Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

VISUAL OBSERVATIONS OF A FLOSONIC NOZZLE SPRAY PATTERN USING NO. 6 FUEL OIL AND COAL-LIQUID MIXTURES

H. Whaley
Combustion and Carbonization Research Laboratory

MAY 1982

ENERGY RESEARCH PROGRAM
ENERGY RESEARCH LABORATORIES
DIVISION REPORT 82-22 (TR)

INTRODUCTION

The major technical barrier to the use of coal-liquid mixtures (CLM's) in the Maritime provinces of Canada has been erosive wear of the burner atomizer components. 1/ 2/ 3/. This critical area is the subject of a former research program sponsored by CANMET 4/ and also by the NRC, CANMET and Scotia Liquicoal in the present project. It is clear that the use of wear resistent on harder materials will, to some extent, alleviate the wear problem but past experience suggests that the atomizer design is of far more importance in selecting or modifying nozzle tips for CLM use. The present report describes the author's visual observation of the Flosonics nozzle when spraying a coal-oil-water emulsion manufactured by Scotia Liquicoal Limited of Halifax, Nova Scotia. Both the nozzle and the fuel are described fully in the report to which this report is appended.

ATOMIZER THEORY

There are many texts on the atomization of liquid fuels, many of which date back to the 1950's when fuel oil was in widespread use as an industrial fuel. A useful list of references on the topic is given in the bibliography.

The main purpose of the atomizer nozzle is to produce a finely-divided spray of oil droplets which will intimately mix with the incoming combustion air to produce a stable flame. This stable flame must produce complete combustion of the fuel within the furnace chamber and with no wall or tube impingement. Many atomizing nozzle-combustion air distribution systems complement each other in integrated proprietary burners and cannot be successfully interchanged (e.g. the Gulf-ORF Vortometric burner). It is often true that complex atomizer nozzles will require similar stabilizing combustion air flow patterns in order to function. Conversly, simple nozzle assemblies can often be successfully interchanged between different combustion-air supply systems. When using heavy fuel oils, preheating is necessary to produce the correct viscosity conditions for spraying.

Rotary Cup Atomizers

In this type of burner, atomization of the fuel is achieved by centrifugal force. Usually the fuel flows through a supply pipe on to the inner surface of a hollow rotating tapered central cup. The fuel is thrown off the end of the cup as small droplets to mix with the incoming combustion air. This cup is usually motor driven, but it can also be driven by a portion of the atomizing air.

Mechanical Atomizer*

Fuel is pumped at high pressure (>700 kPa) through a complex nozzle assembly to produce a fine spray which then mixes with the incoming combustion air. This type of burner is usually susceptible to poor turn-down performance. Due to complex nozzle configurations and fuel directional changes, these nozzles are not usually suitable for use with coal-liquid mixtures.

Auxiliary - Fluid Atomizers

In these atomizers the fuel spray is formed by contact with jets of air or steam. The auxiliary gas or fluid may be at high or low pressure and the contact with the fuel may be achieved within the nozzle body (internally mixed) or just outside the nozzle body (externally mixed).

THE FLOSONIC NOZZLE

The Flosonic nozzle uses low pressure air for atomization and is an internally mixed auxiliary-fluid nozzle. The air and fuel contact each other within an internal chamber and then pass through an annulus and over a specially contoured external surface. (See diagram in main report). Effective atomization is achieved by sonic wave propagation from the edge of the external surface. The Flosonic 930 nozzle, currently being tested for 200 h under actual hot-spray conditions, has been modified for slurry use as noted in the report.

*In Europe these are called pressure-jet atomizers.

SPRAY OBSERVATIONS

Figures 1 through 4 represent photographs of the spray pattern for the following time intervals.

