A STUDY OF SOME CHARACTERISTICS OF SUGAR DUST.

A THESIS

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SUBMITTED BY

APPROVED BY

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I N D E X

<u>SUBJECT</u>:

The subject of this thesis is:

"A Study of Some Characteristics of Sugar Dust."

OBJECT:

The object of this thesis is to study the characteristics of sugar dust with a view to examining its settling properties and to determine whether or not the dust behaves as a mist.

INTRODUCTION:

The refining of raw sugar in the United States is carried on with a very small margin of profit. Each operation in the refinery must progress in such an efficient manner that losses are reduced to a minimum. Because of the continuous, year-round operation in cane sugar refineries, waste apparently insignificant over short periods of time may become an important factor in the reduction of profit for yearly operation.

In the refinery of The Revere Sugar Company, at Charlestown, Massachusetts, the refined sugar crystals from the vacuum pans are partially dried by centrifuging and are then sent through rotary granulators for further drying and breaking up of crystal agglomerates. The granulators are arranged in sets of two in series, the sets being in parallel. Each granulator is of cylindrical construction, steel shells, thirty-four feet long and seven feet in diameter, mounted on a shaft carrying a steam drum for heating and drying. Each granulator is inclined at an angle of about ten degrees with the horizontal and wet sugar, entering at the top of the granulator, i.e., the upper end of the slope, is picked up by fins on the inner surface of the shell and dropped from the fins as they pass the top of the orbit.

Sturtevant fans draw a current of warm air through the granulators, counter-current to the flow of sugar, removing dust and assisting in the drying. Due to the slope of the shells, the sugar passes slowly through the granulator, discharging at the low er end into bucket elevators which carry it to the dry sugar storage bins.

The air laden with dust passes through a dust collector in which a large number of baffles deflect the air current suddenly so that the large dust particles are thrown onto the baffle plates. Hammers, actuated by an exterior mechanism, strike the baffle plates periodically and the sugar adhering thereon drops into hoppers in the bottom where screw conveyors carry it to storage before remelting. This apparatus serves well to remove the large dust particles but has no effect on those particles that are so extremely small that they are deflected with the air because their mass is so small that the inertia is insufficient to throw them out of the air stream. Some entrapment is, of course, effected by the roughness of the surfaces, by mechanical entrainment by the larger particles, by settling from minute eddy currents adjacent to the surfaces, and, perhaps, by some electrical effect due to the friction of the dust laden air against the baffle plates.

The amount of the smallest particles removed in this way is, however, insignificant in comparison to the amount passing through the dust collector unaffected.

In series with and directly following the dust collector mentioned above, The Revere Sugar Company has recently installed a dust washer designed to remove the very small particles by passing the stream of dust-laden air through two screens of water or dilute sugar solution. Long, narrow, perforated trays are attached close to each other on an endless chain which makes two passes across the gas stream. Water or dilute sugar solution drips continuously from the perforations in the bottoms of the trays and forms a screen of liquid through which the dust-laden air must pass.

Before the above-mentioned washer was installed, a series of tests was run by the staff of The Revere Sugar Company to determine the loss of sugar dust from this dust recovery system. From October 18 to November 5, 1926, inclusive, nine tests gave an average loss of 46.1 pounds per hour of sugar lost as dust from the recovery system when sugar produced by the granulators averaged 35,000 pounds per hour. This is a percentage loss of only 0.1317%, but it is an actual loss of approximately $16,600 per year, assuming that there are three hundred working days in a year and that the price of sugar is five cents per pound, and neglecting the cost of packing the sugar lost.

The operation of the washer recently installed has undoubtedly improved these conditions, but the appearance of the exit gases makes it quite obvious that the loss is still very considerable and further improvement would be highly desirable.

At the outset of this investigation, it was thought that a scrutiny of the settling mechanism of sugar dust would be of more value than any other study. Acordingly, a search of the literature was conducted and pertinent works were abstracted. Subsequently, it developed that a more advantageous result would be the determination of whether or not sugar dust in air behaved as a mist and, if so, whether or not it followed tha action of sulfuric acid mists in such apparati as coke boxes, etc. Due to the change in plan, the settling abstracts have not been included but the references are noted in the bibliography.

