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A de-dusting device for removing fines from pellets, granules and coarser powders

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ABSTRACT

Customers buying materials in granular form dislike the fact that the delivered materials contain any dust, which can lead to poor product quality, a poor working environment, or even to handling hazards. In granular filters the filter media can be re-used several times if the accumulated dust can continuously be removed outside the filter.

The results of both de-dusting LDPE pellets, and of an artificially made contaminated sand, using a device designed and developed at the Telemark Technological R&D Centre, show that the device performs efficiently in both cases, although further development is still necessary.

***Key words** : De-dusting device, Pellets, Granules, Fines removal, Coarser powders.*

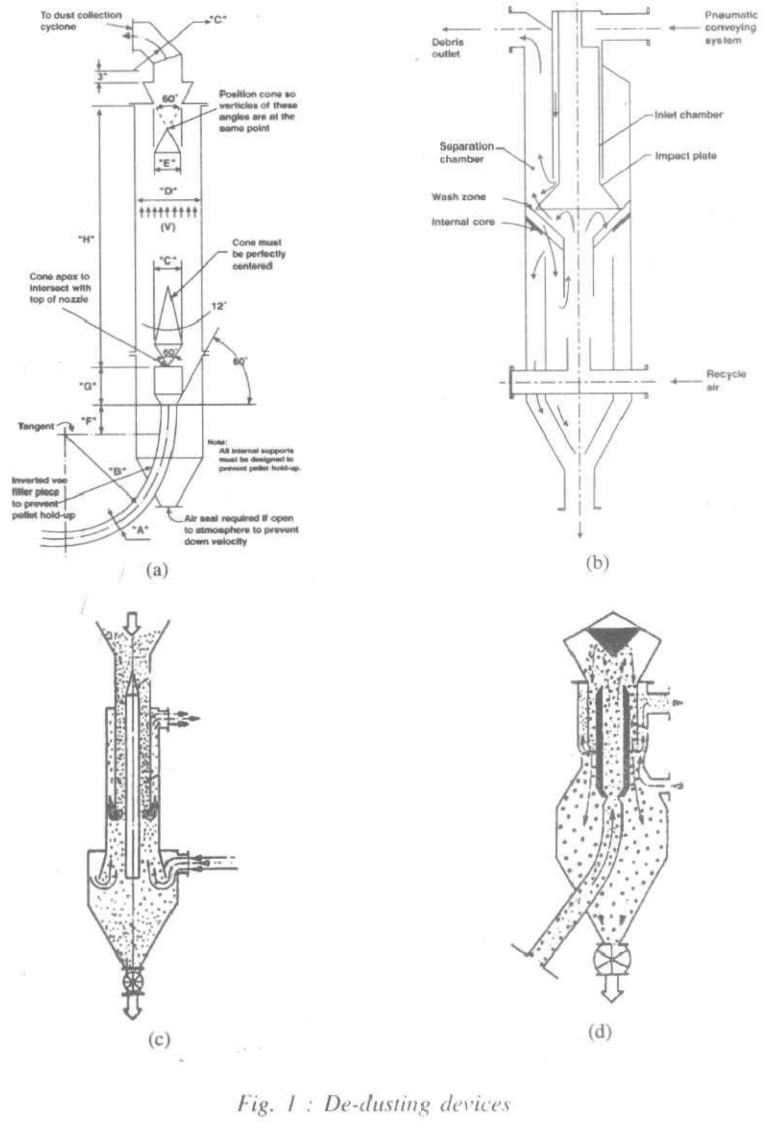
INTRODUCTION

Pellets (e.g. polyethene), granules (e.g. fertilizer) and coarser particulate materials (e.g.explosives, media from granular filters, sand used in castings etc.), often contain a small dust (sub 50-100 μm) fraction, which is undesired. In many cases, customers require the levels of such dust or fibers to be reduced to levels well below 0.5% (in the case of polyethene pellets the level desired is 50 ppm!). While the methods of production and handling can be optimised to prevent the production of such dust, this approach is not always feasible. A number of devices have thus been developed for removing what one may call "fugitive" dust from such products. Some of these are shown in Fig. 1.

As can be seen from the figure, the current devices are fairly complex in construction and not always as efficient as one could wish.

During our work on air classification, POSTEC (the Department of Powder Science and Technology at Telemark University College/Tel-Tek) developed a device for the enhancement of the efficiency of separation. The idea behind the device was that the coarse fraction from the classifier, before leaving it, would be subject to the action of a series of high velocity jets of air. The device is shown in principle in Fig. 2.

During the tests, however, it was found that while the unit improved separation efficiency at coarser cuts (> 30 µm), it was not very effective at cuts below 10µm. The idea of using it as a de-duster was born!



(a) (b)

(c) (d)

Fig. 1 : De-dusting devices

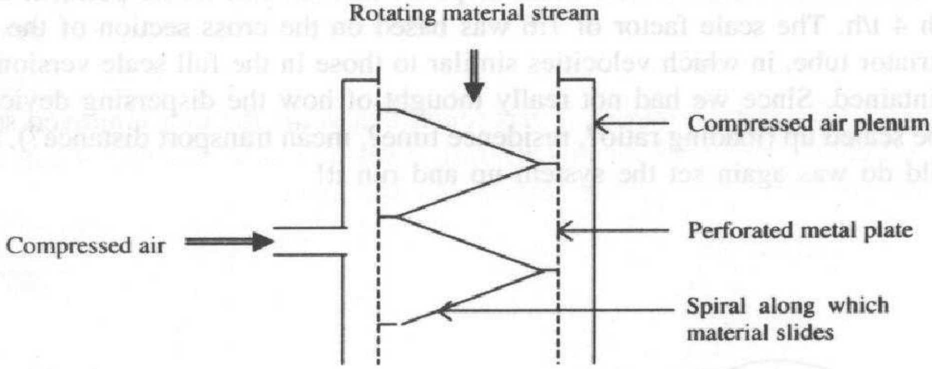


Fig. 2 : Device for the enhancement of classifier efficiency developed by POSTEC

THE DE-DUSTER AS A SYSTEM

Enhancement of an Elutriator

The first application of the dispersion enhancer as a de-dusting system was undertaken for a local company manufacturing polyethene (LDPE) pellets. The pellets were transported after manufacture in a dilute phase pneumatic transport system, which caused them to produce some dust, and some streamers, popularly referred to as "angel hair". After transport, the material was fed into the elutriator shown in Fig. 1(a). The deduster was incorporated into the bottom of the elutriator as shown in Fig. 3[1]. Initial results were promising, but it proved difficult (using air jet sieving) to quantify the improvement obtained.

