SAFETY IN MINES RESEARCH ADVISORY COMMITTEE

SIMRAC

Final Project Report

Title: EXECUTIVE SUMMARY:
REDUCTION OF WORKER EXPOSURE TO DUST IN COLLIERIES

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LIST OF PUBLICATIONS, REPORTS, TECHNICAL AND INTERNAL NOTES ON DUST AND RELATED WORK

Sullivan, P. **An assessment of respirable dust and control measures in continuous Auger Miner sections.** 1990

Appelman, G. **Gravimetric determination of varying concentrations of airborne respirable dust, using the HUND Tmdata.** 04/9

Meyer, C.F. **Effect of last through road air on ventilated headings.** 14/91

Sullivan, P. **A comparison of respirable dust exposure levels for two continuous miner longwall development sections.** 91/05

Van Heerden, J. **Summary of a report on the numerical modelling of the airflow in a continuous miner heading.** 91/06

Sullivan, P. **The dust removal effectiveness of some flooded bed scrubber systems.** 91/07

Sullivan, P. **A survey of intake and operator respirable dust levels at three collieries using continuous miners.** 91/08

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Appelman, G. **Report on the effect of the use of surfactants at Douglas Colliery.** 91/41

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Delmas colliery. Internal Jan/ 92

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Sullivan, P. & Van Heerden, J. **Simulation of environmental conditions in CM developments using CFD.** 01/93, MVS Journal

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Du Plessis, J.J.L. **Airborne dust in a longwaal face.** 1994

Croft, D. **Evaluation of directional sprays in static underground test conditions.** Sep/93

Croft, D. **Guidelines for the installation of the spray fan system in South African Coal Mines.** /93

Pretorius, S.W. **A comparison of respirable dust exposure levels for the operator of a remote control and a conventional CM.** 93/18

Oberholzer, J.W. & Meyer, C.F. **Evaluation of heading ventilation systems through the use of computer simulations.** 1995

Anon. **Efficiency tests on an Engart Scrubber.** Jul/94

Appelman, G. **Dust measurements with 32 rpm and 51 rpm Joy HM9 continuous miners, Matla 3 Mine.** Dec/94

Du Plessis, J. **Assessment of on board scrubbers for use on continuous miners in South African Collieries.** Chapter 21

Du Plessis, J.J.L. **Dust Scrubbers.** 1995

Du Plessis, J.J.L. **Test protocol for dust concentration measurements in headings.** 1995

1) Report on CFD simulations using different ventilation systems to assess heading ventilation, dust and methane.

PART 1:- Full heading development at 30 m
PART 2:- Full split development to the right at 20 m
PART 3:- Different development stages of the heading and splits
PART 4:- Four partial heading development stages and split ventilation

2) Results of tests done at Brandspruit Colliery on the use of different ventilation systems and to verify CFD results - Confidential report for Brandspruit colliery.

Oberholzer, J.W. Techniques to reduce worker exposure to dust . Simrac Symposium September 1995.

Pretorius, S.W. & Du Plessis, J.J.L. Dust fall out in a return airway of a conventional action.

SUMMARY REPORT ON COL027 - REDUCE THE EXPOSURE OF WORKERS TO DUST

1.0 INTRODUCTION

This summary report deals with the work and outputs obtained from the SIMRAC funded project COL 027. Although this project followed on from a CMRCC funded project, it underwent a significant change in direction mid-1993 onwards.
On the whole, the project outputs cannot be characterized by profound findings which would cause major changes in the industry, but rather by smaller incremental improvements and changes.

From July 1993 the project was steered by the Special Interest Group on Dust Suppression (SIGDS) who directed its course, as well as being involved in changing or keeping the outputs pertinent to the problems experienced by the mines.

The outputs required for completion of the project were directed at diminishing the adverse conditions caused by the levels of respirable dust in the underground section. Therefore recommendations and the rendering of assistance to the mines is such that installed dust equipment could be optimized. Where possible innovative or conceptual design was evaluated and, if required, assistance also rendered to manufacturers, allowing these designs to be adapted or improved for use in the underground environment.

The enabling outputs as specified:

Evaluation of current and alternative dust suppression systems, as well as assisting with the development of new systems (Short term, high priority).

