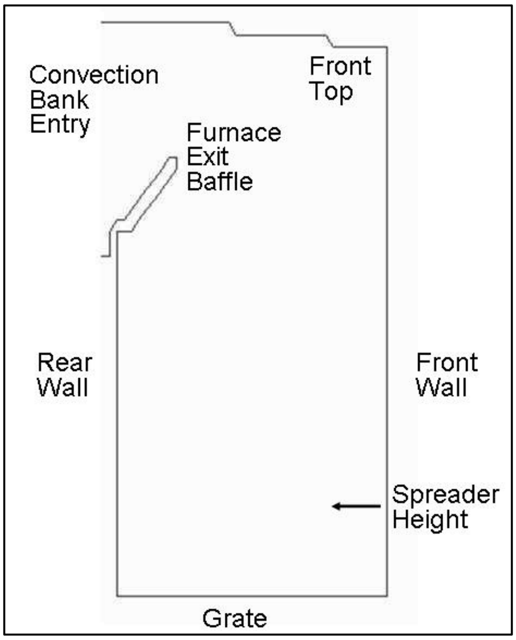

Fig. 1—Description of locations in furnace;

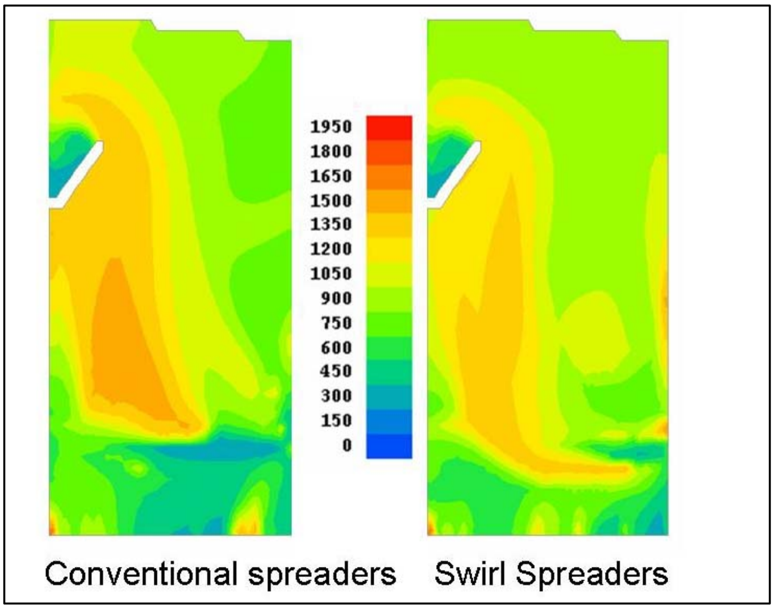

Fig. 2—Furnace side view temperature predictions (°C).

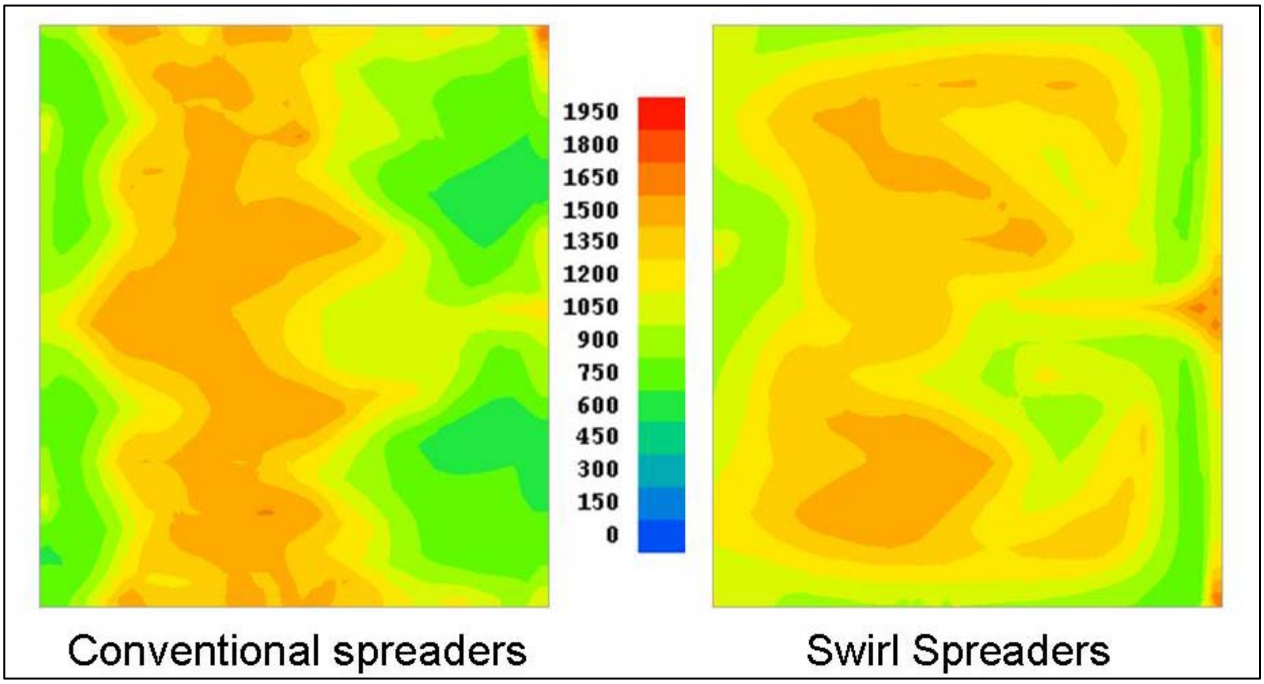

Fig. 3—Furnace plan view temperature predictions (°C) halfway up furnace.

