ACARP Project C14036

Development of a New Shearer Scrubber System for Dust Control

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Introduction

- **Dust exposure of operators on longwall faces remains a challenging task for mine managements.**
- **Dust control techniques have been developed in the USA, UK and other western countries where their applications are more applicable to low to medium coal seam heights up to 3.0m.**
- **Dust control in thick coal seams appears to be more problematic, particularly due to the differences on face airflow patterns and potentially higher dust generation and pick-up in thick seams.**

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Introduction

- **With the support of ACARP, the CSIRO has been involved in the studies of ventilation and respirable dust flow patterns around the longwall shearer and the use of various engineering dust controls through the application of CFD modelling techniques.**

- **During these simulation studies, the longwall shearer scrubber system has shown to be capable of capturing and significantly modifying the airflow patterns around the maingate cutting drum and reduce dust roll-up towards the walkway area.**

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Introduction

- **The objective of this project was therefore to develop and demonstrate an innovative shearer scrubber system to reduce operators dust exposure levels on longwall faces.**

- **The design of the new scrubber system has incorporated the CFD modelling findings, including the desired scrubber capacity, the inlet locations and the airflow discharge direction from the elutriator.**

- **The proposed field trial at the selected mine sites did not materialise as planned due to site access and contractual issues.**

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Introduction

- **It was with the support of BMA's Broadmeadow Mine and their management team that the proposed field trials were finally conducted.**

- **After a few failures during the trials, a modular designed scrubber unit was successfully installed to the MG ranging arm of the longwall shearer.**

- **This allowed the evaluation of the scrubber.**

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CFD Modelling

- **CFD models have been developed to investigate air and respirable dust flow patterns around the longwall shearer.**
- **These CFD models were validated and then used for detailed parametric studies and to investigate the effectiveness of various dust controls options.**
- **Figures 1 and 2 show the 3D model of the longwall and the 3D model of the shearer.**

