Technological Further Development of the Deinking Process

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It has become quite apparent that the number of impurities in waste paper is growing in proportion to the increase in the use of waste paper. But it is not only the absolute quantity of "contraries" that is on the increase, but above all their negative characteristics and effects. A further problem is that paper machines, which are increasingly geared to maximum output, have become more susceptible to trouble.

All these factors are the reason why the deinking systems of the 1980s have to be much more sophisticated than was necessary 10 years ago.

The two graphs, Figs. 1a and 1b, are intended to illustrate this. Whereas in the past greater emphasis was placed on the process stages of deinking and fine cleaning/fine screening, nowadays prescreening is much more elaborate and on the other hand, owing to the high degree of contamination, the discharge efficiencies of the individual process stages have to be substantially better.

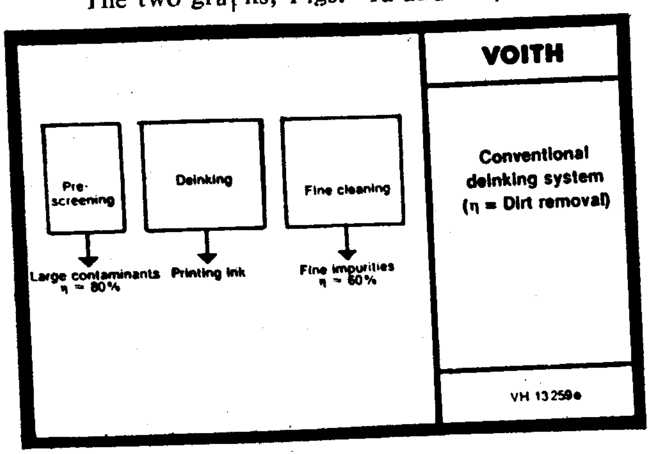

Fig. 1a

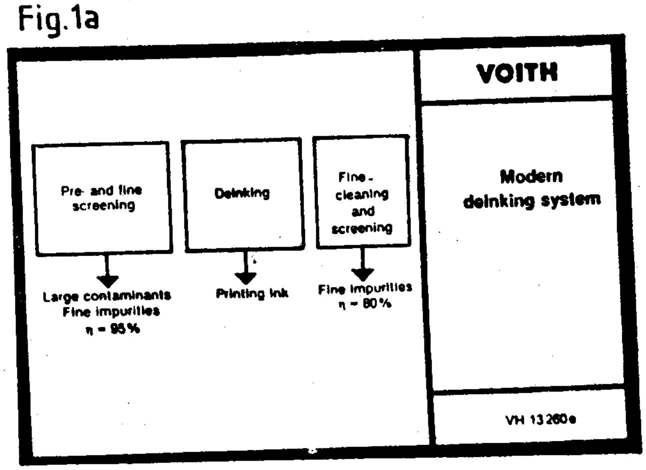

Fig. 1b

The numerical values given in Figs. 1a, b, are mean values of measured systems. The particular figure is dependent not only on the design of the machinery but also on the absolute quantity of pernicious material and its characteristics.

Fig. 2 Shows the simplified representation of a modern deinking system in the form of a block diagram, consisting of the two-stage Prescreening system with turbo separator and Turbosorter - then the high - consistency deinking stage - and finally the fine cleaning/fine screening stage as well as possible additional process stages, depending on requirements.

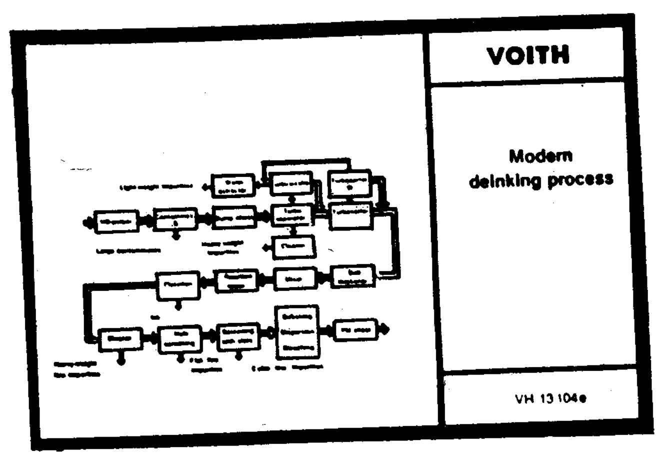

Fig. 2

These process stages are discussed in greater detail in this paper, along with the state of development achieved.

