CASE STUDY

VARB PF Diffuser at Ratcliffe Power Station,

Background.

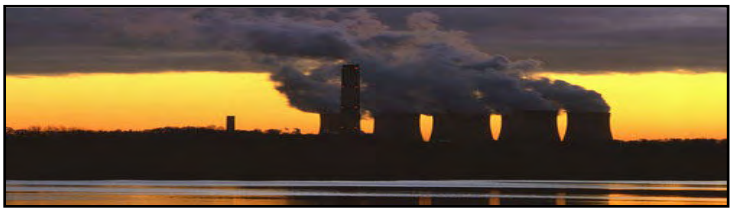
August 2003, Greenbank gave a presentation to Ratcliffe PS on the newly developed Variable Area Rope Breaker (VARB). The VARB had been developed by Greenbank's JV company GAIM Ltd at the University of Nottingham, UK. The concept of the development work was to break the rope and agitate the PF such that random samples of PF could be extracted from the pipe having a true and representative particle size distribution suitable for analysis.

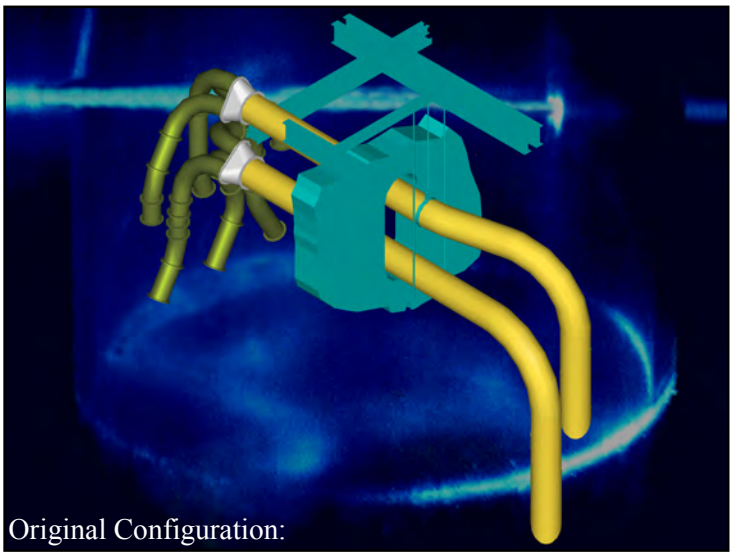
The method slowed down the velocity of the particles and induced a spin or swirl in a vertical section of pipe, this consistently broke the rope and produced a homogeneous particle flow at 1 x D down stream of the VARB. By placing a splitter at this position, it was believed good distribution could be upheld assuming similar pressure drops on each down stream leg.

This was tested at different air/fuel ratios and velocities. It was found that by placing a two or three way splitter 1 x D down stream of the VARB not only produced a good mass flow distribution or split, but also gave consistent particle size distribution down each leg.

In July 2004, Greenbank supplied 2 x VARB's and all the associated pipe work to Ratcliffe, which enabled the 3-way splitter's (known as trifurcator's), to be moved from the original horizontal configuration into the vertical. Greenbank also supplied their PfMaster coal flow monitoring system.

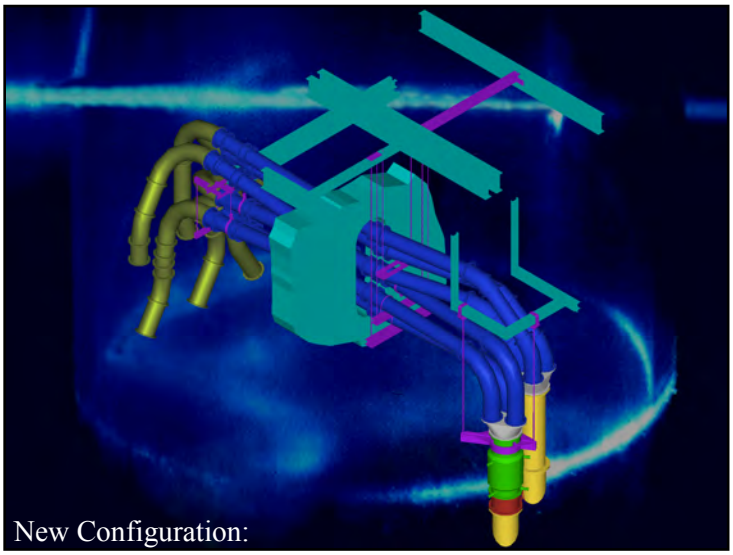
The PfMaster system was installed in advance of the VARB being fitted and as such the distribution data could be analyzed and the improvement in distribution easily noted.





Original Configuration:

Trifurcators in the Horizontal



New Configuration:

Trifurcators in the Vertical, with & without VARB

Outline Performance Data.

