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had any real benefits. The main factor during granulation was free circulation of the mother liquor, so that there were no variations in the solubility relationship throughout the liquor.

Mr. Springer agreed with Mr. Davies that it depended largely on the pan, but he had been able to reduce the time of graining from about 15 minutes to about 7 minutes by shock. This would probably not be the case with high purity syrups and was definitely not the case with refinery liquors.

Mr. Floro asked what was the disadvantage of twinning.

Mr. J. G. Davies then stated that there were no particular disadvantages in twinning. In the manufacture of some sugars it was highly desirable, although they were at present discussing raw sugar. He thought that twinning was the primary stage of conglomeration.

The Chairman then thanked Mr. Davies for his paper.

DUNDER DISPOSAL.

OPEN DISCUSSION.

(Mr. H. C. Nurse in the Chair.)

The President then said that the next item on the Agenda was an open discussion on Dunder Disposal. He thought this a very important subject at this time due to the exigencies of the law recently passed to control the discharging of effluents into streams.

He asked Mr. Nurse to take the chair and Mr. Stretton to open the discussion with a report on some experiments which he had done on the subject at the Sugar Research Office.

Mr. Stretton then gave the following report:—

The experiments described were designed to show the extent to which oxidisable material could be removed from dunder by the action of clarifying precipitants and adsorbents, and to investigate the possibility of producing from it in this way an innocuous liquid which could be discharged into irrigation or river water. They did not represent a complete investigation of the question. They were, frankly, only a preliminary exploration and, as such, would not be described in detail except that it was suggested that an account of them would be suitable as an introduction to this discussion of the problem of dundar disposal.

At the time when this work was done, fresh dunder was not obtainable. The material used came from the pond at Bernard Lodge factory. It was a sour and foul-smelling liquid which had undergone partial decomposition in the pond. It was more dilute than when discharged from the still, as is shown by the following analytical figures:—

Density	4.0° Brix
Total Solids	3.26%
Ash	1.106%
Organic Matter	2.15%
Total Acidity	1.43% as Acetic Acid
Volatile Acidity	0.52% " " "
Fehling's reduction	0.187% as invert sugar
pH	4.1
Oxygen Absorbed from Acid KMnO4	4515 Mg. of oxygen per litre.

I. The first step was to try the effect on this material of some of the common clarifying precipitants. An aqueous solution of the substance to be tested was added to dunder and the mixture left until the precipitate had settled. It was then filtered and the filtrate examined. It was not possible, nor was it thought necessary, to determine quantitatively the oxygen demand of the filtrate in every case. Such properties as colour, odour and acidity gave a qualitative indication of the result achieved.

The following substances produced flocculent precipitates:—

(1) The salts of heavy metals, such as copper sulphate, lead acetate, barium chloride, mercuric chloride and zinc sulphate.
(2) Alcohol and acetone.
(3) Alum and aluminium sulphate.
(4) Ammonium sulphate, when added in sufficient concentration.
(5) Tannic acid.
(6) Alkalis:

NH_4OH and NaOH produced a loose floc.

KOH and Na_2CO_3 gave a fine floc which did not settle as readily as the above. Lime water formed a light brown sludge and the supernatant liquid was lighter in colour than in the other cases.

With limestone, slight effervescence was observed, but the reaction was very slow. A volume of dunder was repeatedly poured through a tube packed with fragments of limestone. The liquid darkened and increased in viscosity after continuous treatment. It was not neutralised, nor was a precipitate produced which could be removed by filtration or sedimentation.

Mineral acids produced no precipitation. Common salt was also without effect.

Sodium aluminate can exist in solution only in the presence of alkali. In the presence of acid, the following reaction takes place:—

$$NaAlO_2 + 2H_2O = Al(OH)_3 + NaOH.$$

It therefore seemed worth while to try its effect on dunder which is an acid material. For besides giving a gelatinous precipitate of alumina, the adsorbent and clarifying powers of which are well known, free alkali would be produced, and it was hoped to remove in this way both the acidity and also much of the oxygen absorbing material present.