Ibbotson[2] developed an ingenious method of (at least qualitatively) estimating the improvements. He washed the pellets repeatedly until all dust and angel hair were removed. Then he added known quantities of dust to his clean pellets. Finally, he sieved the pellet/dust mixture onto a black paper, and took a series of photographs, which later served as calibration standards. These standards are shown in Fig. 4.

He then made several batches of pellets containing ca. 500 ppm of dust, and ran them through the system shown in Fig. 3 using 117 Nm^3/h of air in the transport line and 10 and 20 Nm^3/h air in the dispersing device. The transport rate was 650 kg/h, which gave a loading of about 4:1. His results are shown in Fig. 5.

As is normal in such cases, as soon as a result appears promising, the demands increase! Thus the 650 kg/h achieved were not acceptably high, and since the model we had built was a 1:6 scale model and the capacity required in full scale was 24 t/h, we were asked to prove that the unit would perform as well with 4 t/h. The scale factor of 1:6 was based on the cross section of the upper elutriator tube, in which velocities similar to those in the full scale version were maintained. Since we had not really thought of how the dispersing device was to be scaled up (loading ratio?, residence time?, mean transport distance?), all we could do was again set the system up and run it!

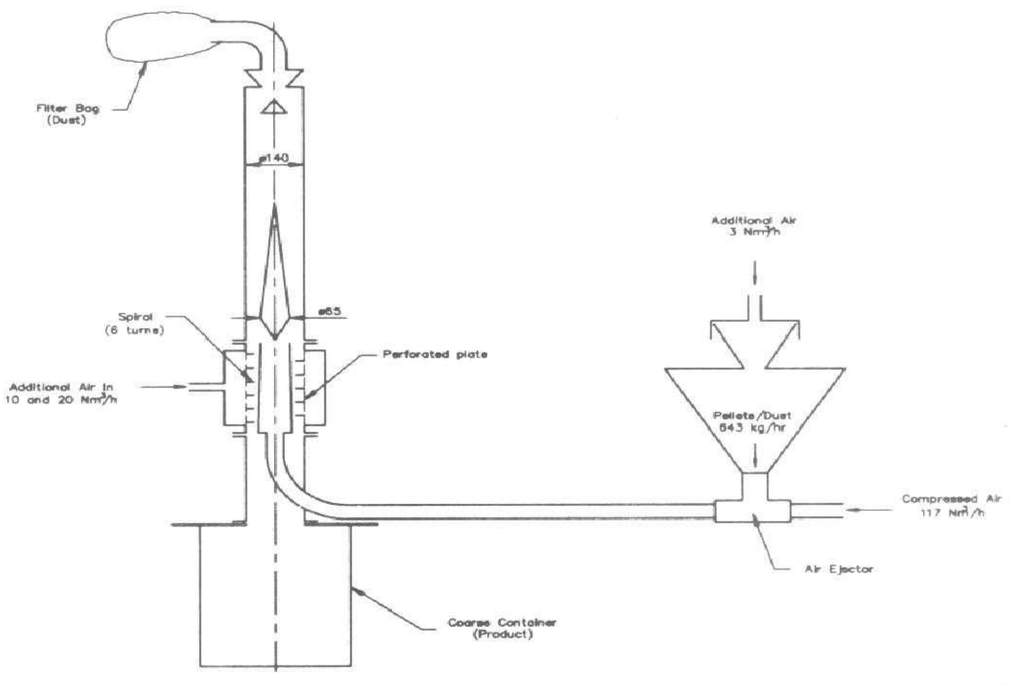


Fig 3 : Enhancement of the performance of an elutriator using POSTEC's de-dusting device

Since it was impossible to transport 5 t/h of pellets through the transport tube shown in Fig. 3, the set up shown in Fig. 6 was used for these tests[3].