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CFD Modelling

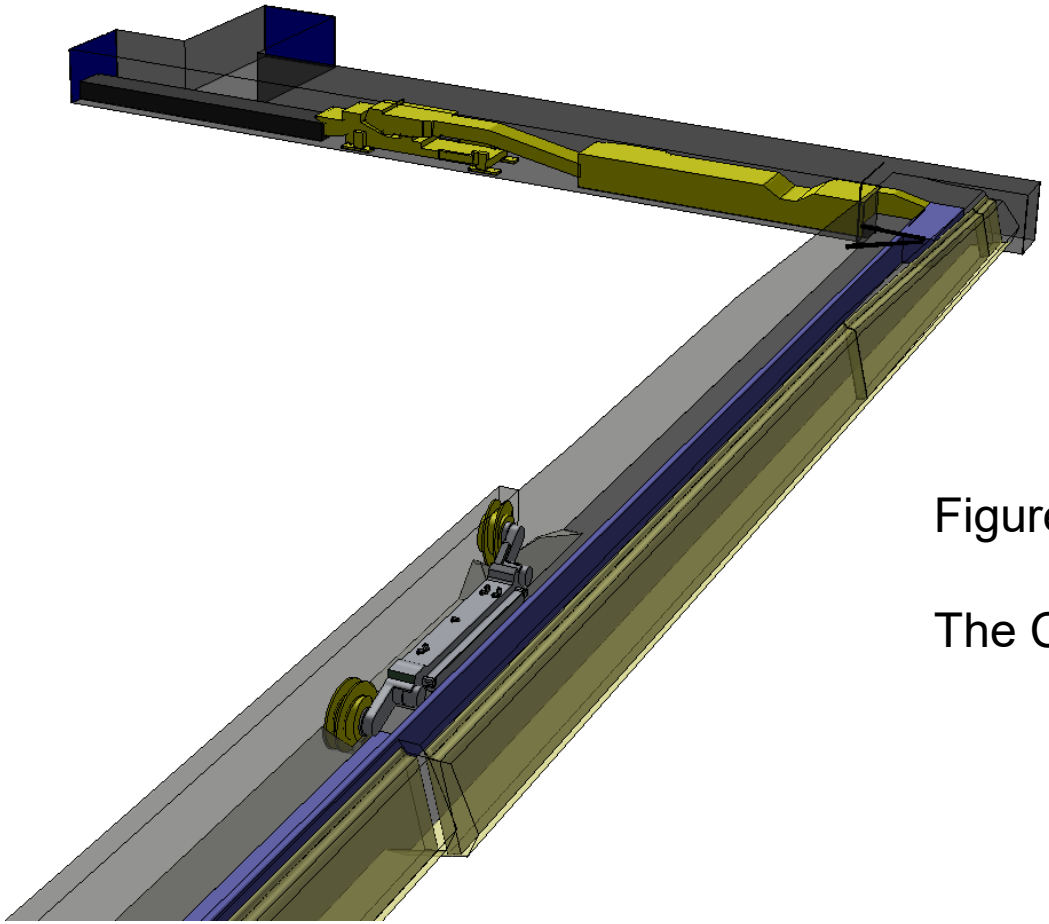

Figure 1

The CFD longwall model

CFD Modelling

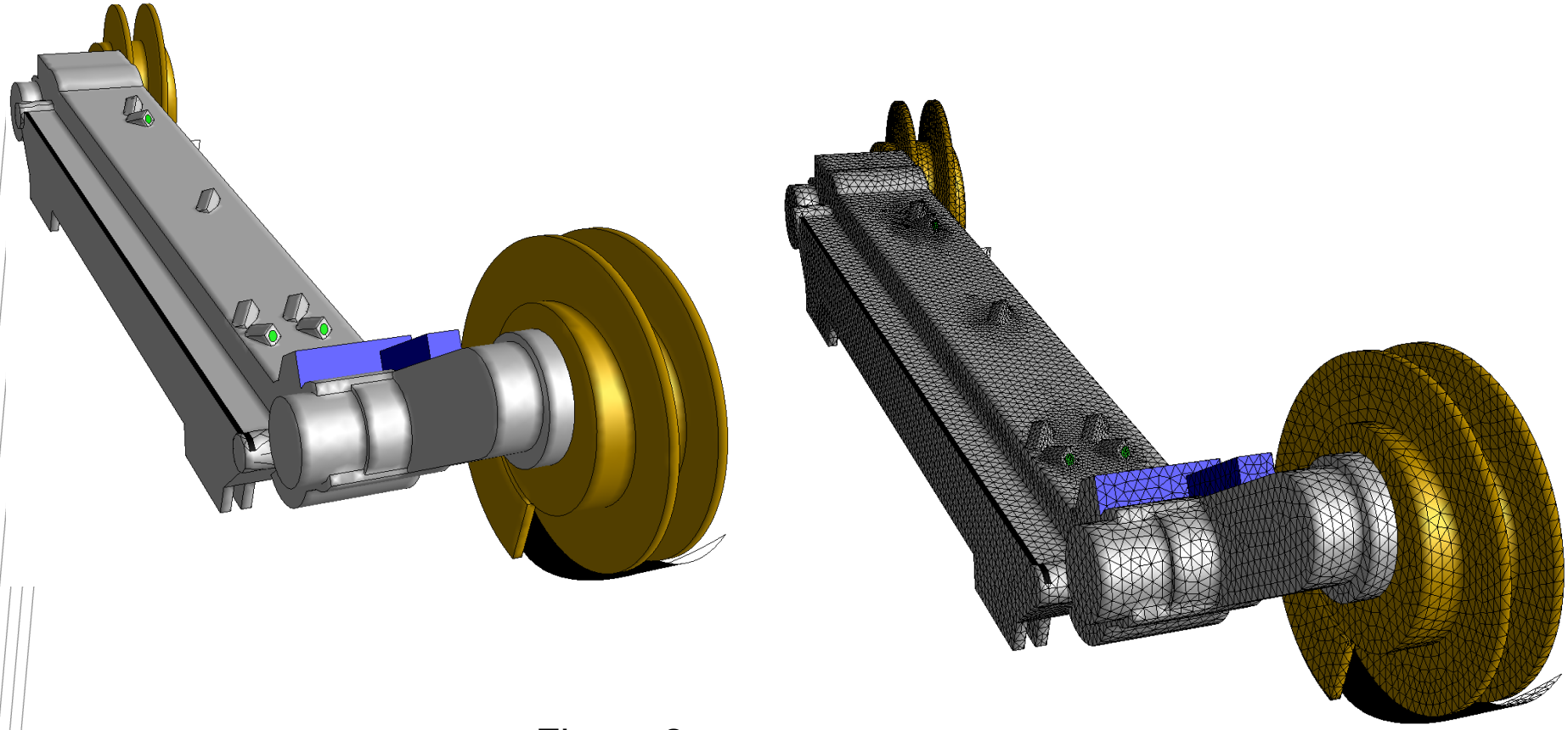

Figure 2

The CFD longwall model

CFD Modelling

- **Figure 3 shows the CFD model layout with the dust scrubber attached to the longwall shearer.**