A portion of dunder was treated with the chemical until it was just alkaline to litmus. It was then filtered and the oxygen demand of the filtrate determined, with the following results:—

	Oxygen absorbed from acid $KMnO_4$
Original dunder	5440 *Mg.* of oxygen per litre
Filtrate	3270 " " " "

Thus, a reduction of 2170 Mg. oxygen per litre resulted. Nevertheless, the filtrate still had a high oxygen demand. The cost of the reagent and the large quantity necessary to neutralize the dunder, made it unsuitable as a practical means of clarification.

From the economic standpoint, one of the few chemicals not prohibitively expensive is lime. Further experiments were therefore carried out with it to learn the optimum conditions of lime flocculation. It was found that in order to get rapid flocculation with good settling of the precipitate, sufficient lime had to be added to raise the pH to 9.

The oxygen demand of the supernatant liquid was determined:—

	Oxygen absorbed from acid $KMnO_4$
Original dunder	5320 Mg. of oxygen per litre
Supernatant liquid	1540 " " " " "

a reduction of 3780 Mg. of oxygen per litre.

The quantity of lime required for this treatment amounted to about 1 lb. per 10 gallons of dunder.

The effect of hot liming was not very different from the above.

II. Clarification by adsorption was attempted, the substances used including Kieselguhr, Fuller's earth, charcoal, calcium aluminosilicate and bauxite. The sample, after treatment with the absorbent, was filtered and the filtrate examined.

Kieselguhr gave a clear, dark-coloured filtrate, not odourless. Fuller's earth gave a filtrate lighter in colour. Charcoal seemed to have very little effect on raw dunder either in the cold or on heating. Calcium aluminosilicate (brick dust) produced a clear, light coloured filtrate which, however, retained much of its original odour. A further trial was made of this substance on a larger scale: a 4 ft. tube was packed with fragments of brick and a quantity of the dunder was passed upwards through the tube repeatedly. Under these conditions, very little clarification took place. Raw bauxite caused some lightening in the colour of dunder. It had a greater effect when activated by heating at 600°C for 1 hour.

The 4 ft. tube mentioned above was packed with activated bauxite and dunder was passed upwards through it as before. This produced very little result, which seemed to indicate that a large proportion of this adsorbent was needed to cause appreciable clarification. A sample of dunder was shaken with activated bauxite, filtered and the filtrate again shaken with fresh bauxite, this process being again repeated. Each filtrate was clearer than the one before.

Dunder was mixed with about one quarter of its weight of activated bauxite in a stoppered bottle and shaken intermittently for three days. It was then filtered and the oxygen demand of the filtrate determined:—

	Oxygen absorbed from acid $KMnO_4$
Original dunder	5440 Mg. of oxygen per litre
Filtrate	3285 " " " " "

III. Finally, the combined effects of chemical precipitation and adsorption were used, the dunder being first flocculated chemically and the filtrate from this being treated with the adsorbent.

Various combinations of the chemicals and adsorbents described above were tried. The three most important from the practical and economic point of view seemed to be lime, bauxite and charcoal. Results obtained with these were not inferior to those obtained with other agents.

In one experiment, dunder was limed to flocculation and filtered. The filtrate was treated with bauxite and again filtered. This filtrate was stood overnight with charcoal and filtered once more. The oxygen demand of the liquid was determined at each stage with the following results:—

	Oxygen absorbed from acid $KMnO_4$
Original dunder	5320 Mg. of oxygen per litre
Filtrate from liming	1540 " " " " "
" " bauxite	1250 " " " " "
" " charcoal	390 " " " " "

The final liquid was odourless and of a very pale yellow colour.

Thus, in the laboratory, a considerable clarification of dunder was achieved by the use of materials readily available in Jamaica, but it is to be doubted whether, on the factory scale, such means would prove a solution to the problem because of the large volume of dunder produced throughout the Island each crop.