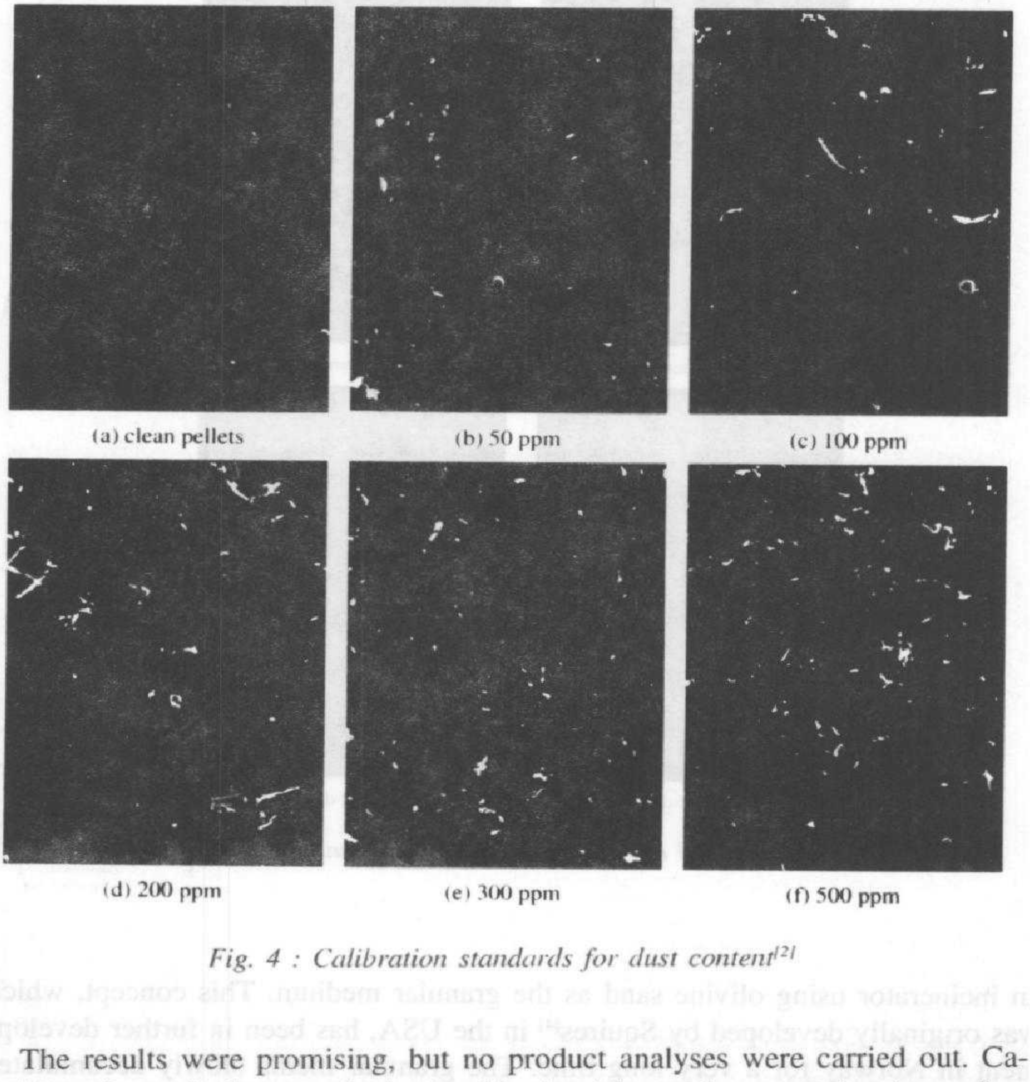
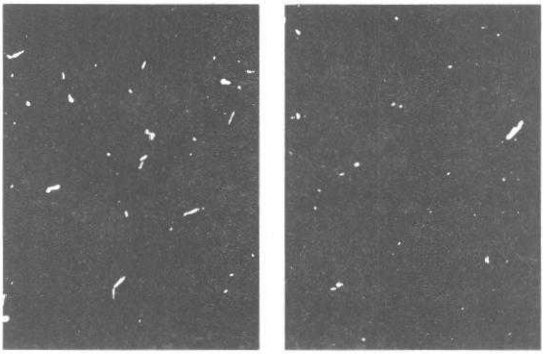

(a) clean pellets (b) 50 ppm (c) 100 ppm
(d) 200 ppm (e) 300 ppm (f) 500 ppm

Fig. 4 : Calibration standards for dust content[2]

The results were promising, but no product analyses were carried out. Capacities of upto 5 t/h were obtained, with visual inspection appearing to confirm adequate cleaning of the pellets. The air required for enhanced dispersion, however, increased to nearly 100 Nm^3/h and the pressure loss over the perforated plate increased from 0.05 to 0.5 bar.

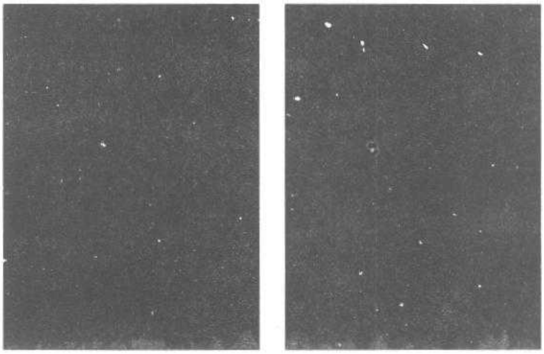
The De-Duster as a Stand-Alone System

In Section 2.1, the de-dusting unit was used to separate very fine particles and streamers from a relatively coarse (3-5 mm) product, and was used to enhance the performance of an existing elutriator. Our next challenge came from a company developing a panel (granular) filter for cleaning soot particles from



(a) Pellets after transport

(b) Pellets from elutriator



(c) 10 Nm^3/h of dispersing air

(d) 20 Nm^3/h of dispersing air

Fig. 5 : Effect of enhanced dispersion on the performance of a standard elutriator.

an incinerator using olivine sand as the granular medium. This concept, which was originally developed by Squires[4] in the USA, has been in further development in Norway for a very long time. The granular media slowly accumulates soot particles, and are then "pulsed" off a set of louvres on which they normally rest. The principle is shown in Fig. 7.

One naturally would like to re-use the media as long as it can be freed of the accumulated soot particles. In order to check how well it would work, a very simple de-duster set up was used in the tests at POSTEC, with contaminated sand simply being allowed to fall into the de-duster through a tube mounted over it. The other end of the tube led to a cyclone where the dust removed from the sand was collected.

A sketch of the system is shown in Fig. 8.