Figure	Time	Fuel
1	0	No. 6 Fuel Oil
2	25 h	CLM
3	100 h	CLM
4	195 h	CLM

A comparison of all the spray patterns for CLM, from 25 h to 195 h, show an excellent spray pattern which does not deteriorate with time. (Figures 2, 3 and 4). A comparison with Figure 1 shows that the spray pattern for fuel oil is not as uniform as with CLM. Despite changes in photographic technique, Figures 2, 3 and 4 are much superior in photographic quality, the No. 6 fuel oil spray is obviously assymetrical and of poorer quality than with CLM. The left side of the photograph shows a reduced droplet density which could lead to a non-uniform or unstable flame pattern. It is noted that when using CLM the spray angle is about 60° compared to 45° with fuel oil. This poor quality spray with No. 6 fuel oil could be attributed to modification in the burner nozzle made for use with the slurry.

CONCLUSIONS

No significant deterioration in spray pattern was observed for a modified flosonic nozzle when spraying hot CLM for about 200 h. The spray pattern observed was much superior to that of No. 6 fuel oil using the same nozzle before its use on CLM. The No. 6 fuel oil spray had a decided assymetry, which may be attributed to nozzle modifications made for slurry use.

BIBLIOGRAPHY

1. Whaley, H and Whalen, P. J. "Burner nozzle wear during coal-oil mixture (COM) combustion trials in a small utility boiler"; Paper No. 94, Corrosion 81 Conference; National Association of Corrosion Engineers; Toronto, April 1981.

2. Whalen, P. J. and Davies, F. W. "Coal-oil slurry firing of a utility boiler"; Report prepared for Energy, Mines and Resources Canada under Supply and Services Canada; Contract No. 18SQ.23440-7-9033; June 1978.

3. Whalen, P. J., Davies, F. W., Lee, L. K. and Mitchell, K. A. "A study of coal agglomeration and coal-in-oil mixture combustion on a utility boiler; Report prepared for Energy, Mines and Resources Canada under Supply and Services Canada; Contract No. 18SQ.23440-7-9055 IV; September 1979.

4. Bruno, L, Deshpande, A. S. and Whaley, H. "Coal/oil slurry combustion and tribology - a Canadian experience; 4th International Conference on Coal Slurry Combustion; Orlando, Florida; May 1982.

5. Taweel, A. M., Murphy, G. and Covill, D; "Erosion in CLM handling systems"; 4th International Conference on Coal Slurry Combustion; Orlando, Florida; May 1982.

6. Hutchings, I. M. "Mechanical and metallurgical aspects of the erosion of metals"; Proceedings Corrosion/Erosion Coal Conversion Conference; Berkely, California; Ed A. V. Levy; p 393; 1979.

7. Moore, M. A. and King, F. S. "Abrasive wear of brittle solids"; Wear 60; p 123; 1980.

8. Giffen, E. and Muraszew, A. "Atomization of liquid fuels"; Chapman and Hall; 1953.

9. Thring, M. W. "The Science of flames and furnaces"; 2nd Edition, Chapman and Hall; pp 243; 1961.

10. Collins, R. C, Mayer, G. H. and Newby, M. P. "The efficiency of momentum production by fluid atomizing burners; Inst Fuel 26; pp 189; 1953.

11. Fraser, R. P. and Eisenclam, P. "Liquidatomization and the drop size of sprays"; Trans Inst Chem Eng; 34 4 p 294; 1956.

12. Clare, H. and Radcliffe, A. "Air blast atomizer for use with viscous fuels"; J Inst Fuel 27; p 510; 1954.

13. Pass, F. and Schwartz. F. "Combustion liquid fuels - very heavy fuel oils"; VGB Kraftswerkstechnik 57 11 p 723; 1977.

