Cleaning boiler flue gas through bagasse drying

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Abstract
With increasing emphasis on environment protection worldwide, most cogeneration plants are aiming to achieve particulate emissions below 50 mg/Nm. This requires capital expenditure on air pollution control (APC) and will quickly erode profit margins in the sugar industry. An integrated approach for drying bagasse to not only meet environment norms, but also become a revenue generating system, was developed. The basic advantages of bagasse drying are known, eg using waste heat from boiler flue gas resulting in bagasse saving, but there is potential for increasing power export and improvement in boiler operation and efficiency. This paper demonstrates the use of bagasse drying as a technology for flue gas cleaning. A hybrid-flash dryer that can be used as dryer and APC device simultaneously results in commercial viability of an environmentally benign project.

Key words
Bagasse flash dryer, WESP (wet electrostatic precipitator), WS (wet scrubber), hybrid model

INTRODUCTION
The bagasse-drying concept was first studied in 1910 by Kerr (1911) using flue gas from a boiler as the drying medium. With the introduction of cogeneration in the mid 1990s into the cane-sugar industries and with further demand for bagasse in other sectors, this concept was revitalized and has met with great interest because of its ability to improve boiler efficiency and clean the flue gas simultaneously.

FLASH DRYING OF BAGASSE
Waste heat from boiler flue gas is used as a heating/drying medium. It is passed through the flash tower (Fig. 1) under induced or forced draft maintaining pre-calculated velocities at an average particle retention time (APRT). The bagasse is fed in at a controlled rate through an air lock feeder and carried upward concurrently with the flue gas. This evaporates the moisture in the bagasse and traps most of the suspended particulates in the hot and dusty flue gas. The dried bagasse is separated through high-efficiency cyclones and a substantially cleaned gas is emitted (Verma 2010).

Fig. 1. Bagasse drier installed at a sugar mill in India.
Data collected from bagasse dryer installations show a moisture reduction of 10-13 units, as well as the following advantages:

- Flue gas cleaning: emission test conducted at the outlet of flash dryers showed a reduction to near 100 mg/Nm³.
- Fly ash management: re-circulation of over 90% of fly ash to the furnace (entrapped in the dried bagasse) greatly simplifies the boiler ash management.
- Un-burnt carbon loss: bottom ash analysis showed over 30% reduction in unburnt carbon and 10% increase in quantity.
- Furnace temperature: furnace temperature increases by about 40-50°C.
- Furnace excess air: excess air quantity reduces (from 35% to 25%) resulting in improved combustion in the furnace.
- Boiler auxiliary power: FD/SA fan and feeder power reduces by over 10%.
- Allowable steam load: average boiler steam load improves by about 10% (on continuous basis and stable boiler operation).

Popular technologies presently being used as APC devices in the sugar industry are dry the Electrostatic Precipitator (DESP) and the Wet Scrubber (WS).

**DRY ELECTROSTATIC PRECIPITATOR (DESP)**

The conventional DESP shows some drawbacks:

- High resistivity of bagasse ash (> normal operating band ($10^8$-$10^{10}$ Ω-cm)).
- Fire hazards due to carry over of unburnt/partially burnt particles from the furnace.
- Varying operating conditions and particle size distribution.

Drawbacks increase with multi-fuel firing applications, because of:

- Different characteristics of ash with different resistivity.
- More gaseous pollutants due to increasing use of fossils fuels.
- Varying fuel-mix ratio and types.

**WET SCRUBBERS (WS)**

The present designs of wet scrubbers (Fig. 2) can achieve near 80 mg/Nm³, with:

- Higher pressure drop (as compared to ESP).
- Threat of corrosion, particularly with fossil fuel.
- Require a slurry dewatering system.
- Limited control on gaseous pollutants.
- Make-up water consumption.