Inspection of the gas temperatures shows that, relative to the conventional spreaders, operation with the swirl spreaders results in a larger more even flame which occupies a greater volume within the furnace, with smaller areas of both hotter and colder gases.

The gas velocities with the swirl spreader operation are predicted to have less recirculation downwards at the front top of the furnace, with a more even gas distribution out of the furnace. Peak gas velocities at the furnace exit baffle and at the tubes at the inlet to the convection bank are predicted to be lower for operation with swirl spreaders.

The use of swirl spreaders with hot air instead of conventional spreaders with secondary air at the same temperature is predicted to significantly improve the utilisation of the available furnace volume.

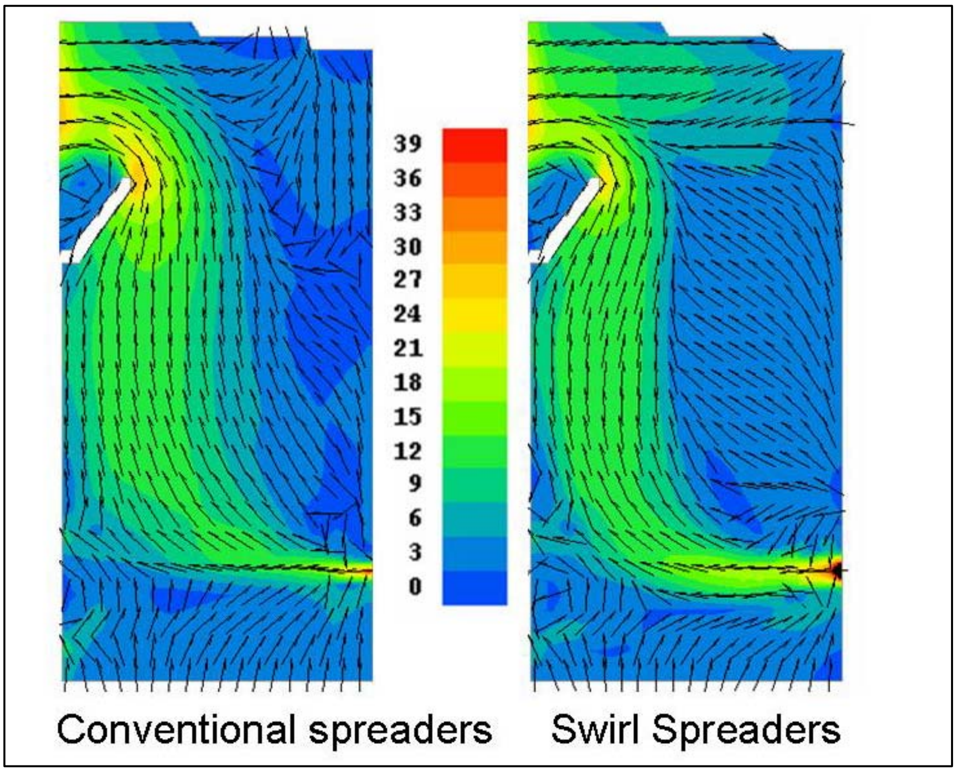

Fig. 4—Furnace side view velocity predictions (m/s).

## Conclusions

Computer modelling has been used to gain some insight into the operation of a furnace with a swirl spreader installation using hot air, relative to a conventional spreader installation using secondary air at the same temperature. Boiler operation with swirl spreaders is predicted to result in a larger more even flame which occupies more of the volume of the furnace, with smaller areas of both hotter and colder gases, resulting in a significant improvement in the utilisation of the available furnace volume. Peak gas velocities at the furnace exit baffle and at the tubes at the inlet to the convection bank are predicted to be lower for operation with the swirl spreaders due to the predicted increase in furnace heat absorption.

## Acknowledgments

Tom Stoneham and Brian Dinnie at Proserpine Mill are acknowledged for resolving a wear problem in the swirl spreader.

## REFERENCES

**Boyd, R.K. and Kent, J.H.** (1986). Three-dimensional furnace computer modelling. Symposium (Int.) on Comb., Comb. Inst., 21: 265–274.

**Dixon, T.F. and Jorgensen, G.M.** (1988). Bagasse spreader design for suspension firing. Proc. Aust. Soc. Sugar Cane Technol., 10: 279–284.