The Chairman then stated that ordinary furnace ash was easily obtainable in the industry, and wondered whether it would work as well as charcoal.

Mr. Munro said that he had conducted some experiments in the laboratory at Bernard Lodge and during them had used a mixture of ashes and white lime. The result of treating dunder in that manner was a liquid of about 500 B.O.D. Mr. Stretton told us that a large quantity of lime was required. It was therefore going to be an extremely expensive operation no matter what chemical was used. He personally did not think that chemical treatment was the solution to the problem.

Mr. J. G. Davies said that at the Bernard Lodge dunder pond whenever the B.O.D., of the liquid decreased to about 600 B.O.D., mosquitoes started to breed. At about the same B.O.D., level he had observed that water fowl was attracted to the pond and nested there. These observations showed that at a B.O.D., level of about 600 the liquid was not disagreeable to those forms of animal life.

Mr. Innes thought there were three possible ways of disposing of dunder which might eventually prove economic. They were dilution, fermentation and some system of dunder fallowing. By the latter he meant the giving up of an area of sugar-cane land in rotation upon which to distribute the dunder at rates determined by the infiltration capacity of the soil. Such land during its dunder fallow might have to be cultivated at intervals. It was quite likely that on alkaline land such treatment might be of great benefit. In any case, the manurial value of dunder so applied, would be considerable. The possibility seemed worthy of actual field investigation. If dunder could be discharged into irrigation water especially where irrigation waters were highly charged with lime or the soils themselves were alkaline, this would appear to be the easiest and best way of disposing of dunder and here again, it seemed desirable to undertake the necessary field investigation without further delay. He believed that any chemical treatment would be commercially impossible because of the enormous cost of the chemicals and the possible, secondary problem, of disposing of the end products.

Mr. J. G. Davies then stated that with regard to Mr. Innes' three methods he thought that controlled dilution would eventually be the answer to the problem. By controlled dilution he meant a system whereby dunder was added to a stream or river under controlled conditions. This entailed observation of the rate of flow of water in the river. The amount of dunder added had to be regulated so that the oxygen content of the water was not reduced to too low a level. The fermentation method had been under extensive investigation at Bernard Lodge now for three years. The results had been communicated to the Association from time to time. No successful treatment had been evolved. At Caymanas recently, they had disposed of their dunder by pumping it on a large area of land. He did not remember the exact acreage but it was something of the order of 100 acres. This again was an expensive method as there were not many factories in the island which could afford to use such large areas of their land for the sole purpose of dunder disposal. Although he had been experimenting on dunder disposal for the past three years, he did not know of any solution which was technically feasible and which would fit in with the present law.

Mr. Munro said that Government was not proving itself very co-operative in the matter. In fact, so far they had not even communicated to the industry

the chemical standards required for a factory effluent. The only information that could be got from Government was that the effluent should not kill any fish.

Mr. Stretton then stated that the most disconcerting part of the dunder disposal problem was the enormous quantity of effluent which was produced each year. He did not know the exact figures but had no doubt that Mr. Innes' suggestion of putting it on the land and letting nature take its course was not a bad one. Under the conditions, the processes of nature would eventually produce an innocuous liquid. But from the commercial point of view, what was needed was a process which would work at a reasonable rate. No process as far as he knew was able to turn dunder into pure water in a few days.

Mr. Springer said that at Monymusk some experiments had been attempted by the Research Department by running dunder into irrigation water. The irrigation flowed at the rate of 250 cubic yards per hour. Dunder was added at three different rates, 300 gallons, 1800 gallons and 3300 gallons per 24 hours. It was found that the 300 and 1800 gallon rates had no harmful effect on the cane but it was damaged to some extent by the 3300 gallon rate. The cane not damaged by the 300 and 1800 gallon rates had a better appearance than cane on adjoining land which had been irrigated with water containing no dunder. It was unfortunate that Mr. Thompson was not present to give further details, as his department had attended to the field part of the work.

The Chairman asked if Mr. Springer had any figures on juice purities.