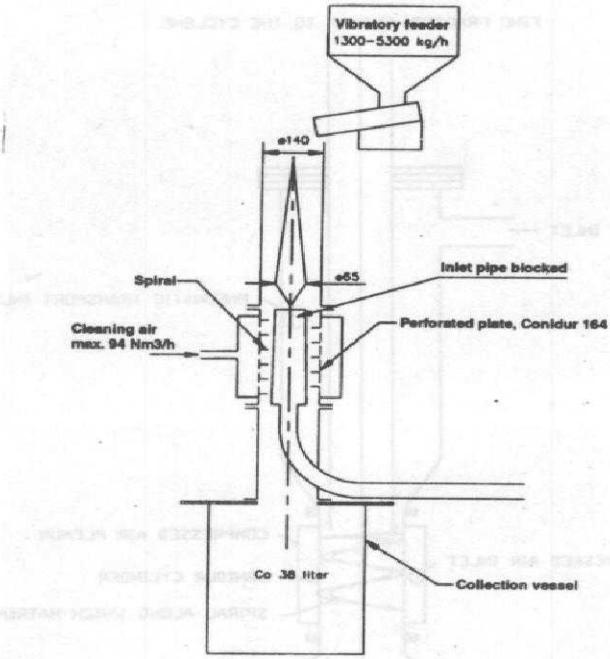


Fig. 6 : Set up used to test maximum capacity of enhanced dispersion device

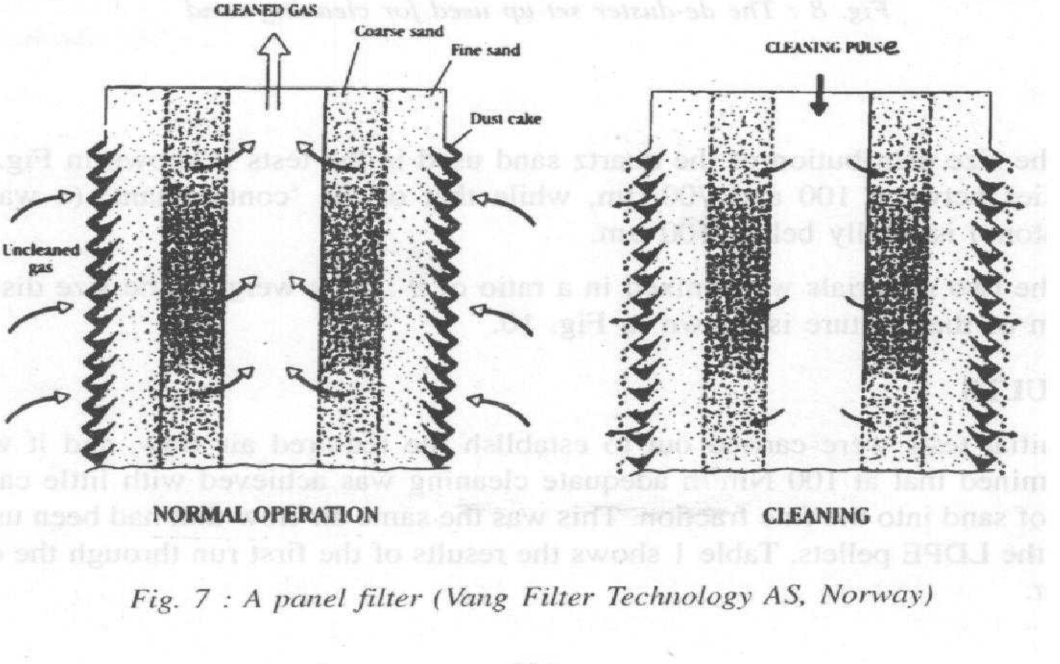


Fig. 7 : A panel filter (Vang Filter Technology AS, Norway)

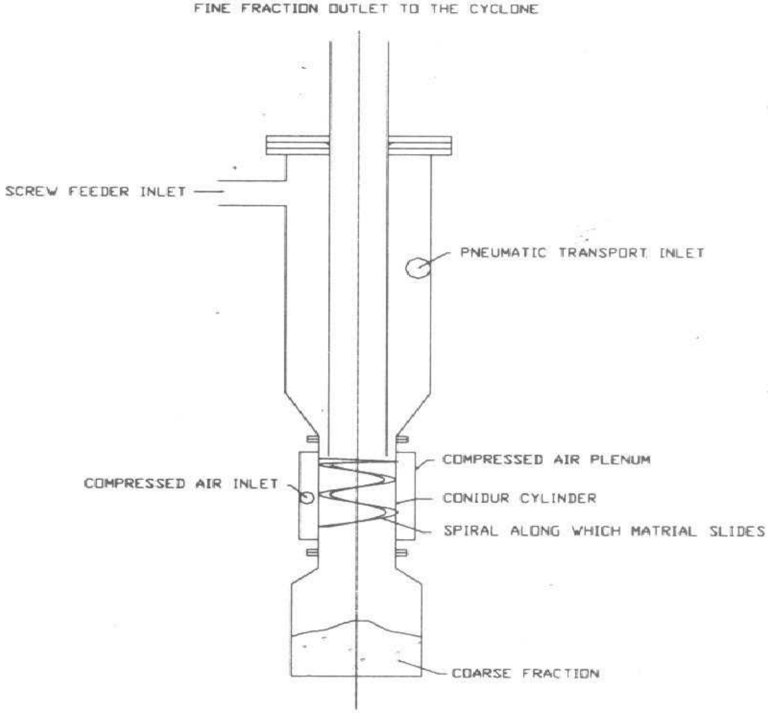


Fig. 8 : The de-duster set up used for cleaning sand

The size distribution of the quartz sand used in the tests is shown in Fig. 9, and lies between 100 and 700 μm, while that of the 'contaminant' (a waste limestone) is totally below 100 μm.

The two materials were mixed in a ratio of 9 : 1 by weight. The size distribution of the mixture is shown in Fig. 10.

RESULTS

Initial tests were carried out to establish the required air flow, and it was determined that at 100 Nm^3/h adequate cleaning was achieved with little carry over of sand into the fine fraction. This was the same air flow that had been used with the LDPE pellets. Table 1 shows the results of the first run through the de-duster.