**Dixon, T.F. and Plaza, F.** (1995). Options for upgrading bagasse furnace performance. Proc. Aust. Soc. Sugar Cane Technol., 17: 317–324.

**Mann, A.P., Stoneham, T., Wesener, M., Spencer, S.M., Dixon, T.F., Joyce, K.N., Pennisi, S.N. and Plaza, F.** (2004). Operation, testing and modelling of the advanced swirl spreader and secondary air system installation at Proserpine mill. Proc. Aust. Soc. Sugar Cane Technol., (CD-ROM), 26: 10 p.

**Woodfield, P.L., Kent, J.H. and Dixon, T.F.** (1997). Temperature measurements in a bagasse-fired furnace – experimental and numerical results. Proc. Aust. Soc. Sugar Cane Technol., 19: 473–478.

**Woodfield, P.L., Kent, J.H. and Dixon, T.F.** (1998). Computational modelling of a bagasse-fired furnace – effects of fuel moisture. Proc. Aust. Soc. Sugar Cane Technol., 20: 458–464.

# MODELLISATION DES EFFETS DU SYSTEME SWIRL SRI POUR LA DISTRIBUTION DE LA BAGASSE AUX CHAUDIERES

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**MOTS CLEFS: Chaudière, Bagasse, Combustion, Foyer, Swirl.**

## Résume

LE SYSTEME conventionnel pour l’alimentation de la bagasse aux chaudières a été utilise pendant plus de 40 ans. Ce système est bien établi et son opération est relativement aisé, mais il présente des désavantagés. Une forte humidité de la bagasse, par exemple, cause des problèmes d’alimentation qui réduisent le débit de vapeur et déstabilisent l’opération de la chaudière. La pression devient instable ce qui peut causer des dégâts. On a aussi trouve que les flammes sont concentrées a l’arrière du fourneau, réduisant le volume utilise. Le système Swirl évite ce problème en distribuant la bagasse d’une façon efficiente et en réduisant les dépôts de matériel non brûle. Les systèmes Swirl en opération ont permit une amélioration de 10% au débit de vapeur et facilitent l’opération avec de la bagasse plus humide. On peut aussi améliorer la performance en utilisant de l’air chaud avec le système Swirl. On s’est servie du logiciel FURNACE en «Computational Fluid Dynamics, CFD» pour comparer le système Swirl au système conventionnel, avec de l’air chaud dans les deux cas. Le model montre que le système Swirl donne une température plus uniforme au foyer, avec moins de régions plus froides ou chaudes; la flamme est situe plus prés de la grille**.** Le model indique que Swirl réduit la fourchette de la température et de la vélocité des gaz a la sortie du foyer et aux tubes, grâce a une absorption de chaleur plus efficiente.

# MODELAMIENTO DEL EFECTO DEL SISTEMA DE COMBUSTIÓN BASADO EN EL DISPERSOR DE TORBELLINO PARA COMBUSTION DE BAGAZO SRI EN LA OPERACION DEL HORNO DE CALDERA

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**PALABRAS CLAVE: Calderas, Bagazo,
Horno, Combustión, Torbellino.**

## Resumen

LOS SISTEMAS convencionales neumáticos para el lanzamiento de bagazo con chorro plano de aire para alimentar el bagazo en calderas de ingenios han sido ampliamente usado por cerca de 40 años. Relativamente simples y confiables los lanzadores neumáticos han servido bien a la industria. Sin embargo tienen deficiencias significativas. Primero, con contenidos altos de humedad de bagazo hay amontonamiento de bagazo en la parrilla que limita la generación de vapor y puede causar inestabilidad de la combustión. Las variaciones de presión debidas a la inestabilidad de combustión pueden generar significativo deterioro de la caldera. En segundo lugar, al inspeccionar el hogar por las mirillas es evidente que las llamas se concentran hacia la parte trasera del hogar, dejando una porción importante del volumen del mismo subutilizada. El lanzador de torbellino aborda el tema haciendo girar en torbellino la corriente de bagazo en su entrada a la caldera, logrando una mejor dispersión sobre la parrilla y una menor deposición en la misma de material inquemado. Las actuales instalaciones de lanzadores de torbellino han hecho posible el aumento de la generación de vapor hasta en un 10% y han permitido mayor tolerancia a los contenidos altos de humedad. Es posible un mejoramiento adicional con el uso de aire caliente en el lanzador. El código FURNACE basado en Dinámica Computacional de Fluidos (CFD) fue utilizado para comparar los lanzadores convencionales y el tipo torbellino, en ambos casos usando aire caliente, y predecir el comportamiento de la operación del horno. Los modelos predicen que los lanzadores de torbellino logran una temperatura más uniforme en el hogar con zonas muy frías o muy calientes más pequeñas y con una llama localizada mas cerca de la parrilla. Se obtuvieron predicciones de los valores de las temperaturas y velocidades del gas a la salida del hogar y a la entrada del banco convectivo, tanto pico como promedio, más bajos con el lanzador de torbellino, debido al incremento de la absorción de calor en el hogar.