14. Perry, R. H. and Chilton, G. H. Editors; Chemical Engineers Handbook; 5th Edition; McGraw-Hill; p 1863; 1973.

15. Carmi, S. and Ghassemzadeh, M. R. "Viscosity and spray formation studies of coal-oil mixtures"; Fuel 60 p 529 1981.

Fig. 1 - The new Flosonics 930 nozzle spraying No. 6 fuel oil

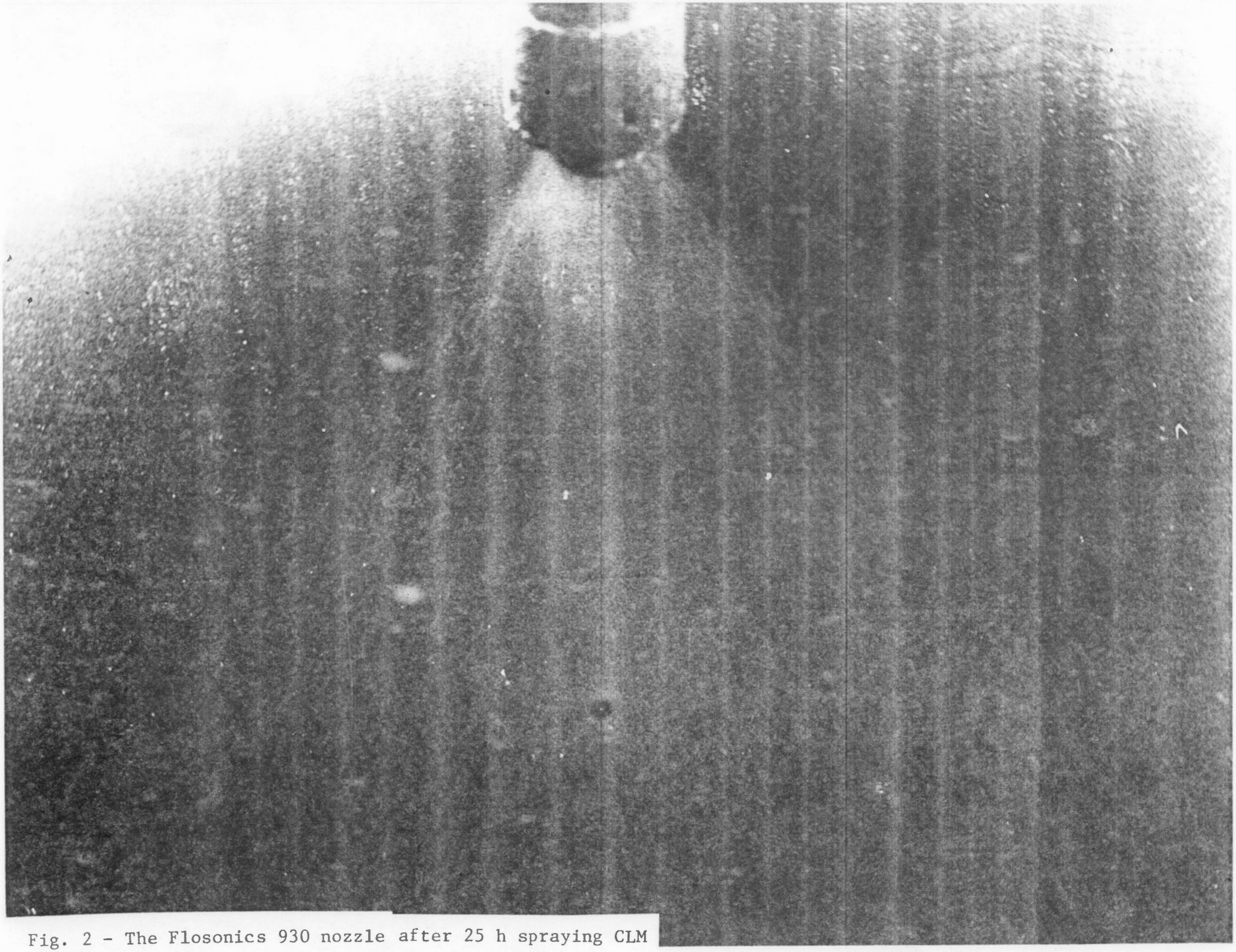

Fig. 2 - The Flosonics 930 nozzle after 25 h spraying CLM