Mr. Springer replied that the plots would be reaped in 1947 and figures would then be available. He added that the dunder was mostly fresh from the stills and at the point of mixing the mean temperature of dunder and irrigation water was about 125°F.

Mr. Floro commented on Mr. Stretton's experiments with chemical methods combined with adsorbents, and thought it possible that a subsidiary problem would arise in disposing of the removed substances. This would probably have an unpleasant smell which would be a worse nuisance than the original dunder.

The Chairman then thanked Mr. Stretton for leading the discussion by describing the experiments and thought that everyone would agree that it had been extremely interesting. The second part of the discussion would be on Imperial College Circular No. 55 by Yearwood and Fitzwilliam. In the circular it was proposed that dunder should be disposed of by evaporation in flue gases. He then asked Mr. J. G. Davies to introduce the subject.

Mr. J. G. Davies then stated that the proposed method of disposal to his mind was more a problem for the engineers than for the chemists. It involved pumping the dunder through a nozzle in the base of the chimney and recirculating the liquid until a sufficiently high concentration was obtained. The concentrated liquid was then disposed of. The first thing that struck his mind after reading the circular was that it did not contain any actual experimental results. It was just an idea which the authors introduced, and their opinion as to whether or not it would work was based upon a series of calculations. It therefore required practical proof and to do this it was necessary to install a complete plant. This entailed a preliminary estimate of the size of the nozzle, capacity of pump and so on. He therefore suggested that the Chairman ask the engineers to continue the discussion.

The Chairman said that the circular had been considered at the British Guiana Conference and the opinion there was that it would lead to corrosion in the chimneys.

Mr. Munro replied that a full scale plant would have to be erected at some factory willing to take the risk. There was no other way in which it could be done. The first requirement was that the factory should be equipped with forced or induced draught.

The Chairman said that while he did not wish to condemn the work of Mr. Yearwood, he thought the risk entailed in installing an experimental plant would be a very great one.

Mr. Munro suggested that a full scale experimental plant would first require proper financial support. It was going to be an expensive experiment.

Mr. Floro said that if dunder could be concentrated successfully he thought that the subsequent problem on disposal could be easily managed.

Mr. Innes mentioned that the author had suggested mixing the concentrated material with bagasse and thought that this would lead to some difficulty in the furnace due to the formation of large quantities of easily fusible ash.

Mr. Munro said that he had now come to the stage where he would try anything in order to get rid of this dunder problem. It was the most serious thing that faced the industry. If we could get the necessary financial backing for an experimental plant, he thought we should go ahead and try it.

The Chairman asked whether he would be prepared to ask his Principals for the available funds.

Mr. Munro thought it was a question for the entire S.M.A. One factory should not be expected to undertake the experiment. The whole industry should do it.

Mr. J. G. Davies said that if financial support was forthcoming, then they should invite Messrs. Yearwood and Fitzwilliam to Jamaica to undertake the experiment. It was their idea, and so far they had produced no experimental results. If the experiment succeeded they should get the kudos. If the experiment failed they should be here to see why it failed.

Mr. Munro suggested that the matter be taken up by the B.W.I.S.A., because it affected the whole West Indies. It might be possible for Messrs. Yearwood and Fitzwilliam to arrange to conduct an experiment in Trinidad.

Hon. A. S. Campbell said that since the matter was one of such great importance, he would suggest that a small Committee of Engineers be formed to go into the matter of costs etc.

The Chairman then informed the Meeting that a Committee of Engineers of the Association had already been formed to consider this method of dunder disposal.

Mr. Munro stated that the risk in conducting the experiment was the difficulty in maintaining proper furnace conditions and the factories would then have to shut down. This was not pleasant during crop.

The Chairman in summing up the discussion said it was agreed that should funds be provided for conducting the experiment, that Messrs. Yearwood and Fitzwilliam be invited to carry out the work. The meeting agreed.

Mr. Munro then assumed the chair, thanked the author and members for the parts they had played in the discussion, and adjourned the meeting.