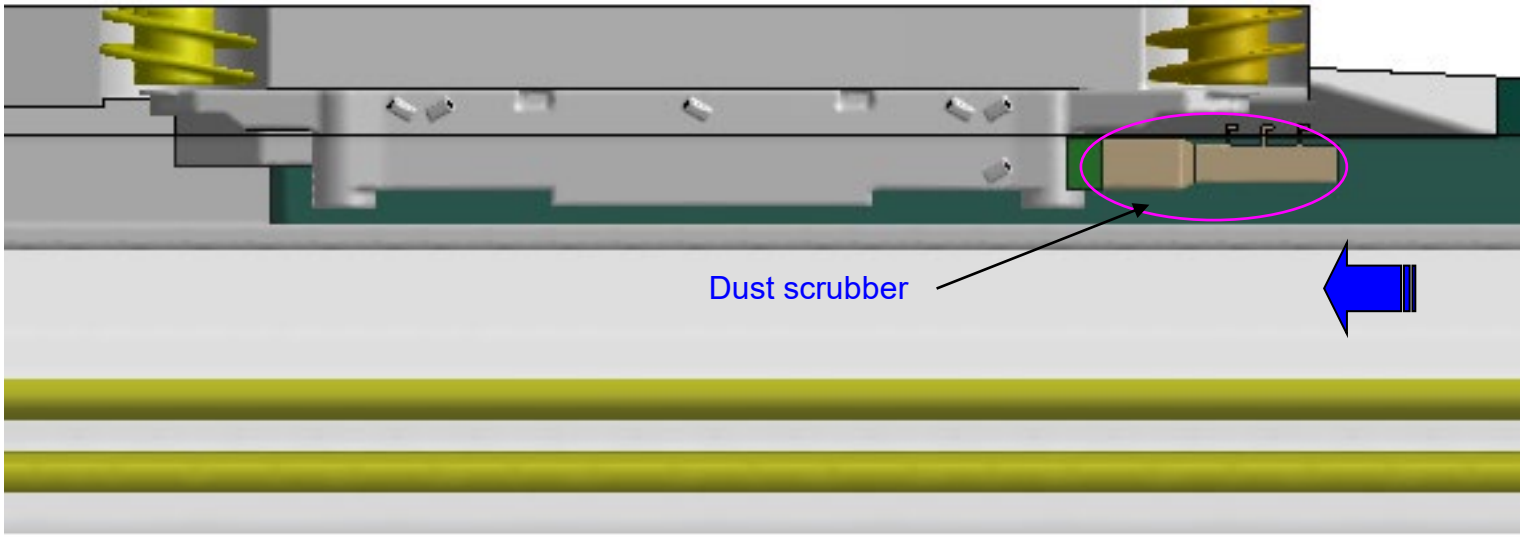

Figure 3.

CFD Modelling

- **Figure 4 (a) & (b) shows the modelling results for the dust scrubber with inlets facing the shearer drum and ventilation direction.**