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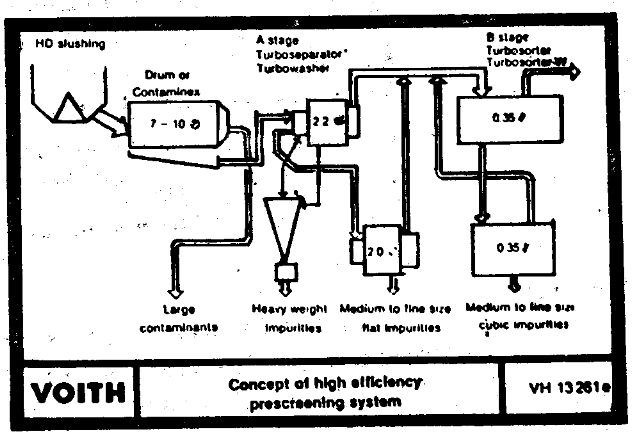
Pre-screening

Fig. 3 shows a modern pre-screeing system. The gentle slushing in the high-consistency pulper[1] and the technology advocated by Voith, namely, to operate the pre-scŕeening section at the lowest possible temperatures and with the minimum posible addition of chemicals, create ideal prerequisites for a high screening efficiency because the impurities remain large and screenable[2].



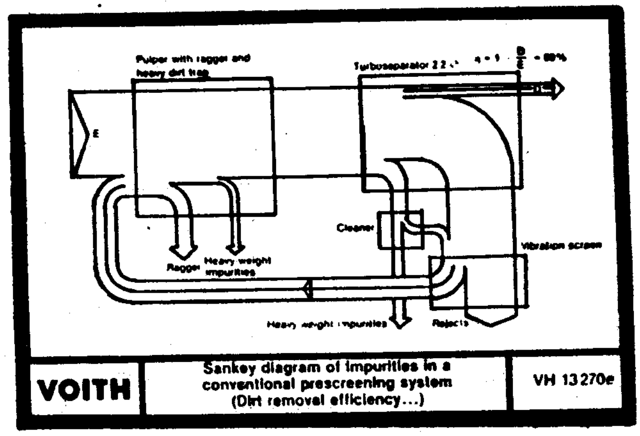
Concept of high efficiency prescreening system VH 13261e

Fig.3

This technology has already been discussed in an eariler paper, so it has not been thought necessary to deal with it at length here.

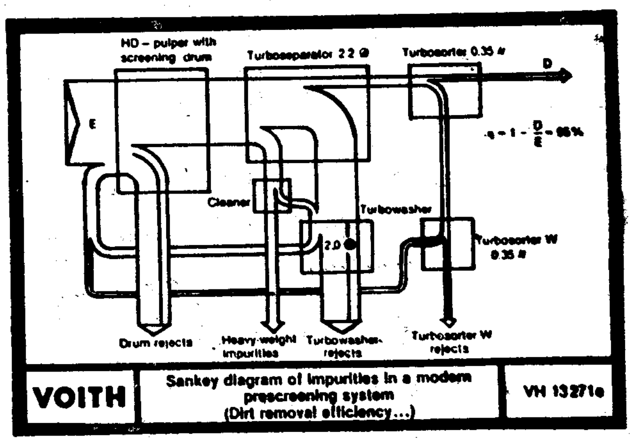
A further, very important contribution to the efficiency of the pre-screening stage has, however, been made by the newly developed final stage (under the name of Turbowasher) for the turbo separator, and the new slotted screening stage for the medium stock-consistency range. consisting of Turbosorter and Turbosorter W as its final stage, These final stages with the same or smaller screen-Plate perforations or slot widths guarantee the same or an even better efficiency than the primary stage, so a forward arrangement of the through-going stock is admissible,

By plotting a Sankey-diagram of the impurities and comparing conventional systems (Fig. 4)—consisting of continuous pulpers with ragger operation followed by turbo separator with vibration screen, with the modern system shown in Figure 3 (Fig. 5), the following becomes evident :



Sankey diagram of impurities in a conventional prescreening system (Dirt removal efficiency...) VH 13270e

Fig.4



Sankey diagram of impurities in a modern prescreening system (Dirt removal efficiency...) VH 13271e

Fig.5

- owing to the poor screnning effect of the vibration screen, the return of extraneous material around the shaded area is higher rendering the total efficiency of the pre-screening stage perceptibly poorer.
- modern systems discharge much more extraneous materials as early as in the first stage - the drum-and.
- owing to the efficient final-stage Turbowasher and Turbosorter W, the return of extraneous material is much lower, i.e. impurities circulate for less time in the system, which means they hit impact edges less frequently and thus remain larger and more easily screenable.