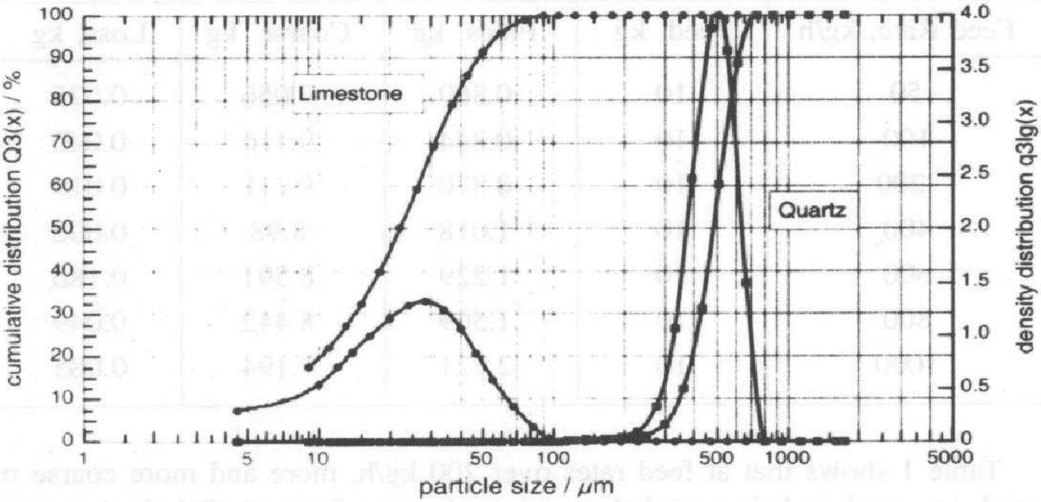


Fig. 9 : Size distributions of quartz sand and limestone used in the tests

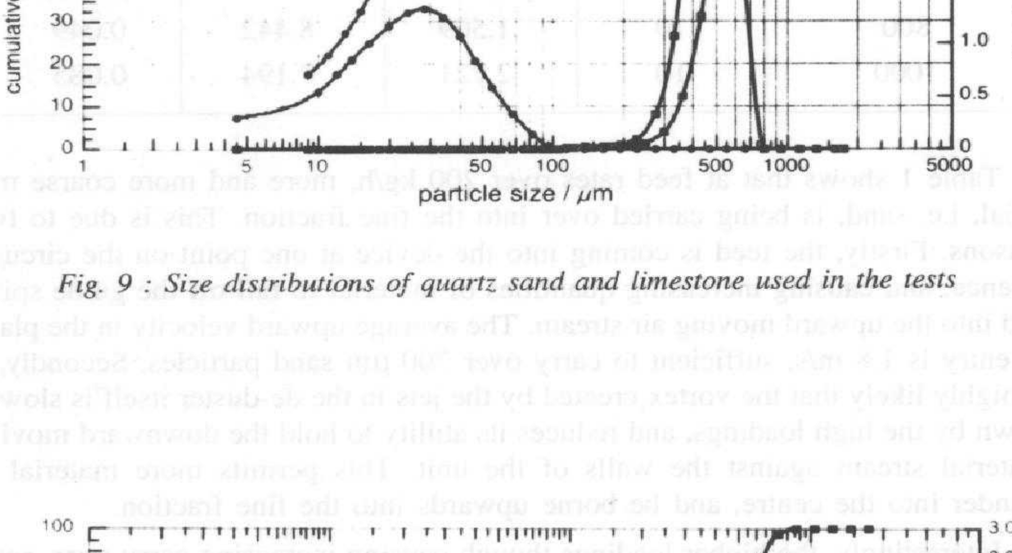


Fig. 10 : Size distribution of the quartz sand/limestone mixture used in the tests

Table 1 : Results of de-dusting a mixture of quartz sand (90%) and limestone (10%). Air flow 100 Nm³/h.

Feed Rate, kg/h	Feed, kg	Fines, kg	Coarse, kg	Loss, kg
50	10	0.869	9.056	0.075
100	10	0.844	9.116	0.040
200	10	0.870	9.111	0.019
400	10	1.018	8.98	0.002
600	10	1.229	8.591	0.180
800	10	1.509	8.442	0.049
1000	10	2.721	7.194	0.085

Table 1 shows that at feed rates over 200 kg/h, more and more coarse material, i.e. sand, is being carried over into the fine fraction. This is due to two reasons. Firstly, the feed is coming into the device at one point on the circumference, and causing increasing quantities of material to fall off the guide spiral and into the upward moving air stream. The average upward velocity in the plane of entry is 1.8 m/s, sufficient to carry over 700 μm sand particles. Secondly, it is highly likely that the vortex created by the jets in the de-duster itself is slowed down by the high loadings, and reduces its ability to hold the downward moving material stream against the walls of the unit. This permits more material to wander into the centre, and be borne upwards into the fine fraction.

Interestingly, the higher loadings though causing increasing carry over, actually improve the cleaning ability. There is less and less dust in the coarse fraction with each increase in loading. This is not however incompatible with the conclusions drawn above and, indeed tend to support them! Fig. 11 (a) and (b) show the size analyses of the coarse fraction from the runs at 200 kg/h (a), and 1000 kg/h (b), while Figures 12 (a) and (b) show the corresponding size distributions of the fine fractions.

A close inspection of Figure 11(a) shows that the run at 200 kg/h still contains 3.17% by weight of material under 105μm, while the coarse fraction from the test at 1000 kg/h only contains 0.81%. In order to establish whether a second run would remove the remaining 'dust', all the coarse fractions from the tests in Table 1 were re-run at the same conditions as the first series of tests. The results are shown in Table 2.

The size distributions of the coarse fractions from these tests are shown for 200 and 1000 kg/h in Figs. 13(a) and (b), and those of the fine fractions in Figs. 14 (a) and (b).