Determine the potential for the reduction of the make of dust through the application of the latest coal cutting technology (Mid to longer term, high priority).

Prepare guidelines and procedures to reduce worker exposure to dust (Short term).

Investigate solutions to address future technology requirements (Mid to longer term).

In conducting this project further deliverables would become available mainly:

Standardized test procedures for dust make, scrubber and ventilation effectiveness.

Computer programs to design drums to minimize the make of dust.

Guidelines in a usable form for the basis of staff training

Even though the focus of the outputs changed over the course of the project, by the Special Interest Group, outputs from the project were in keeping with that originally agreed to. Additional work ie. a refocus of the major efforts into ventilation methods, the preliminary investigation into air-jet fans, inputs into the DMEA's guidelines, as well as contributions to MRAC, were also covered.

With regard to the funding of the project, funds were approved on an annual basis over the duration of the project. Notwithstanding the changes to the scope, outputs were delivered without incurring an over-expenditure.

The interest group decided the guidelines would form the major part of the final report, and to avoid duplication the report as presented during the project life need not be presented again but listed in a short summary report, wherein the overall progress of the project should be presented.

2.0 WORKSHOP RESULTS

In the early part of 1993 a feeling arose that work regarding the dust problem was not yielding the desired results fast enough. Therefore, to effect a more significant influence on the dust levels in the section, the focus of the work should concentrate on more pressing problems, and the results of this work transferred to the Coal mining industry faster than within the normal SIMRAC reporting process.

To this end a workshop was held with over thirty industry, research and academic participants. Here the strategy to combat dust was confirmed for future use and priorities for the work set. To ensure results of the research work was transferred to the industry, as well as to maintain the relevance of the work, a special interest group was established.

Throughout the period of the project, its outputs were reported to this group, under the chairmanship of J Guthrie of Anglo American. To ensure relevancy of outputs, and avoid confusion in the industry with partly completed work, no outputs were reported to a higher committee or released to the industry, before having been passed through this group, who ensured the level of outputs, and the relevancy of the work, was maintained throughout the life of the project.

3.0 FINDINGS AND RESULTS ACHIEVED

3.1 OUTPUT 1 - EVALUATION OF DUST SUPPRESSION SYSTEMS

A test protocol was established whereby the efficiency of dust scrubbers on a continuous miner could be tested. The efficiency of scrubbers being the relationship of the dust entering the scrubber and the amount of dust removed by the scrubber. This did not include the ability of the scrubber to capture the amount of dust in the air, which is mainly determined by ventilation aspects in and around the cutting area and the inlet of the scrubber itself (The need for this work was identified but is being carried out under a separate project).

Scrubber efficiencies in the underground section were found to vary between 45 and 90%, while in a test conducted in a surface gallery, it was found to vary between 90 and 97%. Therefore it was concluded that present-day scrubbers are more than adequate in terms of efficiency, and to further pursue an increase in efficiency would not be cost effective in terms of the results expected. It was also felt that such work could lead to a lowering of the capture efficiency as the amount of air flowing through the scrubbers would be subject to higher resistances.

Work into innovative systems indicated that other principles like a waterspinner or flooded brush scrubber can give excellent results. When these mine-worthy prototypes had to be manufactured, however, it was found the cost involved was prohibitive for the manufacturers involved.

The use of surfactants were tested both as an additive to the water-sprays, as well as in the scrubber water. In both cases, in the case of inefficient systems, the addition of surfactants decrease the dust levels. When the system was working at higher efficiency levels the addition of surfactants only made a marginal difference. On the whole the problem of using surfactants does not lie in the usage or cost implications, but rather in the inadequacy of the dosing pumps. It would seem the reliability of these pumps leave much to be desired.

Spray jet fans, as developed in the United States of America, were adapted and developed for use in South African collieries. Not a direct dust removal system, but rather a airmover, its use still contributed to keeping rollback dust away from the operator, while maintaining effective ventilation in the face area. By now the use of this is standard on most mines.

The redirected work into ventilation, as requested during the workshop, was done under the heading of this output. Part of this work was the evaluation of different ventilation systems and the effect on dust distribution and behaviour in mainly continuous miner headings.