What the absolute figures do not express is that the screening, quality is improved by the additional slotted screening, i.e. medium-sized cubic impurities such as adhesive spine fragments and po'ystyrene particles are discharged as early as in the pre-screening stage. Without the slotted stage these particles would get into the fine screening section.

The boldness of the arrows of the flow diagrams shown in Fig. 4 corresponds to the weights of the extraneous materials flowing through. For reasons of clarity solely the overall flow is shown more boldly than would correspond to the actual percentage.

Deinking

Pre-cleaning is follwed in most systems by the deinking stage proper, flotation. This consists of a reaction for the detachment of printing inks and a machine for discharge of the ink particles, the flotation cells (Fig. 6).

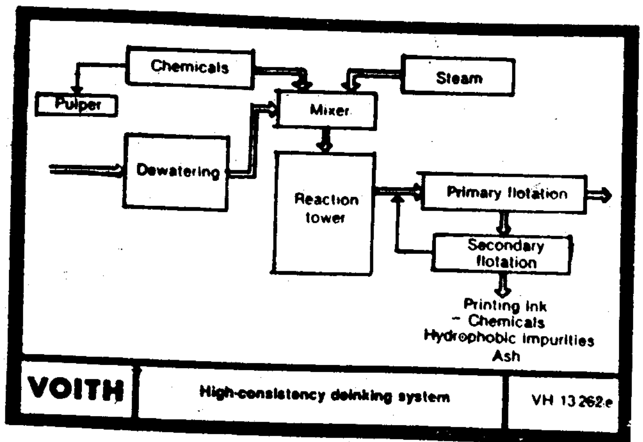


Fig.6

Figure 7 shows in principle a section through the Voith injector type flotation cell and Figure 8 a 200 to/24 h system. The advantage of the injector cell is that, despite a significantly lower energy requirement, enormous quantities of air can be drawn in.

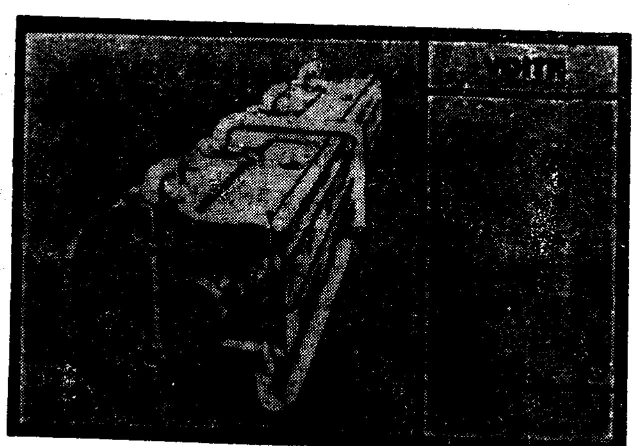


Fig 7

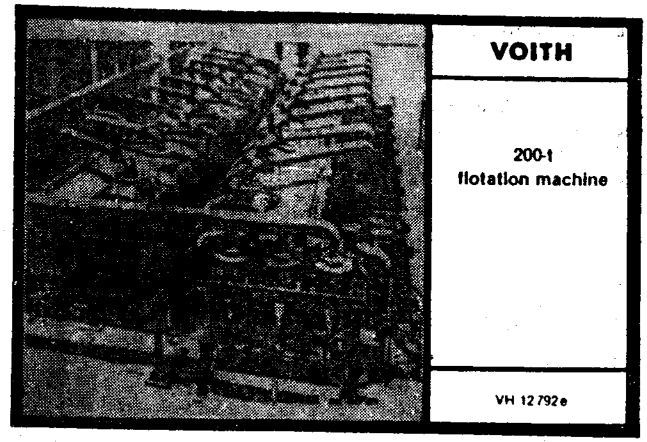


Fig.8

Each individual injector is completely plugging-free and is therefore very adaptable to different operating conditions and throughputs[4].