Table 2 : Results of running the coarse fractions of the tests in Table 1 through the de-duster a second time

Feed rate kg/h	Feed kg	Fines kg	Fines %	Coarse kg	Coarse %	Loss kg	Loss %
50	8.759	0.406	4.64	8.342	95.24	0.011	0.12
100	8.898	0.330	3.71	8.566	96.27	0.002	0.02
200	8.829	0.258	2.92	8.563	96.99	0.008	0.09
400	8.686	0.252	2.90	8.432	97.08	0.002	0.02
600	8.394	0.399	4.75	7.995	95.25	0.000	0.00
800	7.531	0.459	6.09	7.036	93.43	0.036	0.48
1000	6.957	0.522	7.50	6.434	92.48	0.001	0.02

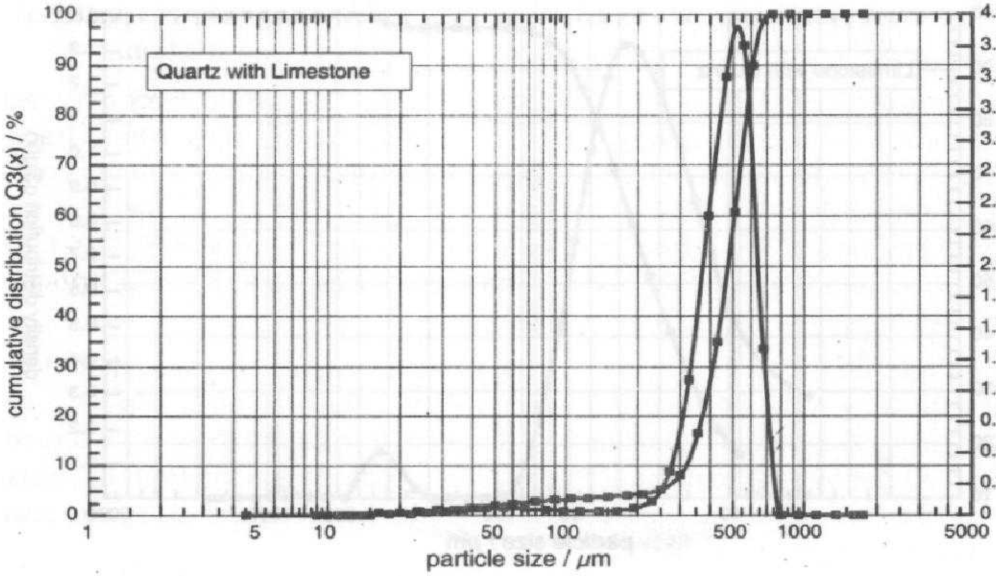


Fig. 11a : Size analysis of the coarse fraction from the test listed in Table 1 at 200 kg/h

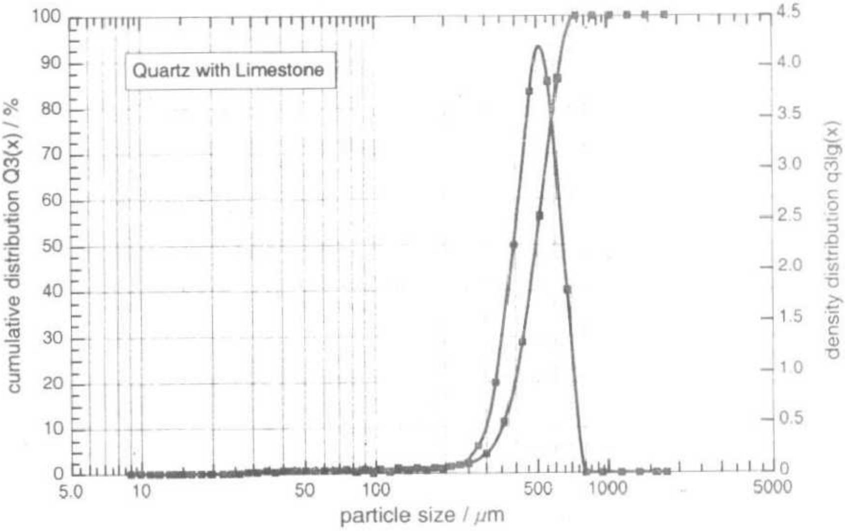


Fig. 11b : Size analysis of the course fraction from the test listed in Table 1 at 1000 kg/h

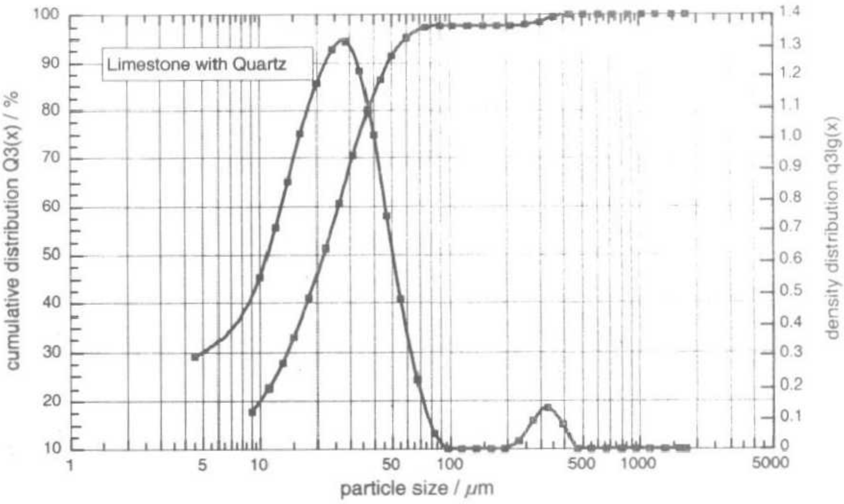


Fig. 12a : Size analysis of the fine fraction from the test listed in Table 1 at 200 kg/h