PREVIOUS WORK:

On the behaviour of sugar dust other than in explosions, the literature is singularly silent. With regard to smokes and fogs, there is a better selection, but the only article found which is particularly relevant to the question at hand is one on mists by Harold C. Weber.[1]

"A mist or fog is made up of small particles of varying sizes. These particles may be either liquid or solid. One concept is that each individual particle is surrounded by an air film which effectively insulates it from its neighbors. According to this idea, then, any method of analysis to be effective must present some means of breaking through this air film. It is possible, however, to explain practically all the peculiarities associated with mist analysis and absorption without assuming the existence of this air film. If we assume that the mist particles are so small that they do not settle out readily by gravity and that they are so large that their rate of diffusion is extremely small compared with the diffusion rate for gases, it is possible to see that extreme difficulty would be experienced in dissolving them."

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[1] "Quantitative Analysis of Mists and Fogs," H. C. Weber, J. Ind. Eng. Chem., 16, 1215, 1921.

Dusts, smokes, fogs and mists have often been successfully removed by using some form of a Cottrell electrical precipitator. This apparatus would not be acceptable in sugar dust operations because of the danger of explosion. The greatest care must be exercised in regard to this danger.

SUMMARY OF PROCEDURE:

By means of a rotary air pump, dust laden air was drawn from the duct leaving the dust collector, through a sampling tube into an experimental coke-tower. Meters measured the amount of air out of the coke-tower. Sugar dust removed was determined by correlation of analyses at the entrance and exit of the coke-tower.

RESULTS:

No results had been obtained at the conclusion of this investigation.