In addition to this further optimization of the cell, we have placed the main emphasis of our development on the adaptation of the flotation machine and the entire "deinking" process stage to new requirements, such as those relating to modern printing inks and the increasing proportion of coated papers.

The high-consistency process (Fig. 6), based on a joint development between Dagussa and Voith, was developed for the improved detachment of offset inks and greater utilization of bleaching chemicals[3].

It has meanwhile proven successful many times over throughout the world. In addition to a better utilization of bleaching chemicals and intensified detachment of ink, this method offers the additional advantage that, through drainage to approx. 22% stock consistency, the water circuits of the slushing and pre-screening stages and the deinking stage proper are separated.

This permits the pre-screening stage to be operated at low temperature and with a very low chemical load, both of which are conducive to the separation of stickies. Heating and the addition of chemicals takes place only directly ahead of the reaction tower in the high-consistency mixer.

One variant of the high-consistency method was developed in order to be able to deink highly smearing, partially soluble printing inks (Fig. 9). In this

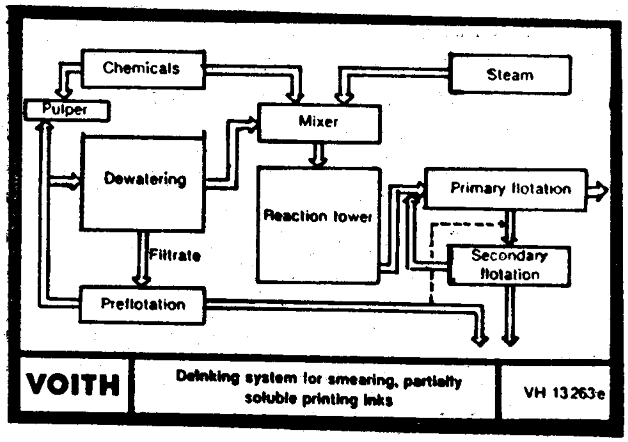


Fig.9

case, machines with a good washing-out effect, such as inclined screw thickeners of the Drainator type, are used instead of belt thickeners for dewatering.

The filtrate accumulating there contains a far greater number of fibres and is heavily loaded with printing inks owing to the washing effect. This is why it is cleaned with a special pre-flotation stage before it is reused in the process. The froth can be discarded directly or fed to the secondary stage of the main flotation process.

The chemical splitting for this special case must take account of the smearing character of the printing ink and differs from traditional processes (Fig. 6) With the arrangement shown in Fig. 9 it is possible to avoid an accumulation of detached and soluble printing inks in the pre-screening circuit, which on the whole leads to improved brightness of the entire process stage.

Offset inks that have hardened and aged for over 1 year should be treated in a completely opposite way in their behaviour to these smearing printing inks. The process shown in Fig. 10 makes it possible to deink such prints well.

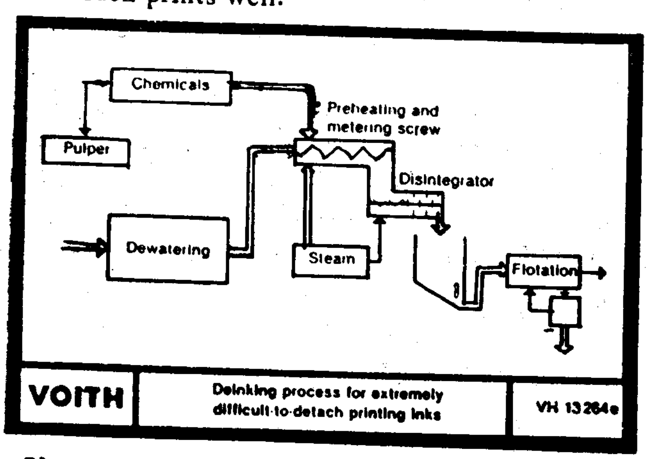


Fig.10

In place of the well-known double-shaft high-consistency mixer and the reaction tower, here a high-temperature treatment is used with the brief application of intensive shearing forces in the disintegrator.

After dewatering to approx. 25 % the stock is heated in the preheating screw to approx. 95°C and is mixed with chemicals.