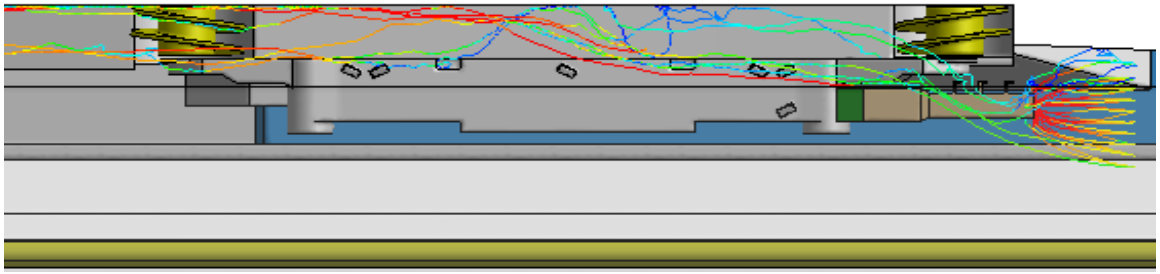

Figure 4(a) Scrubber inlet facing the ventilation direction

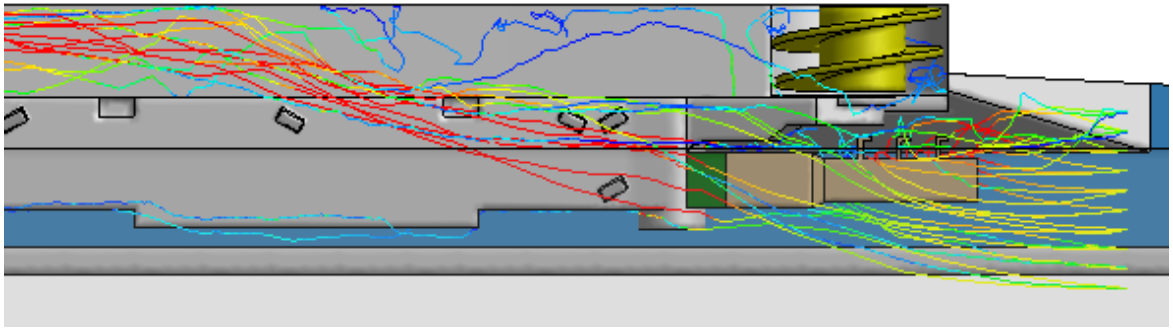

Figure 4(b) Scrubber inlet facing the shearer drum

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CFD Modelling

- **Modelling studies showed that it is important to correctly position the scrubber outlet location and discharge direction to improve the overall diversion of escaped dust particles away from the face walkway.**

- **Figure 5 shows the CFD modelling results of dust particle capture and flow patterns by tilting the scrubber discharge at 10˚ (degree) towards the face.**

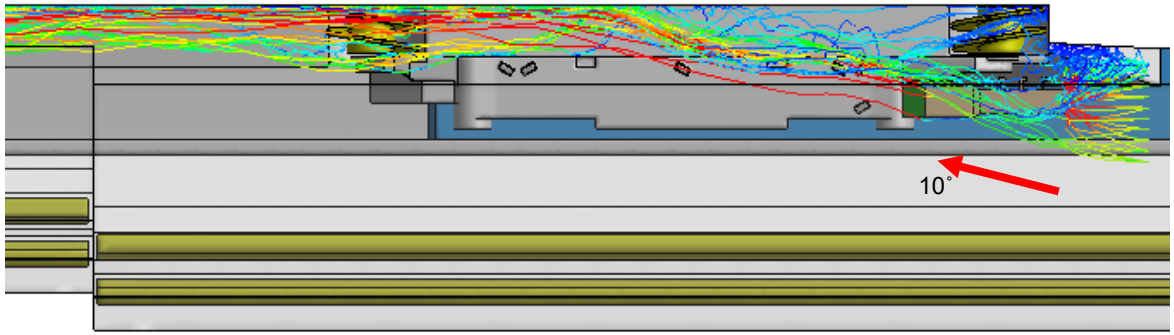

Figure 5. Dust particle capture and flow patterns – scrubber discharge tilted towards the face

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Shearer Scrubber Design

- **The completion of this project required the design and manufacture of 3 individual units before the final design was successfully fitted and trialled at BHP Billiton's Broadmeadow Colliery in the Bowen Basin North Queensland.**

- **Prior to the final scrubber design several major mining operational issues had to be considered. The most pressing problem was to design a system that would actually stay on the shearer.**

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Our Failures

Our Failures

Our Failures

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Our Failures

Shearer Scrubber Design

- **The scrubber is a modular designed system consisting of an intake hood directed into the intake ventilation, a hydraulic driven fan sucking the air into an impact filtration system and a discharge duct forcing the clean air under the shearer body towards the face.**

- **A series of sprays are incorporated into the sides of the intake hood to create the first agglomeration impact point for the dust/ water mixture prior to impact filtration removal and also to provide a positive pressure resistance to firstly create an 'air curtain' and secondly to entrain airborne dust out of the walkway.**

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Shearer Scrubber Design

In summary, final design included the following key features as indicated by CFD modelling:

- **The scrubber was designed as a compact modular unit to fit the limited space between the ranging arm and the shearer body;**
- **Scrubber intake duct facing the ventilation direction ;**
- **Fine water sprays embedded into the intake duct to increase scrubber collection area and additional function of 'air curtain' to suppress and streamline dust particles;**
- **Scrubber exhaust under the ranging arm and tilted 15° towards the face and 45° toward the tailgate.**

