

**The Greenbank Group**

Enhancing the performance of our customers plant and equipment



# VARB<sup>®</sup>

## COAL FLOW BALANCING SYSTEM

**Greenbank Energy Solutions Inc., offers a revolutionary non-intrusive rope breaker for Pulverized Fuel (PF).**

The purpose of the VARB<sup>®</sup> (Variable Area Rope Breaker) is to break the PF 'rope' which is the tight formation of PF particles that occur when PF is conveyed through pipework by the primary air from the pulverizer mill classifier to the burners.

Where the mill discharge pipes split into two or more branches, the presence of a rope will produce uneven distribution which can lead to poor fuel to air ratio, combustion inefficiencies and accelerated erosion.

The patented VARB<sup>®</sup> PF Diffusing System together with Greenbank's Control-Gate<sup>®</sup> technology will destroy the rope then control and balance the Pf flow and in addition trim the air / fuel ratio to attain the desired distribution in each splitter leg for balanced flow to the burners.

### A FEW BENEFITS OF BALANCED COAL FLOW

#### Higher Combustion Efficiency

- Stable Combustion
- Reduced pipe erosion and wear.
- Elimination of riffle boxes / dampers
- Reduction in pressure drop across the PF piping system.

#### Improved Burn

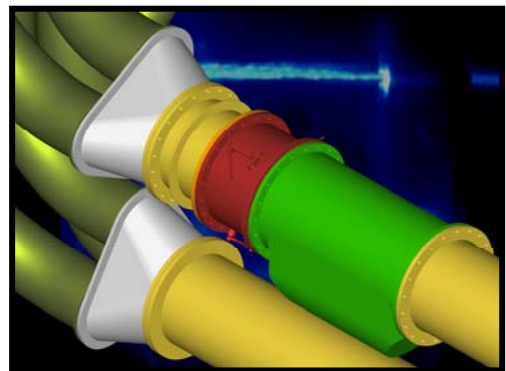
- Reduction in flame length
- Elimination of flame detachment occurrences.
- Low load flame stabilizer.

#### Reduced Carbon-in-Ash.

- Saleable ash
- Avoidance of disposal and environmental problems.

#### Reduction of NOx

- A function made possible by lowering secondary air levels under stable operating conditions.



# VARB® COAL FLOW BALANCING SYSTEM

The technology behind the success of the VARB® PF diffuser was developed in conjunction with a GESI affiliated company GAIM.

GAIM (Greenbank Advanced Instrumentation and Measurement Ltd) is a joint venture between the University of Nottingham in England and The Greenbank Group Inc. (GESI's & GAIM's parent company).

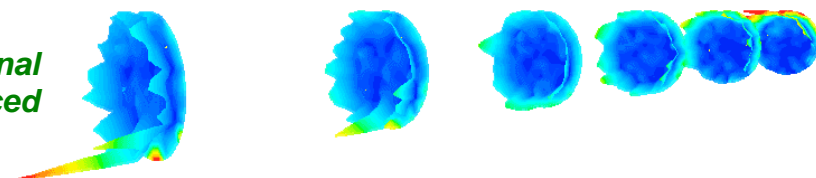
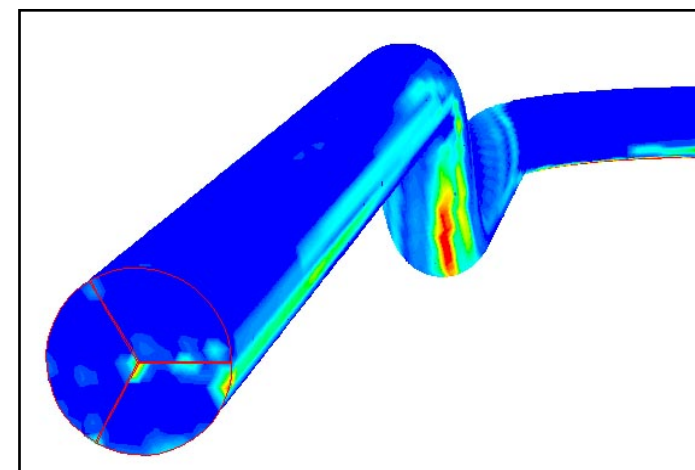
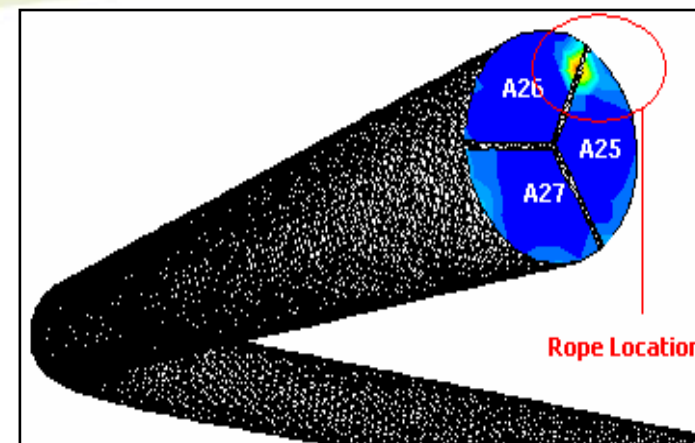
Together, utilizing both academic and industrial expertise, they developed the family of VARB® PF Diffusers.