To expedite findings most of the work consisted of CFD simulations with a number of underground investigations to verify the CFD results. Out of the CFD results, detailed investigations into the use of jet fans was initiated, although completed under a different project. However, the conclusions regarding jet fans will also be mentioned in this report.

The scenarios which were investigated included the following:

1) Full heading development to a distance of 30 m from the LTR and different development stages of the heading.
2) Split developments to the right and left of the headings at different development distances.
3) The cutting sequences of the CM inside the headings were varied and the position of the cutting head were also varied.
4) A number of ventilation systems were evaluated in the process. The aim was to find a system which would be best suitable to ventilate continuous miner headings. These systems include the following:

- Jet fans in different positions and configurations
- Force/exhaust systems
- On-board scrubbers
- Exhaust systems including trailing exhausts
- Directional sprayfans systems
- Jet fans in semi-series
- Jet fans in semi-series with a force duct
- The LTR air velocity was varied and the direction of the airflow was also changed.

The following conclusions flowed out of this:

- For right handed machines the air in the LTR should flow from right to left past the heading and vice versa.
- The force systems should be installed and used in the upstream position.
- Air quantities delivered by the auxiliary systems should be balanced to control recirculation and rollback.
- Recommended system for dust control is the trailing exhaust system.
- The directional sprayfan system is essential for good airflow conditions on the face and for good dust control.
- The outlet of the scrubber should be directed in such a manner that the outlet air reaches the LTR in the shortest possible time without interfering with the driver of the shuttle car.
- Jet fans should be tested thoroughly before installation and use. The factors which influence the performance of jet fans, such as outlet spin- and forward velocity, should be kept in mind when new fans are evaluated. The fans should be able to create a figure of eight flow pattern on the face.
- The air inside the section should be coursed through the section.
- Distance of auxiliary ventilation appliances from the face should be between 10 m and 15 m to control the dust.
- Until proven differently, the splits should be ventilated by means of force ducting.
- Jet fans in semi-series, or other systems in semi- series, are not recommended for ventilating splits.
- In medium to low seams it is irrelevant whether the jet fans are placed against the roof or on the floor. In high to ultra high seams, however, it is advised to install these fans against the roof to ensure airflow in these areas.
- Inlet of exhaust or scrubber systems should be kept as close as possible to the face to enhance the capture efficiency of these systems.
- The type of airflow inside the headings is determined by the ventilation systems, but also by the seam height. In medium to low seams the air flows in a two dimensional manner. In medium to high seams this phenomena changes to three dimensional which makes it more difficult to ventilate the headings and to control the dust.

The purpose of this effort was twofold. Firstly to create a tool which could be used to simulate the latest cutting drum types and then to use this tool to predict the potential make of dust from the cutting process using these new types of cutting elements. The second aspect was to look at newer overseas technology, evaluate it by means of the program and then assist the mines in adapting such technology for use in South African collieries.

Under CSIR STEP funding, the CUTSIM program, which was written in Hewlett Packard code was transferred to code which could run on a PC. This code was then adapted and enhanced to enable other drums, apart from a drum type cutter heads, to be simulated. The ability to simulate non-circular cutting paths was also incorporated into the code of the program. The final addition to the program was to make it user friendly, which required the writing of an inference model whereby the program was able to recognize impossible cutting configurations and warn the user.

To enable the program to simulate the make of dust a significant amount of testing was required to correlate the various cutting configurations with the actual dust made. However, to do this required a longer term test procedure, both in the laboratory and in the underground situation. As this work was not supported by the SIMRAC system, it was terminated. At present the CUTSIM program is available to allow more efficient cutting drums to be designed for mines.

Work done at the Matla colliery indicated a significant reduction in the amount of dust made when the drum revolutions were dropped down to 35 RPM. This reduction in dust was achieved without a discernable loss in production rate even though the slower revolutions should have brought about a lower cutting rate.

During the investigations into innovative cutting processes, the development of the Linear cutting principle of the USBM was closely followed. This process has been proved to reduce the amount of dust make significantly but had to be developed beyond the design stage. Unfortunately no manufacturer could be found for this and as yet the concept has to progress to the design stage. It is further anticipated, to enable this principle to work in South Africa, significant enhancements will have to be done to realize the required rate of cutting.