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Shearer Scrubber Design

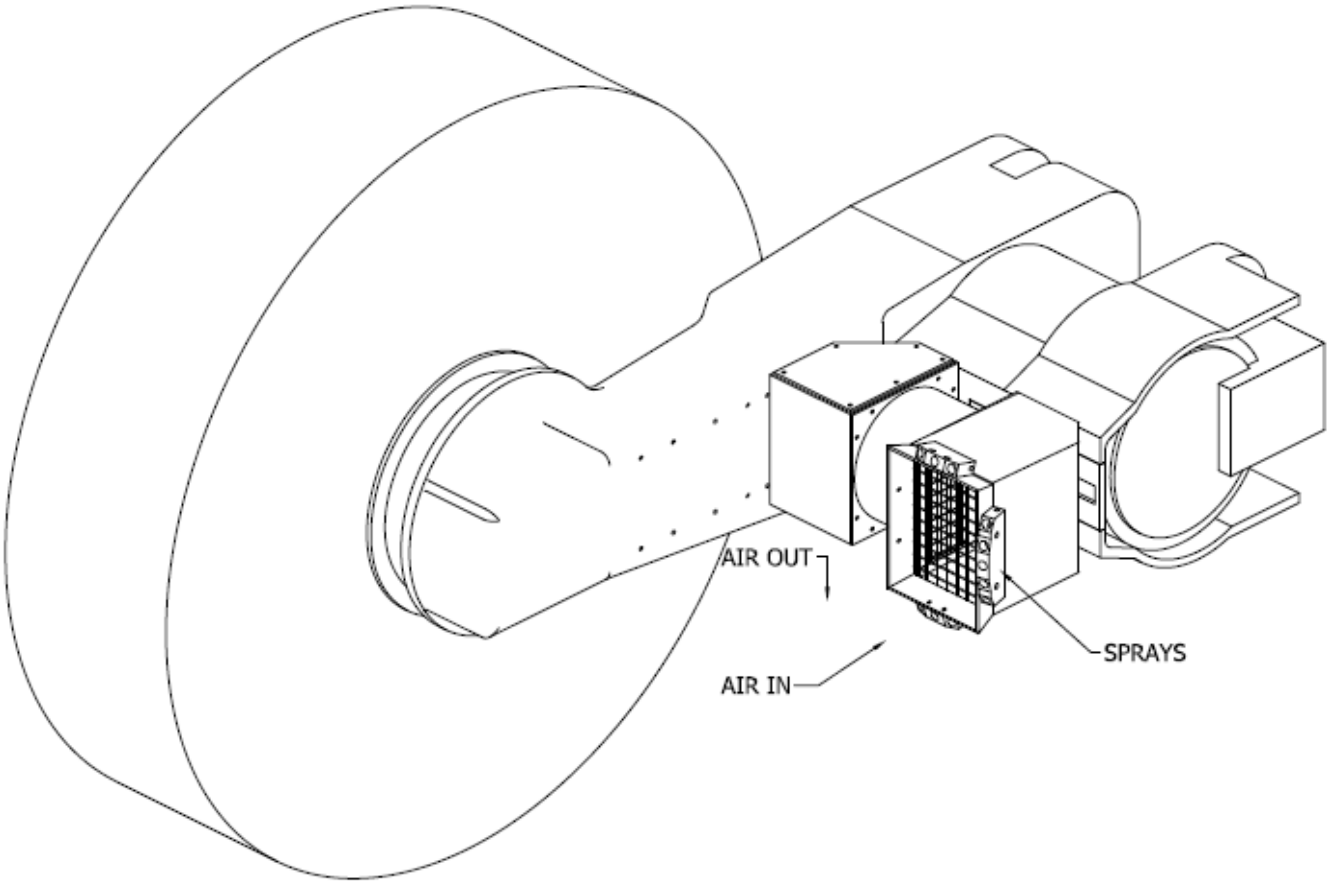

Figure 6. A 3D view of the final design of the shearer scrubber

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Field Trials

- **The final field trials took place at BMA's Broadmeadow Mine.**
- **The dust scrubber was fitted to the longwall shearer on maintenance shift in May 2009.**
- **Figure 7 shows the installation of the final scrubber design.**