The joint venture company employs specialists in particulate analysis and control. Their understanding of the particulate characteristics being transported in air is second to none.

GAIM offers both CFD analysis and a scaled test rig where concepts can be brought to life and tested prior to delivery to the customer.

The methodology rigorously applied for each and every VARB design consists of the following steps:

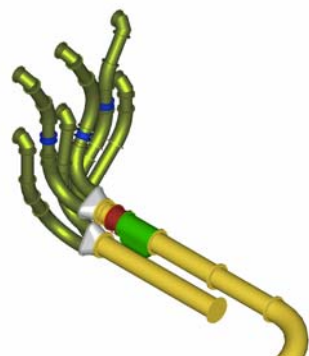
- **Acquisition of customer existing PF distribution data and techniques.**
  - **Creation of a computational model (CFD) and the numerical simulation of the existing distribution.**
  - **Prediction and analysis of the PF rope position.**
  - **Introduction of the VARB® design within the computational model by our skilled technicians and in house PhD's.**
  - **Optimization of the VARB® (and Control Gate) design and location within the numerical model.**
  - **Verification of Rope position by survey and detailed analysis.**
  - **Installation and optimization of VARB® (and Control Gate). Final calibration using GGI's patented techniques. End Result — Balanced Flow.**





# VARB<sup>®</sup>

## COAL FLOW BALANCING SYSTEM



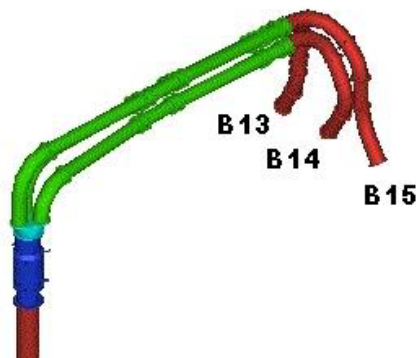
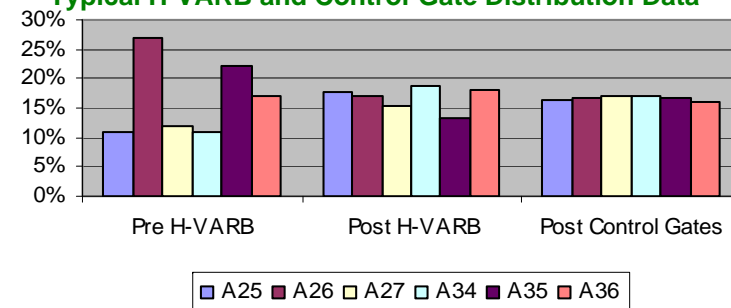
### H-VARB<sup>®</sup>

The H-VARB is the latest generation in the VARB family. It was developed to balance the air / fuel ratio equally at bifurcations, trifurcations & multi-outlet splitters.

In conjunction with the Control-Gate the performance of the H-VARB is repeatable to within  $\pm 3\%$  of the mean distribution under different fuel / air loadings.

Since its development it has been proven to work equally well in the vertical mode.

Typical H-VARB and Control-Gate Distribution Data



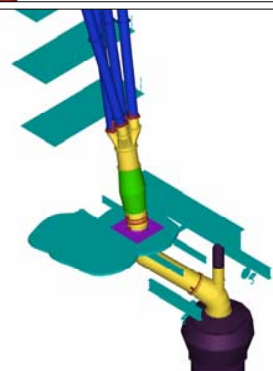
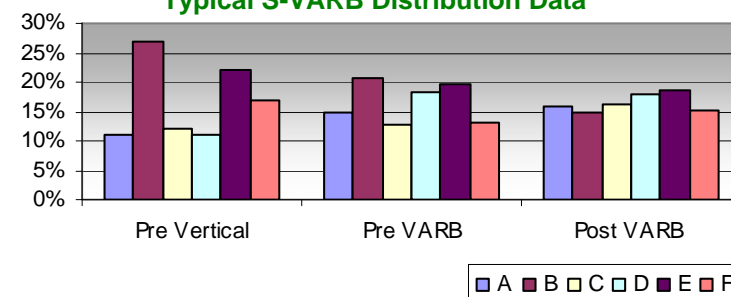
### S-VARB<sup>®</sup>

The S-VARB was the original VARB design developed to break the PF rope and produce a homogenized mixture of PF and air at the outlet in the vertical mode.