![Fig. 2. Wet scrubbers installed in Thailand.](image-url)
WET ELECTROSTATIC PRECIPITATORS (WESP) - AN INTEGRATION OF ESP AND WS

WESP (Fig. 3) is a technology that overcomes the concerns and limitations of ESP and WS, making it very suitable for controlling emissions. The working principle of WESP is similar to the conventional DESP, except for the working atmosphere. WESP works under high humidity atmosphere lowering the electrical resistivity of most particulates. Ultra fines are collected efficiently at low voltage (40-60 kV as against 80-120 kV in DESP) due to increased conductivity of moist particulates and reduced re-entrainment.

WESP seems to be an ideal solution for sugar factories with multi-fuel boiler operations (Verma 2011). However, to meet emission limits of below 50 mg/Nm³, increased investment is needed.

Fig. 3. WESP Installed at one of the plants.

FLASH DRYER-HYBRID MODEL - A ROAD MAP

As the result of above concerns a ‘Hybrid Model’ (Fig. 4) has been developed. Its principal mode of operation consists of two steps:

- Flash-drying wet bagasse with hot and dust containing flue gas
- dust particles get entrapped in dried bagasse
- cleaned flue gas still contains near 100 mg/Nm³
- Passage through an integrated low pressure-drop WESP
- to clean it further by separating fines (to meet prevailing norms).

The advantages of such integration are:

- Low emissions (< 10 mg/Nm³)
- Reduced capital cost on APC-WESP
- Return on Investment benefitting from dried bagasse
- Ability to control on gaseous pollutants
- Improved boiler performance.
CONCLUSIONS

The proposed integration of a bagasse dryer with WESP is an ideal solution to generate revenue (saving on bagasse and/or prolonged cogeneration) as well as meeting the present and future emission standards for particulate matter in the sugar industry.

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REFERENCES

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Nettoyage des gaz de combustion des chaudières par séchage de la bagasse

Résumé. La protection de l’environnement prend une importance de plus en plus grande dans le monde entier; les usines de cogénération devraient produire des émissions de particules inférieures à 50 mg/Nm. Cela exige des dépenses en capital sur la pollution de l’air (APC)
et pourrait rapidement réduire les marges de profit dans l’industrie sucrière. Une approche intégrée pour le séchage de bagasse pour non seulement répondre aux normes de l’environnement, mais aussi pour générer un revenu, a été développée. Les avantages du séchage de la bagasse sont connus, par exemple en utilisant la chaleur des gaz de combustion on économise de la bagasse, mais il existe un potentiel pour accroître l’exportation de la puissance et l’amélioration dans le fonctionnement de la chaudière et son efficacité. Ce document démontre l’utilisation du séchage de la bagasse comme une technique pour l’épuration des fumées. Un séchoir hybride-flash qui peut être utilisé comme séchoir et dispositif d’APC en même temps, se traduit par une viabilité commerciale d’un projet inoffensif pour l’environnement.

**Mots-clés:** Sécheur de bagasse, WESP (filtre électrostatique humide), WS (dépoussiéreur par voie humide), modèle hybride

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Limpieza de los gases de caldera usando un secador de bagazo

**Resumen.** Con el enfasis creciente respecto a la protección ambiental en el mundo, muchas plantas de cogeneracion tienen como objetivo lograr emisiones de partículas abajo de 50 mg/nm. Esto requiere inversión de capital en control de contaminacion del aire (APC, por sus siglas en ingles) y rápidamente erosionara los margenes de utilidad en la industria azucarera. Un enfoque integral del secador de bagazo para no solo cumplir con las normas ambientales, sino también convertirse en un sistema generador de ingresos, fue desarrollado. Las ventajas basicas de un secador de bagazo son conocidas, por ejemplo al usar el calor sobrante de los gases de combustion de la caldera resultaria en un ahorro de bagazo, pero tambien existe el potencial para aumentar la exaparicion de energia y mejorar la eficiencia y la operacion de la caldera. Este trabajo demuestra el uso del secador de bagazo como una tecnologia para la limpieza de los gases de combustion. Un secador hibrido-flash que puede ser usado como secador y como un instrumento de control de contaminacion del aire simultaneamente resulta comercialmente viable en un proyecto ambientalmente benigno.

**Palabras clave:** Secador flash de bagazo, WESP (precipitador electrostático humedo), WS (scrubber humedo), modelo hibrido