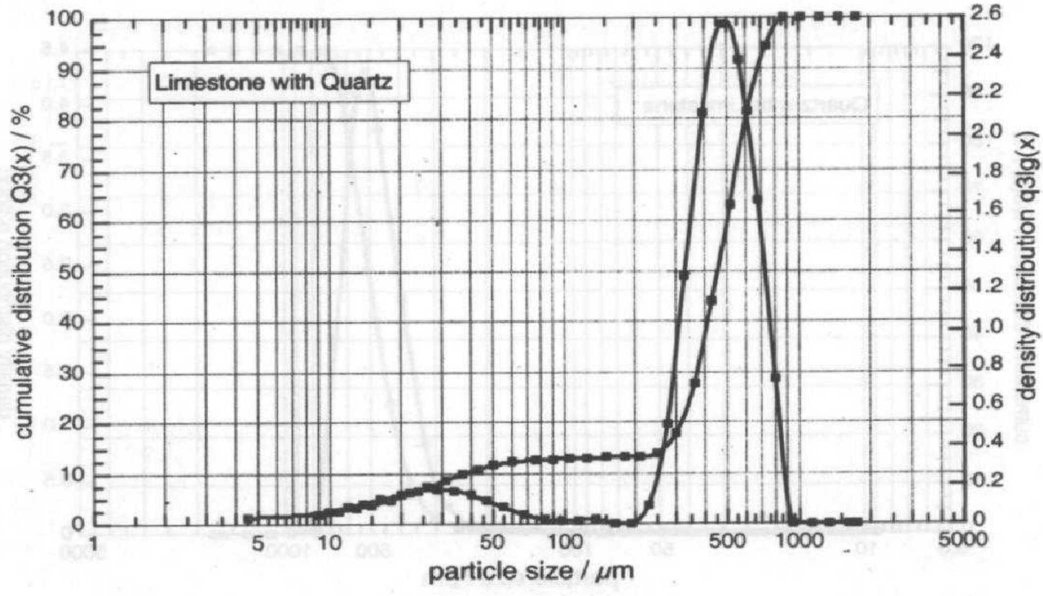


Fig. 12b : Size analysis

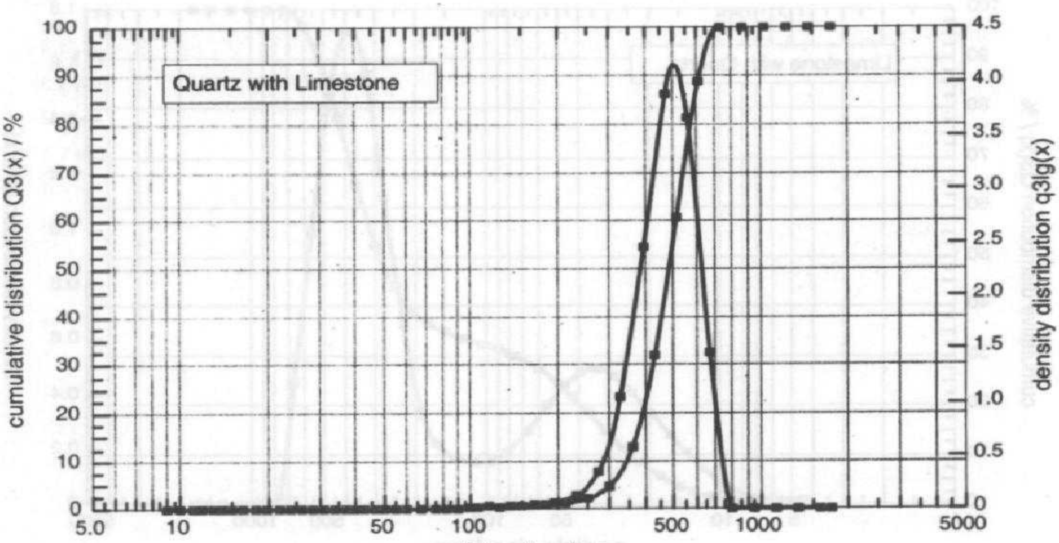


Fig 13a : Size analysis of the coarse fraction of the test in Table 2 at 200 kg/h.

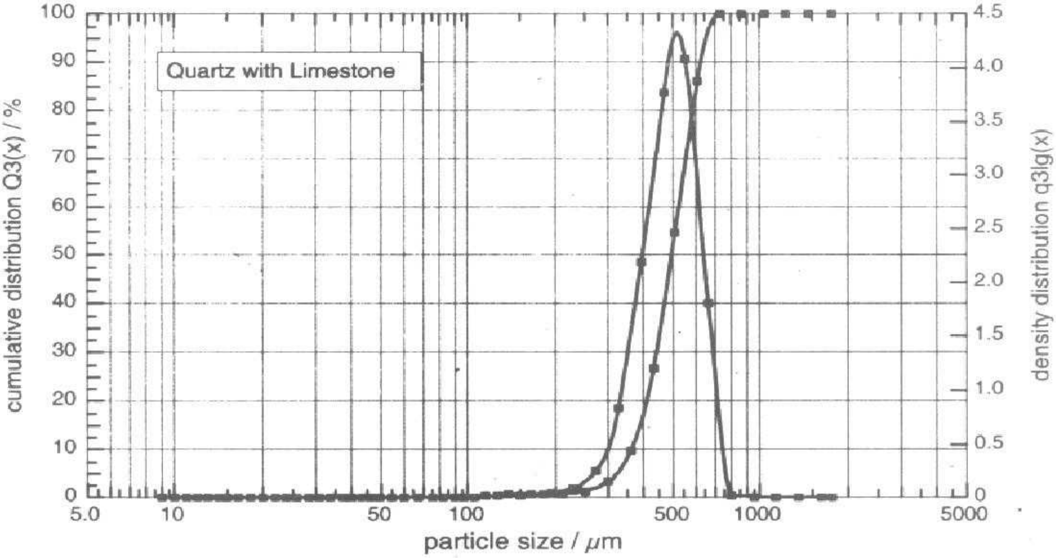


Fig. 13b : Size analysis of the coarse fraction of the test in Table 2 at 1000 kg/h.