Following this, there is intensive mechanical treatment with a well defined dwell time in the disintegrator-preferably in the single shaft disintegrator owing to better kneading effect-in order to separate even hardened printing inks from the fibres under these severe conditions.

Immediately after this treatment the stock is diluted and flotated without further reaction time.

This method is however, limited to certain printing inks-it can not be applied if the inks tend to smears because they would then inevitably be irreversibly rubbed into the fibres. Long reaction times at the high temperature in the alkaline range, too, must be avoided owing to the risk of yellowing. Nevertheless, this method represents an interesting alternative.

All three deinking methods discussed have, incidentally, been built on a full industrial scale are in successful operation.

In contrast to the special systems just discussed, in the supply of raw materials to deinking plants we observe an even greater trend toward collective household waste, which means that the system suitable for this would have to be universally applicable to the widest variety of print and ink types. The situation is unfortunately such that a compromise can never achieve the same good results as a process specially tailored to a specific raw material. The purpose of this account was to show examples of what is technically feasible today on the part of the industry that manufactures such systems. From this experience, however, knowledge can also be derived which comes in useful for systems processing a greater mixture of waste papers.

Fine Cleaning – Fine Screening

Flotation is followed by fine cleaning and fine screening. The traditional system (Fig. 11) consists mainly of a cleaner system and a hole screening stage.

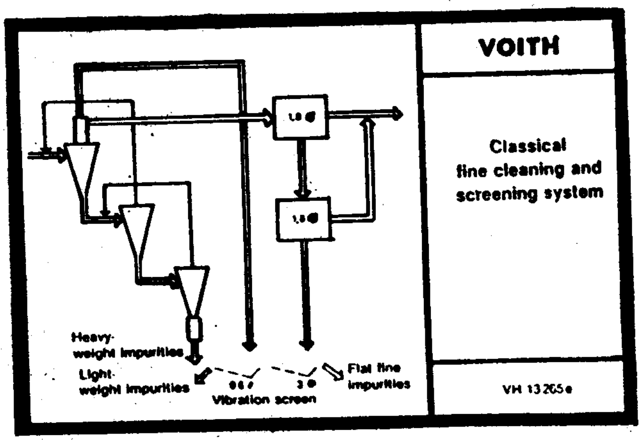


Fig.11

The first cleaner stage is equipped with cleaners with lightweight impurities discharge (E-type cleaners). These lightweight impurities are post-screened on vibration screens having 0.6-mm slotted screen plates. The final stage of the hole screening section was and is in many cases the vibration screen. Furthermore, it should be noted that it was general practice in the past almost everywhere to arrange for the stock of the 2nd stage to pass forwards.

Modern systems (Fig. 12) designed for maximum discharge efficiency are, on the one hand, more extensive as regards apparatus, but above all they are more efficient from a technological point of view. For example, in cleaner systems today both the first and the second stage are equipped with lightweight impurities discharge. This lightweight impurities fraction is post-screened on a Minisorter with a very fine slot width (0.2 mm), which is substantially more effective than with the three times larger slot width of the vibration screens. We adopt the same principle in the screening stages, too.

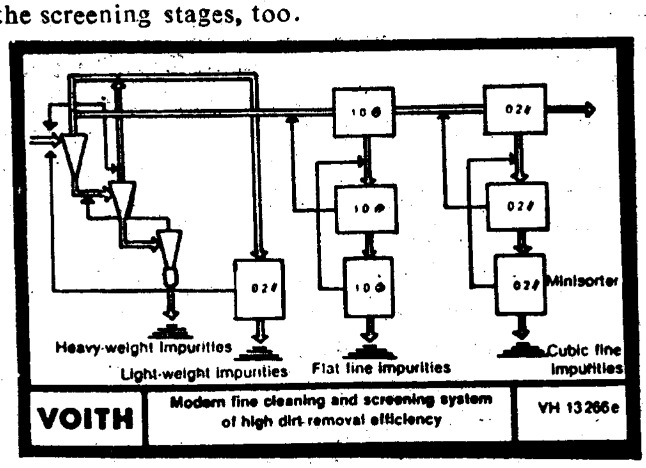


Fig.12

But not only the improved end stages, called Minisorters, used instead of vibration screens increase the discharge of extraneous meterials; through newly developed screen baskets it has been possible to obtain much smaller bole diameters and slot widths. In deinking systems for groundwood-containing waste papers we today use hole diameters up to 1 mm and slot widths up to 0.15 mm.