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Field Trials

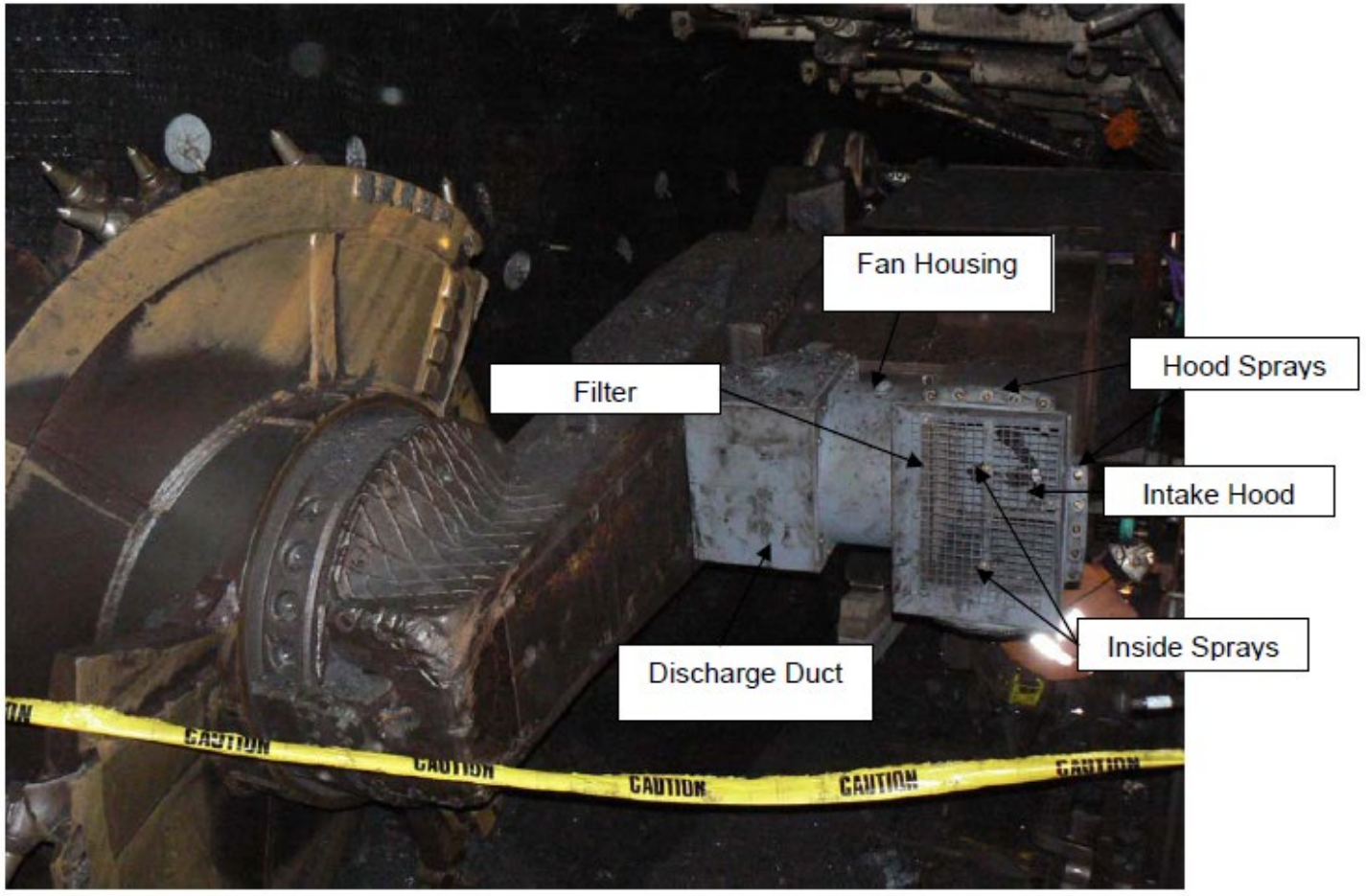

Figure 7. The installation of the final scrubber design

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Field Trials

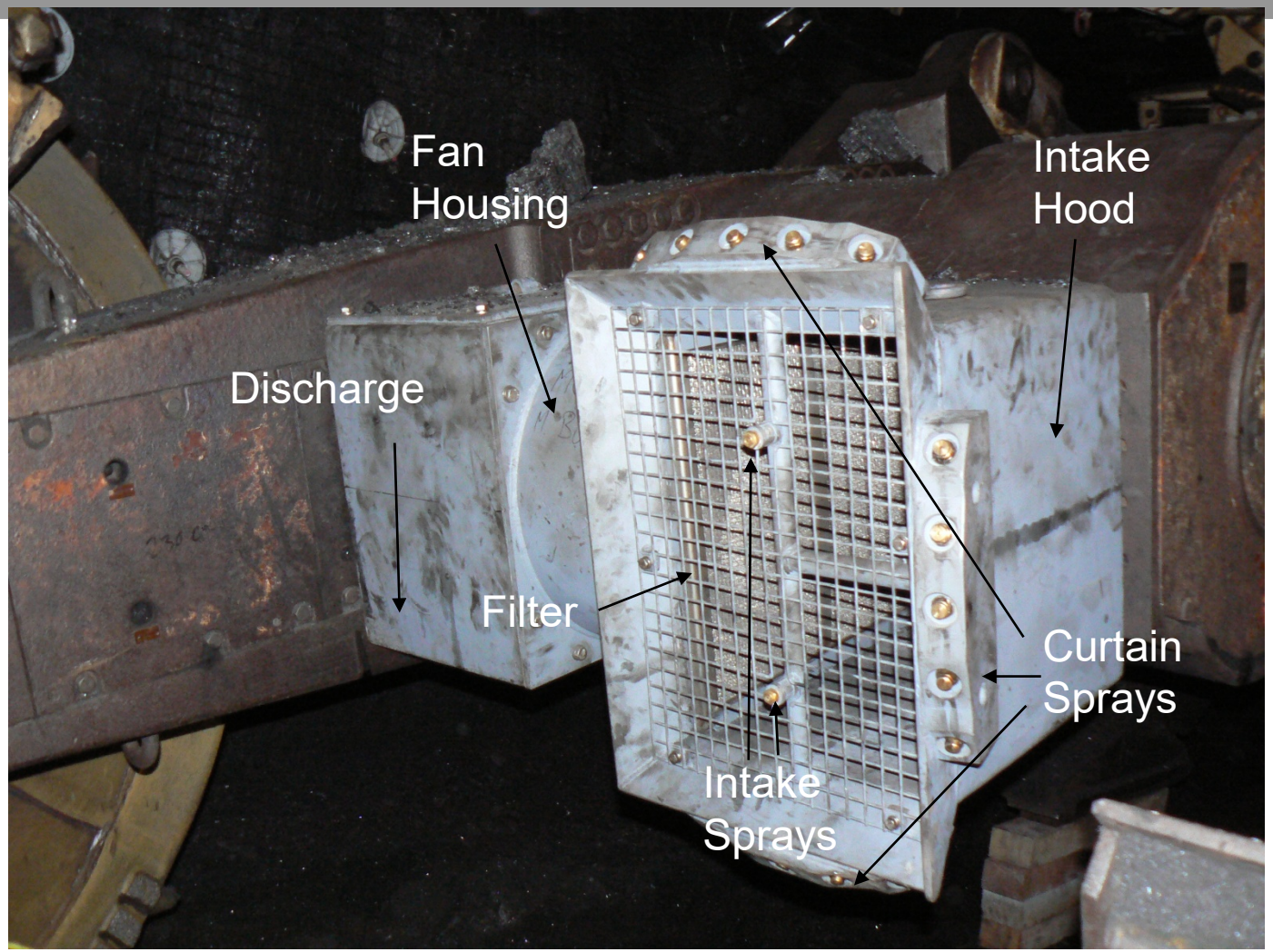

Figure 8. Hood Sprays

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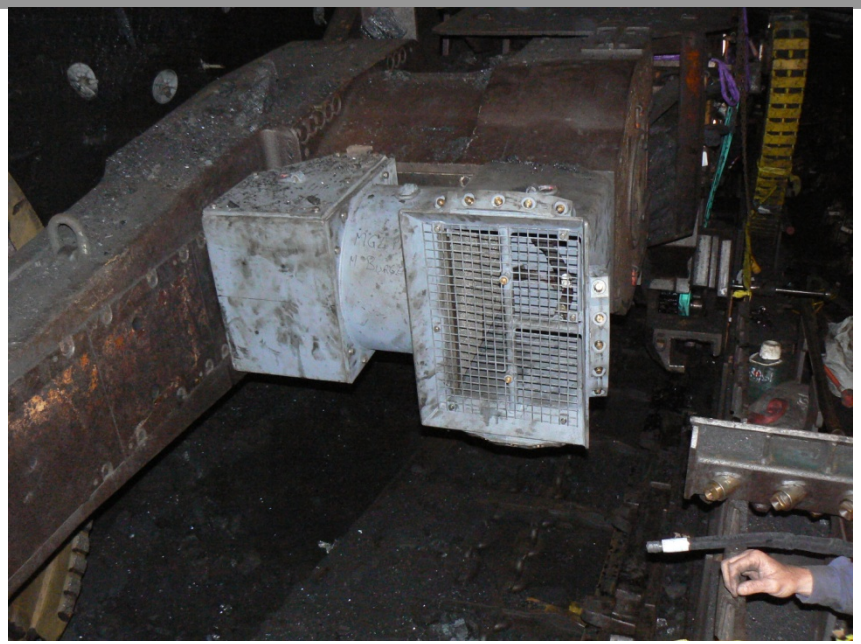
Field Trials



- **For the scrubber to operate effectively, it had to be capable of being started and stopped via the remote control used by the shearer driver.**
- **The oil was supplied via the unused cowl circuit in the valve bank.**
- **The problem with this initially was that this circuit was not de-tented.**

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Field Trials

The shearer scrubber created several operating problems:

Problem:

- **The scrubber created overheating problems for the shearer resulting in the shearer reaching the shutdown temperature of 68 degrees after 40 minutes of cutting;**

Solution:

- **This was rectified by the installation of a shell and tube heat exchanger which reduced the shearer operating temperature by 6 degrees and allowed the shearer to cut with the scrubber operating;**

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Field Trials

Problem:

- **The scrubber was continually damaged by hitting unretracted flipper bars;**

Solution:

- **This was rectified by a unique bi directional hinge system that allows the scrubber to remain in an almost horizontal position, thus reducing the potential for flipper collision.**

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Scrubber Test Results

- **During the field trial period, dust surveys were conducted to establish the effectiveness of the longwall shearer scrubber on respirable dust reduction for operators during cutting operational cycle.**
- **Two IS approved Hund instantaneous dust samplers with several parallel gravimetric dust samplers were used along the longwall face at different locations.**
- **Four cycles were monitored with the first two undertaken by a day-shift crew and the second two by a night-shift crew.**

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Scrubber Test Results

- **Table 1 shows the dust survey results from the instantaneous Hund monitors.**

Test Cycle Conditions	Monitoring Position's Average Dust Conc. mg/m^3	
	At Shearer Operator	At four chocks outbye of Shearer Operator
Shear Cycle #1 Scrubber Off	1.59	1.54
Shear Cycle #2 Scrubber On	0.70	0.79
Dust Reduction, %	55.7	48.7

Test Cycle Conditions	Monitoring Position's Average Dust Conc. mg/m^3	
	At Shearer Operator	At four chocks outbye of Shearer Operator
Shear Cycle #1 Scrubber Off	1.59	1.35
Shear Cycle #3 Scrubber On	0.77	0.77
Dust Reduction, %	51.4	42.7

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Conclusion

- **Extensive CFD modelling studies of longwall shearer dust scrubber system have been conducted and modelling results used in the design optimisation process for the new shearer dust scrubber system.**
- **A new scrubber system has been designed, manufactured and field trials were successfully conducted at BMA's Broadmeadow Mine.**
- **Dust monitoring results concluded that the shearer scrubber monitored will reduce respirable dust exposure of the shearer operator.**
- **Dust reduction efficiencies for the Shearer Scrubber measured during the evaluations ranged from as high as 56% down to 14%.**

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Conclusion

- **The current scrubber system can be viewed as work in progress and continued improvements need to be made on scrubber operation and cleaning to fully integrate the scrubber into the longwall shearer automation system.**

- **The following work should be carried out in future studies:**

  - Improved design of scrubber inlet clearance by incorporating backflush functions in the scrubber system;
  - Additional field trials to the scrubber system in medium and thick seam longwalls;
  - Detailed assessment of scrubber performance in dust reduction and environmental impacts such as noise and visibility;
  - Development of a shearer scrubber with improved suction capacity.

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Acknowledgements

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- **CSIRO**

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