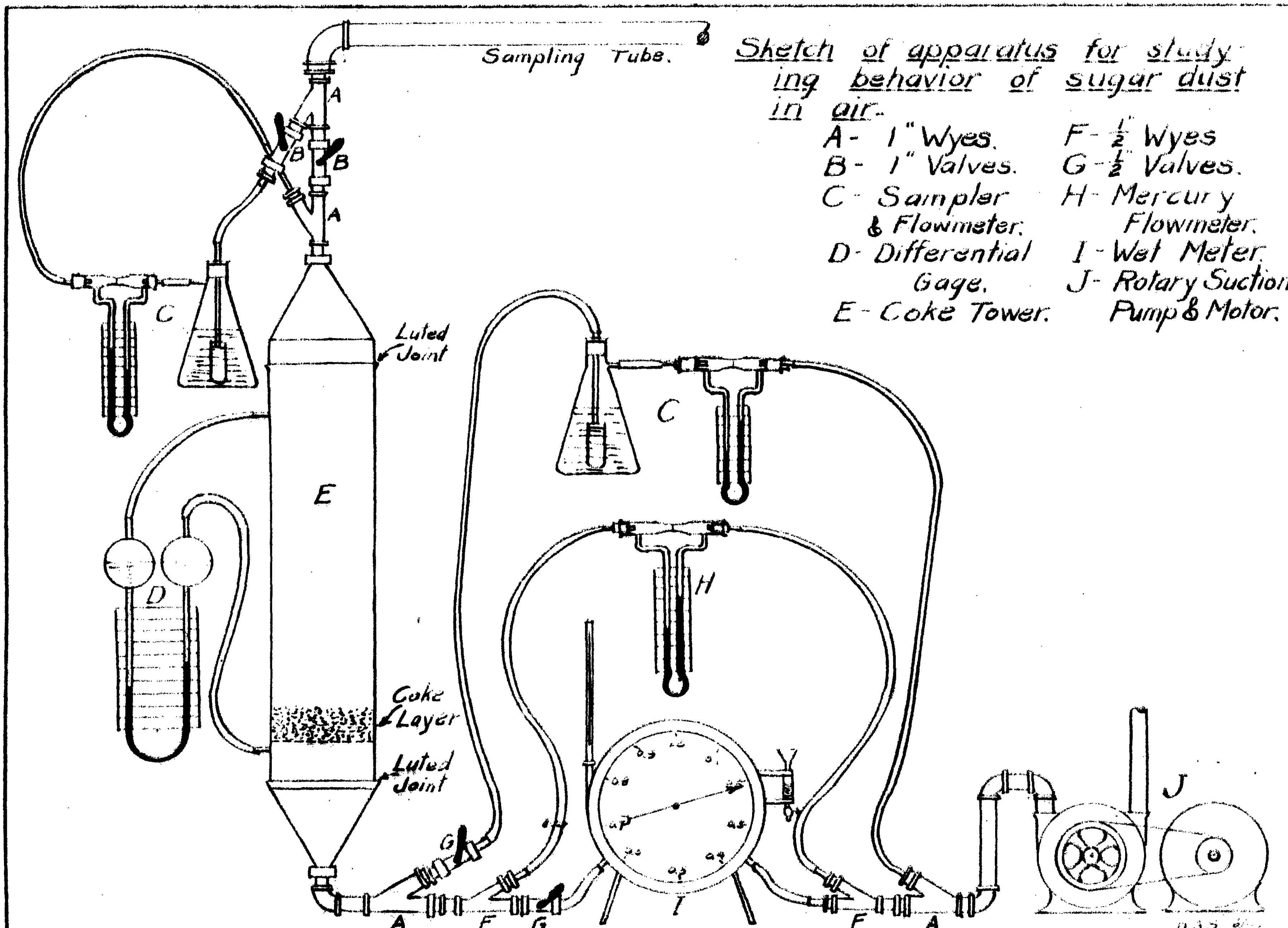
APPENDIX

METHOD OF PROCEDURE:

The sample pipe for the mist removal apparatus consisted of a two and one-half foot length of one and one-quarter inch cast iron pipe. A by-pass from the sampling line led to an alundum thimble absorption apparatus in series with a flow meter. The coke-tower itself was made up of a galvanized sheet iron tube six inches in diameter and four feet, eight inches long. Connections with the one inch pipe on either side of the coke box were made through special sheet iron reducing couplings. In the inlet coupling, a sheet iron cone was placed so that the entering gas was forced to pass through an annular space between the cone and the coupling, thus preventing difficulties which might result from channeling of the gas and insuring good distribution of the gas over the cross section of the tower. Four inches above the bottom of the tower, a screen was set on supporting rods and a coke layer of a desired thickness was placed on the screen. In this investigation, two inches of three to four mesh coke were used. Connections for a manometer above and below the coke layer were built into the tower so that the pressure drop through the coke might be easily obtained. After the coke-tower, the gas line splits into three branches, each supplied with a valve. One line led through a wet meter for measuring the slower rates of flow. The second line led through a mercury flow-meter for measuring high rates of gas flow. And the third line led through an alundum thimble absorption apparatus in series with a flow-meter for sampling the gas leaving the coke-tower. The three lines then converged into a single pipe which was connected to the rotary air pump whence the gas was exhausted to the atmosphere. A sketch of this apparatus appears on page 13.

With the arrangement just described, it was planned to investigate the effects of two variables; (1.) Velocity of dust-laden gas through the coke layer; and (2.) Thickness of the coke layer.

An opening to the air near the blower was provided with a valve so that variable amounts of air might be bled into the pump, thus varying the flow through the remainder of the apparatus and allowing the gas flow through the coke-tower to be regulated throughout a range from zero to the maximum capacity of the pump. The capacity of the pump was such that a maximum velocity of forty feet


Sketch of apparatus for studying behavior of sugar dust in air.
A - 1" Wyes.
B - 1" Valves.
C - Sampler & Flowmeter.
D - Differential Gage.
E - Coke Tower.
F - 1/2" Wyes
G - 1/2" Valves.
H - Mercury Flowmeter.
I - Wet Meter.
J - Rotary Suction Pump & Motor.
Sampling Tube.
Luted Joint
Coke Layer
Luted Joint
A
B
C
D
E
F
G
H
I
J

per minute might be obtained through the coke-tower.

The thickness of the coke layer was determined by measuring the distance from the top of the cylindrical part of the tower to the top of the coke layer and subtracting this distance from the known distance to the screen on which the coke layer rested.

The sampling apparatus at the entrance and the exit to the tower is shown in detail in a sketch on the preceding page. The minute pores of the alundum thimble cause the gas to enter the water used as the absorbing liquid in the form of very small bubbles, thus minimizing the distance necessary for the sugar particles to diffuse through the air in order to reach the interface of the absorbing medium. In this manner, complete and very rapid absorption is obtained. This apparatus has been used successfully in the analysis of hydrochloric and nitric acid mists. The alundum thimble is one-half inch in diameter and approximately two inches long. Ordinary six-hundred cubic centimeter suction filter flasks were used to contain the absorbing liquid. The flow-meter, indicating the rate of flow of gas through the absorption apparatus, was placed after the absorber so that any density correct-

Mis-numbered page error - Pg. 15 does not exist.

ion for the sugar dust would be obviated. The volume of the sugar dust was neglected in the determination of the volume flowing.