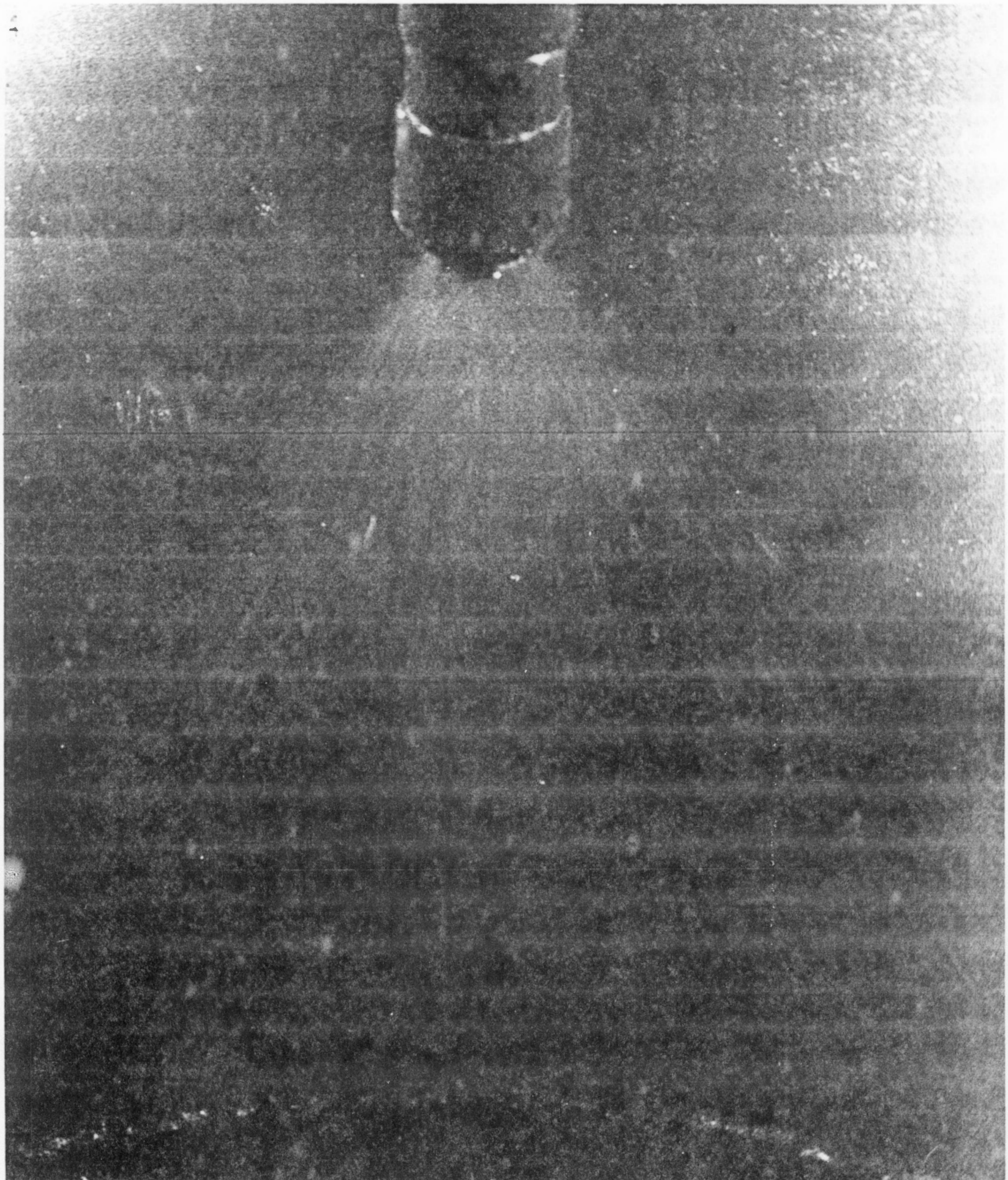

Fig. 3 - The Flosonics 930 nozzle after 100 h spraying CLM

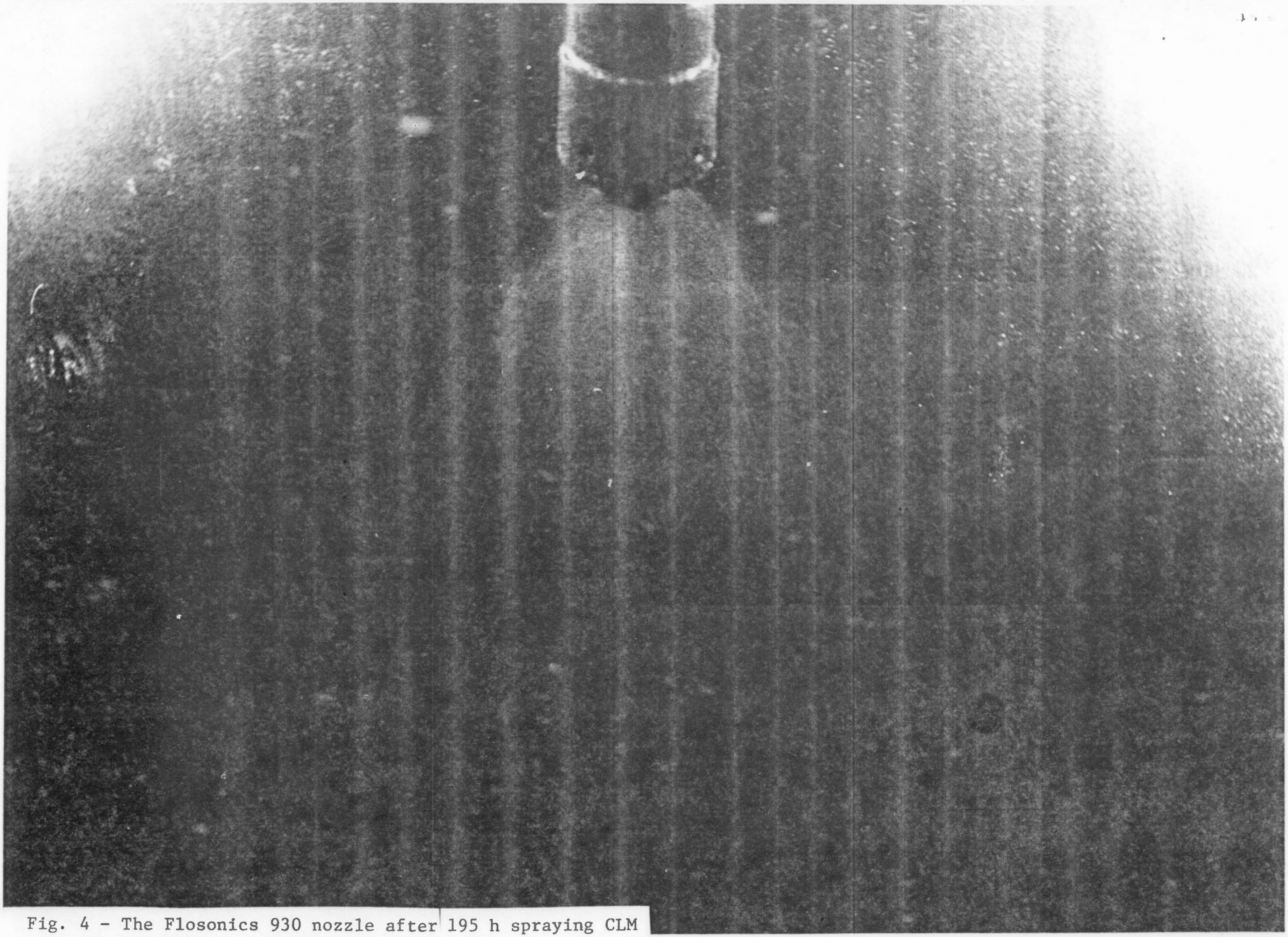

Fig. 4 - The Flosonics 930 nozzle after 195 h spraying CLM