Utilizing gravity it works by reducing the velocity and inducing spin so the PF particles become thoroughly mixed in the transport air at the VARB's exit.

Again, the S-VARB operates under differing air / fuel ratios and is unaffected by moisture or coal type changes.

Typical S-VARB Distribution Data

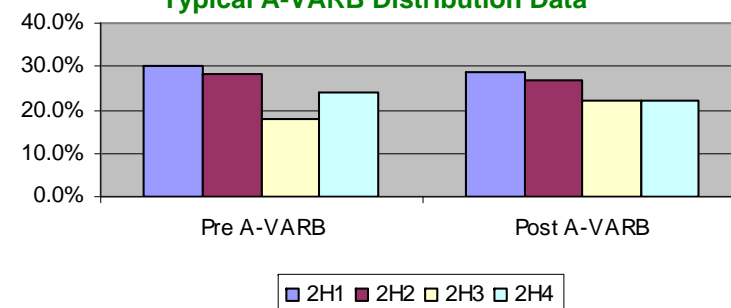


### A-VARB<sup>®</sup>

The A-VARB is designed to combat particularly aggressive rope situations. Working in the same manner as the S-VARB it incorporates a throttle to agitate the rope before it is destroyed.

The A-VARB has operated successfully in front of 4-way splitters and has improved PF distribution compared with multi-outlet dynamic classifiers which were replaced with a HP static classifiers to gain increased throughput.

Typical A-VARB Distribution Data



# VARB<sup>®</sup>

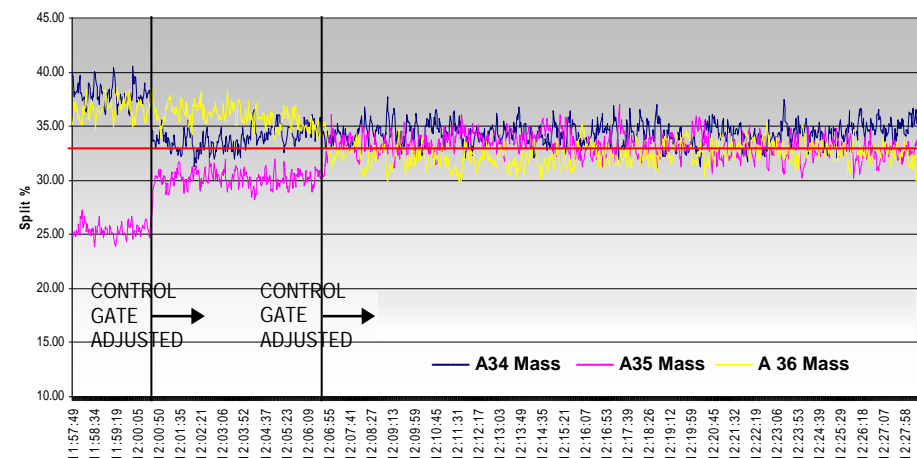
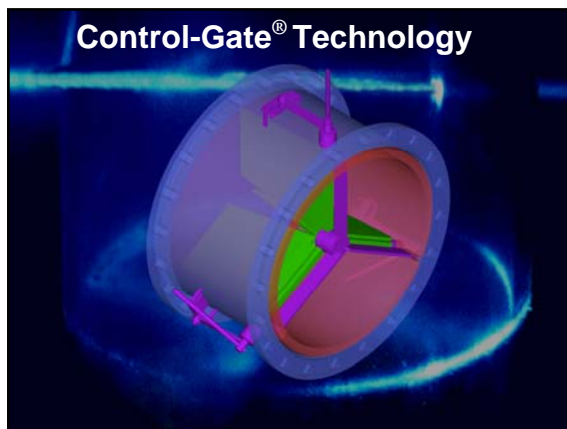
## COAL FLOW BALANCING SYSTEM

One of the benefits of coal flow balancing is a significant reduction of carbon-in-ash. Typically, poor distribution can have an exponential effect on the carbon-in-ash. Coal flow balancing lowers the carbon levels without having to make further changes to boiler controls. This can also allow the boiler operators to optimize for NOx having their carbon levels minimized.

Greenbank Control-Gates<sup>®</sup> optimizes the VARB technology and, in turn, fine tunes the PF distribution to the boiler. The optimized position of each gate can quickly and easily be found using a on-line measurement product such as the **PfMaster<sup>®</sup> Coal Flow Monitoring System** supplied by GESI.

The Greenbank Control-Gates<sup>®</sup> are designed to increase or decrease the flow of PF into any of the outlet legs without affecting the airflow.

It can be seen from the on-line data provided (below right) by the PfMaster output screen, that the Greenbank Control-Gates<sup>®</sup> can be trimmed to provide optimum distribution at a splitter pipe.



Each of the three lines shows the % of the fuel mass conveyed by each leg of the trifurcator (3-way splitter) and the graph demonstrates the perfect split achieved with the H-VARB/Control Gate combination.



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