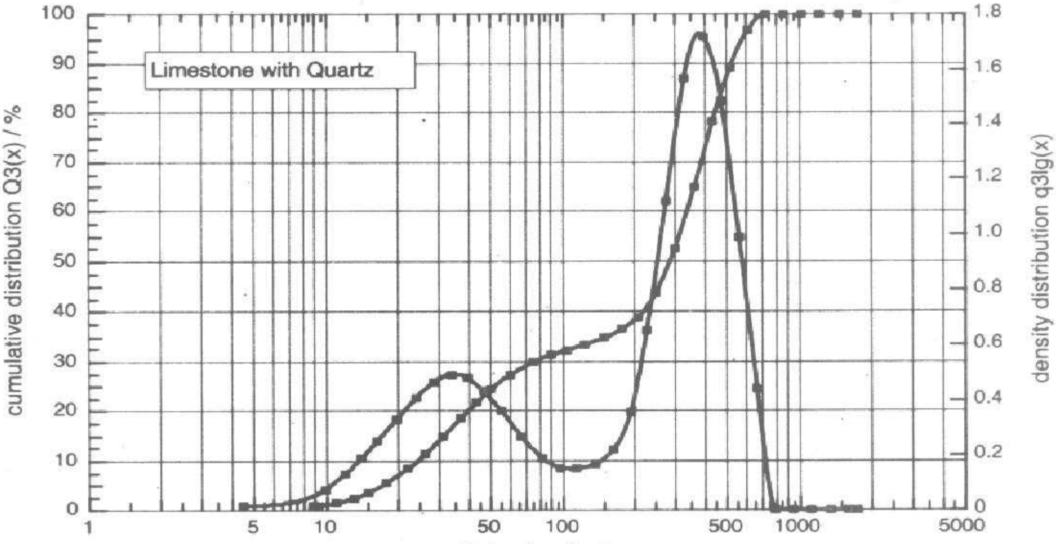


Fig. 14a : Size analysis of the fine fraction of the test in Table 2 at 200 kg/h.

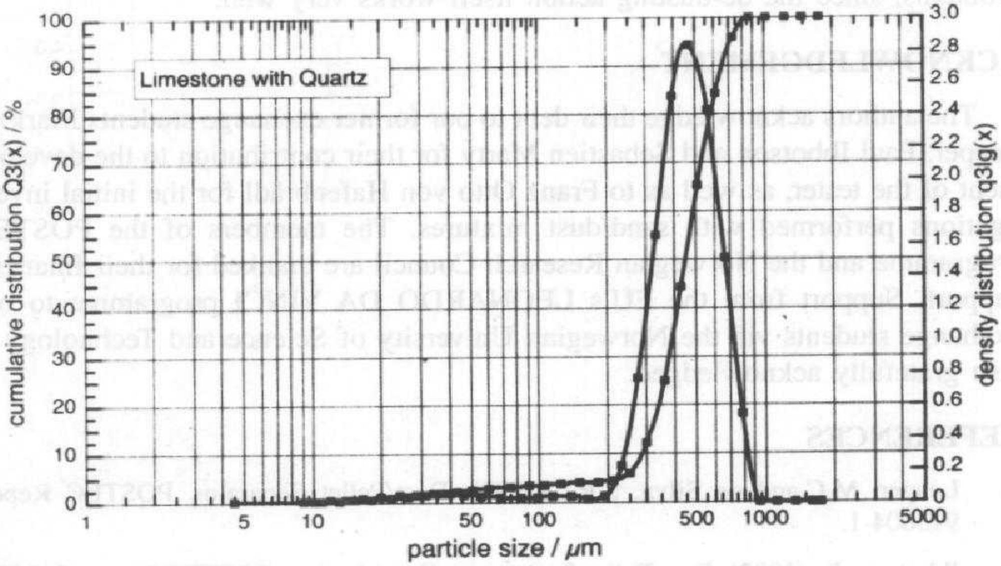


Fig. 14b : Size analysis of the fine fraction of the test in Table 2 at 1000 kg/h.

The sub 105 µm fractions are now reduced to 0.07 % at 200 kg/h and to 0% at 1000 kg/h. Interestingly the result at 400 kg/h was nearly as good with regard to the material reporting to the fine fraction as was the case with 200 kg/h. What is disturbing is that most of the material reporting to the fine fraction is over 105 µm, and covers the entire size range of the coarse fraction. Repeated tests showed that this carry over of coarse material to the fines was essentially size-independent, which points to a design shortcoming in the unit.

CONCLUSION

The de-duster developed by POSTEC, based on the use of high speed air jets to free coarser particles of fines adhering to them has been shown to work very well at separating dust and streamers from materials much coarser than the dust fraction, with very satisfactory cleaning being obtained at loadings of up to 50: 1. Its performance when the dust and coarse fractions have overlapping sizes, however, is not as satisfactory - with the main problem being a carry over of coarse particles into the fine fraction. The de-dusting action itself is very satisfactory with good cleaning being achieved even at loadings of 10 : 1. The carry over of coarse particles into the fine fraction is probably the result of two effects: (a) the overloading of the spiral at the point where the material enters the de-duster, and (b) the slowing down of the vortex due to overloading, causing the coarse particles to fall off the spiral and enter the upward moving air flow all along the spiral. Future efforts must be directed at finding solutions to these two problems, since the de-dusting action itself works very well.

ACKNOWLEDGEMENT

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