After an appropriate volume of the dust laden air had flowed through the sampling apparatus, the sample was to be analyzed by determining the amount of sugar absorbed in the distilled water with a Brix hydrometer, which would give values correct to one tenth of one percent of sugar. The hydrometer determination was to be checked frequently by a determination with an immersion refractometer.

With an analysis giving the sugar content of the air entering and leaving the apparatus, the amount of sugar dust taken out of the air by the layer of coke would have been calculated

The two flow-meters on the sampling apparati and the mercury flow-meter in parallel with the wet meter were calibrated by connecting them in series with the wet meter and drawing air through them. This gave satisfactory calibrations for the water flow-meters but the mercury flow-meter was further calibrated by connecting the water flow-meters and the wet meter in parallel and then connecting this arrangement in series with the mercury flow-meter to give a calibration for it at higher velocities.

DISCUSSION OF EXPERIMENTATION:

In spite of the care taken in the preparation for an investigation of this nature, unforeseen difficulties usually arise. The enumeration of these difficulties and a brief discussion with reference to them may be of service to future investigators in this field.

The sampling and analysis of the stream flowing through the apparatus was unsatisfactory. During a run, vigorous bubbling through the alundum absorption thimbles in the sampling apparati was obvious but subsequent examination in an immersion refractometer gave no indication of the presence of sugar. This was followed by the familiar alpha-naphthol test for sugar and gave a negative result. The latter test will show sugar present if there are as many as one hundred parts in a million by weight. The failure to obtain any trace of sugar during the absorption suggested possible channelling of the gas stream through the pipes and connections leading to the coke box. The pipes and fittings were accordingly dismantled and, without exception, showed traces of sugar adhering to the walls. Furthermore, the coke layer in the coke tower was covered with sugar dust. These facts were regarded as conclusive in indicating that channelling was not sufficient to prevent drawing some sugar dust through the sampling apparatus. The cause for this apparent anomaly was not determined.

Although the sampling tube used to draw the dust-laden air into the experimental apparatus was as short as possible under the conditions, considerable sugar dust lodged on the inner surface of the tube and never reached the experimental apparatus. This was not important in this investigation because it was not necessary to obtain a representative sample of the air in the duct. The difficulty would, however, have assumed more importance if a plant test had been run.

D A T A

Flowmeter Calibration:

Flowmeter	Reading ("H_2O)	Volume flowing (cu.ft.)	Time (min.)	Rate (cu.ft./min.)
Entrance Sampler	1.2	0.880	4	0.220
	2.2	1.560	5	0.312
	4.2	2.155	5	0.431
	6.2	2.610	5	0.522
Exit Sampler	0.4	0.275	1	0.275
	1.4	1.110	2	0.505
	2.4	2.220	3	0.740
	3.4	4.530	5	0.906
	4.4	4.955	5	0.991
	7.4	8.640	8	1.080

BIBLIOGRAPHY FOR SUGAR DUST INVESTIGATION

The Industrial Treatment of Fumes and Dusty Gases,

by W. E. Gibbs, D. SC.

J. SOC. CHEM. IND. 41, 189T-196T(1922)

Has a good theoretical treatment of the forces acting on settling particles from a mathematical point of view.

A Jet Dust Counting Apparatus,

by J. S. Owens, M.D.

JOUR.IND.HYGIENE 4, 522-534(1922-23)

A discussion of prevailing methods for counting and measuring dust particles and a description of the construction and operation of the author's apparatus for those determinations.

A Method of Determining the Size of Particles in Smokes,

by R. W. Gray & J. B. Speakman.

PROC. ROY. SOC. of LONDON

102A, 615 et seq.(1923)

A discussion of the authors' method for determining the number, size and average

mass of minute dust partécles in air. The method necessitates the use of a micro-balance and requires a highly developed technique.

(Many other articles under "Dust," "Smoke," and"Powder" in the library at the Massachusetts Institute of Technology were found irrelevant as far as sugar dust is concerned.)