Another special feature of modern high efficiency screening systems is the systematic cascade arrangement of the 2nd and 3rd stages.

The reason why we do this is shown by the theoretical calculation of the total efficiency of a three-stage screening system, in the one case with forward screening of the 2nd stage and in the other case with cascade arrangement of the 3rd stage (Fig 13).

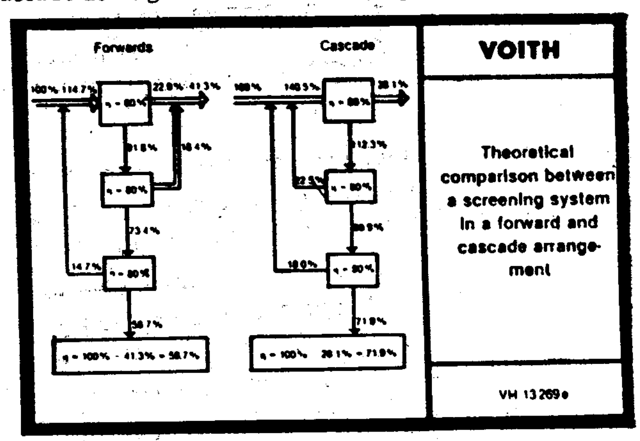


Fig.13

It has been assumed that all screens should have the same high discharge efficiency of 80%. This is a fairly accurate assumption when the final stage is a Minisorter. Under these premises forward screening displays a total discharge efficiency of 58.7%, whereas the cascade arrangement shows 71.9%.

This surprising difference is due only to a changed arrangement, without the screens themselves having been changed. However, we do not wish to conceal the fact that the cascade arrangement requires a larger 1st stage, as greater throughputs have to be coped with.

If a comparison is made here with an arrangement (Fig. 14) having different efficiencies in different screening stages and vibration screens as the final stage (Fig. 14, left), which is more realistic for conventional systems, it is found that even when very high

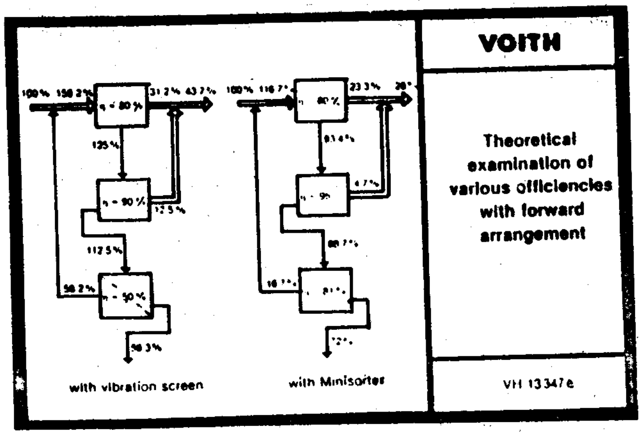


Fig.14

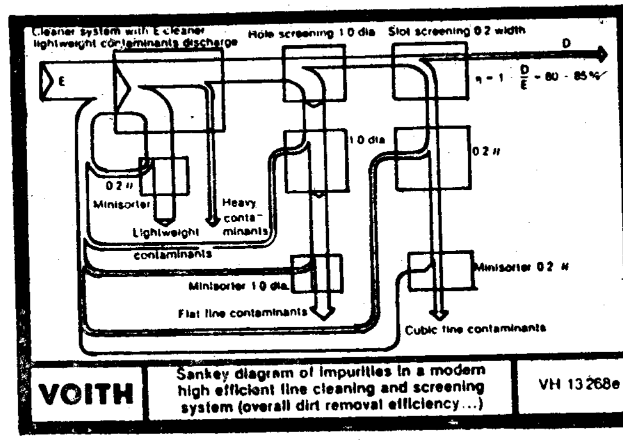


Fig.16

discharge efficiencies of 80 and 90 % respectively are assumed for the first and second stage, the total discharge is unsatisfactory due to the poor effect of the vibration screen ($\eta = 50\%$).

To achieve a comparable effect with the cascade arrangement (Fig. 13, right) despite forward screening, the second and third stage would have to have 95 % and 81 % efficiencv respectively with forward arrangement (Fig 14, right), which is scarcely feasible from a technical point of view. The theoretical consideration shows that if the best overall efficiency is to be achieved with the finest hole diameters and slot widths that are still operationally reliable, the cascade arrangement (Fig. 13, right) using a Minisorter as final stage is the right solution.