OUTPUT 3 - GUIDELINES

During the previous year, project work into awareness indicated that the level of awareness regarding dust, its health implications, the testing of levels, as well as the measure to combat it, is appallingly low. A package was designed to increase awareness and was tested on a mine, resulting in a significant increase in awareness amongst those who attended the course.

As it was felt that the establishment of training materials was not part of the SIMRAC ambit, such a packet was established using CSIR funds but with the technological input and overall coordination being done through the project and the Special Interest Group on Dust. The package was completed and distributed to various mines.

Due to a lack of support the generic video was not completed but in the event of mines wanting a video, the material exists to enable such a video to be completed and this is at a lower cost (than when embarking on such a venture from the beginning).

OUTPUT 4 - INVESTIGATE FUTURE TECHNOLOGY NEEDS

To determine technology needs, use was made of a *Dust Matrix* wherein a listing of all the known information, with regard to the dust allaying strategy, was entered. By using this information and from industry needs, areas for future technology could be determined.

The following are some of the technology needs which have been identified:

- Development of methods to allow continuous miner drum to rotate at significantly lower (in the order of 20 RPM) speeds while still maintaining the required cutting output.

- Methods to alert operators to the blunting of coal cutting picks.

- Methods to predict the dust make for a specific coalcutting configuration.

- Methods to allow the operator to be removed form the cab and still maintain the required control.

- Methods to quantify the effects on the quartz content in the dust when cutting roof and floor stone. This will make the implications of such cutting to made available.

- Methods to keep the continuous miner to the right horizon so that roof and floor stone is not cut as part of the normal cutting cycle.

- Methods to link the ventilation system to the continuous miner position so that the energy transferred into the coal can be kept to a minimum for the situation.

- Methods whereby the ability of the dust scrubbing system to capture the dust can be increased.

- Indications from overseas and locally tend to indicate that an increase in the capacity of the scrubber does not lead to an decrease in the amount of dust in the air. Firstly an increase in airflow could lead to a increase in the amount of dust entrained in the air which could lead to a decrease in capture efficiency. Secondly an increase in the airflow could create more complex ventilation currents which could cause the dust-laden air to escape and roll back past the inlet of the scrubber. This optimum airflow would also have to be determined.

3.5 GENERAL OTPUTS NOT DIRECTLY FALLING UNDER PROJECT ENABLING OUTPUTS

During the period of this project in excess of 200 underground tests were conducted. In many cases the findings were incorporated into the research work but in all cases the results were communicated to the involved mine management. The following are of the aspects investigated:

- Spatial distribution of airborne dust in workings
- Size distribution of airborne dust particles
- Dust scrubbing efficiency of flooded bed scrubbers (CDCS)
- Dust scrubbing efficiency of "wet-fan" scrubbers (Engart)& (Axial Dust Control)
- Dust scrubbing efficiency of cyclone scrubbers (Flosep)
- Dust concentration in recirculated ventilation
- The effect of jet fans on distribution of dust in headings
- The effect of "spray-fans" on distribution of dust
- The effect of service water additives on airborne dust
- The effect of remote control on dust exposure of CM drivers
- The effect of different drum rotational speeds of continuous miners on dust production
- Dust fall-out against distance from source along an airway
- Workers'awareness and knowledge of dust, its dangers and ways to reduce exposure to dust.

The results of these tests provide valuable information on some properties and the behaviour of dust, on the effectiveness of ventilation arrangements with regard to dust control, on the importance of good housekeeping and maintenance of equipment, and on typical dust concentration figures during the cutting or shearing cycles.

Tests done to determine the effect of using radio remote control indicated that by moving the operator into the fresh air the dust levels which the operators are subjected to could be reduced by a factor of about ten, well below the lower threshold value of 2 mg/m^3. In the event of the operator moving closer to the machine, to see what happens with the horizon, he can be subjected to almost double the amount of dust than at the cab. This has led to the conclusion that a significant reduction in dust levels can be achieved by using radio remote control, but control systems will have to be installed which will enable the operator to control his machine in a more effective way thereby reducing the need for him to move into the high dust areas.