- Air to Fuel Ratio: 2.6 to 3.4:1 , Velocity: 68-83 ft/s, Coal Type: Black (Varies)
- Pipe Inlet Diameter: (26"), Pipe Outlet Diameter: (15")
- Pipe Linings: Zalcon & Basalt

VARB Arrangement:

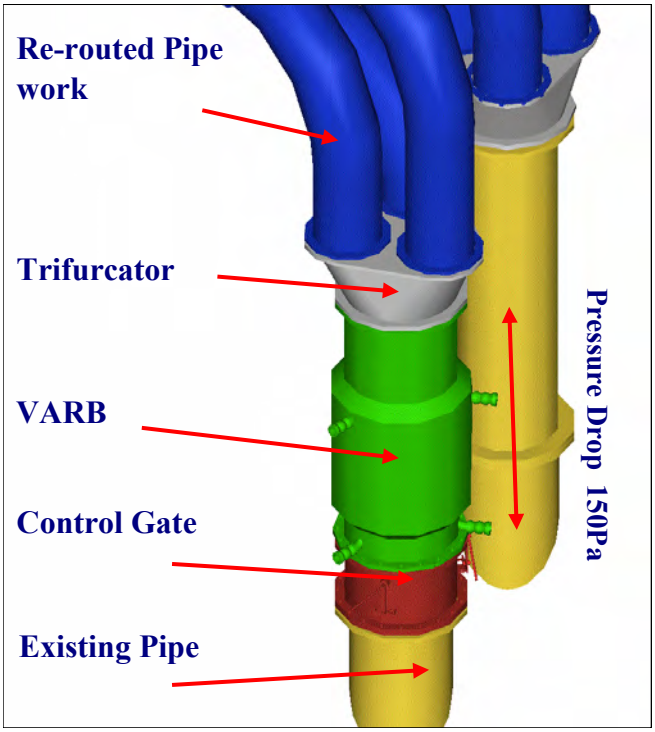
Installation and Operation:

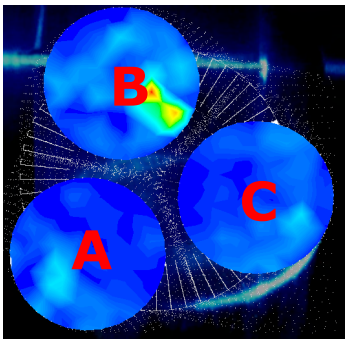
The pipe work was re-routed in order to place the Trifurcator in the vertical orientation. This enabled the VARB to operate in accordance with its development test work. The VARB is dependant on swirling, and the effect of gravity at lower velocities. This enables particles to 'drop out' in flow, mixing utilizing swirling effect and be re-accelerated though the outlet.. The pressure drop throughout this device is minimal as there are no parts intruding into the bore of the pipe.

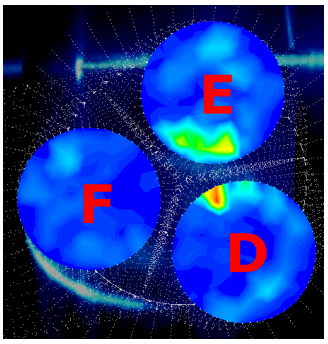
If the rope is very strong, a more aggressive VARB is needed. If there is insufficient spin, it can be induced by mechanical or pneumatic means.

In this instance the VARB was installed at the top of a long vertical straight, such the rope was not too strong.

A Control gate was installed prior to the VARB. This can be utilized to create swirl or to bias the distribution towards any desired outlet.







Results:

The results are outlined below showing the installation before and after the VARB was fitted. In this instance 2 x VARB's were fitted to one mill, such the distribution is over 6 outlets. The results are shown stating:

% Distribution: Which is a percentage of the total mass flow.

% Deviation: Which is the percentage deviation from the required mean.

Results	Outlet:	A	B	C	D	E	F
% Distribution	Pre VARB	14.75%	20.82%	14.74%	18.33%	19.65%	13.01%
	Post VARB	**15.97%**	**14.99%**	**16.31%**	**17.76%**	**18.79%**	**15.16%**
% Deviation	Pre VARB	-13%	25%	-13%	10%	18%	-28%
	Post VARB	**-4.4%**	**-11.2%**	**-2.2%**	**6.5%**	**12.8%**	**-10.0%**

Bespoke Design:

Using the principles developed by our sister company GAIM Ltd., each application is studied on its own merits. The methods used are as follows. A CFD model is developed to replicate the existing pipe configuration (from mill to splitter), performance range and flow distribution. Once the CFD model replicates the existing distribution characteristics, the model is changed to incorporate the proposed VARB.

The design of the VARB is then tailored to obtain the best results over a range of air to fuel ratios and velocities. Once the design of the VARB is complete it can be physically tested on our 1/3 scale rig which is situated at the University of Nottingham.