If a comparison is now made between the behaviour of the discharge of contraries from conventional fine screening and cleaning systems (Fig. 15) measured in existing plants and modern designs (Fig. 16) by means of a impurities-Sankey diagram, the consequences are as follows :

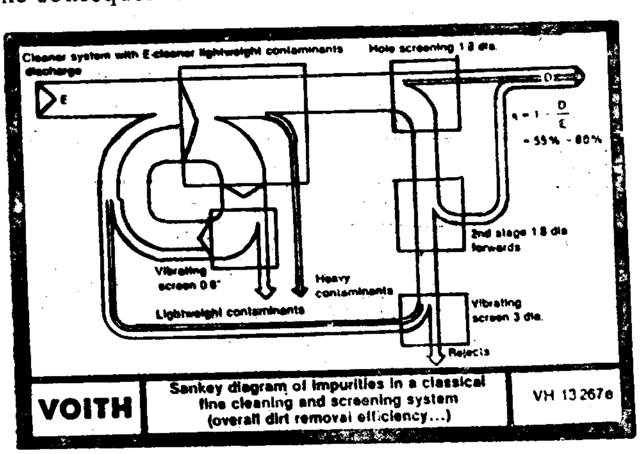


Fig.15

— because of the relatively large slot width of the vibration screen, large quantities of fine and lightweight impurities pass through and circulate in the system (hatched areas), whereas the Minisorter (Fig. 16) discharges with far greater efficiency.

— The high quantity of circulating impurities in conventional systems adversely affects the total efficiency.

— The smaller hole diameters and slot widths of systems improve the discharge efficiency of each stage and,

— as mentioned above, the cascade arrangement also additionally increases the efficiency.

— Finally, the additional slotted stage produces a further major advantage especially with regard to the separation of very fine cubic and granular impurities. A prerequisite for the use of these fine slotted screen baskets is, however, an effective separation of sand by preceding cleaner systems so that the grains of sand and other fine granular heavy impurities do not plug the slots.

For reasons of clarity, the proportion of extraneous material passing through is again shown in disproportionately bold lines in Figs 15 and 16, whereas the boldness of the other flows is shown in proportion to the mean measured value of several systems.

Unfortunately, it is still not possible today to preclude all impurities, even when using the finest slots that can be manufactured at present.

Depending on requirements, it is therefore necessary to use additional process stages for homogenization of the stock.

Disintegration–Dispersion

For this purpose disintegration systems are used which are usually arranged after final dewatering. Depending on the tasks to be accomplished, we adopt two different principles :

For homogenization chiefly by means of shearing forces we have the single - shaft disintegrator (Fig, 17). This is particularly suitable for the comminution of printing inks[5] which cannot be deinked or have not been deinked below the limit of visibility in order to give the sheet a homogeneous, clean appearance. The relatively gentle kneading treatment produces either no rise at all or only a minimum rise in freeness - and therefore does not negatively affect the dewatering behaviour. In a number of cases even an improvement in the dewatering behaviour was achieved by the cockling of the fibres due to the kneading treatment.

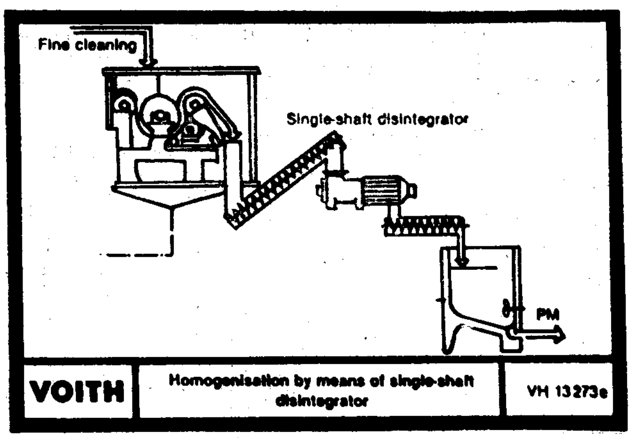


Fig.17

If the task is to comminute very fine remaining stickies and other impurities, the disc disintegrator (Fig. 18) with its high impactedge treatment is better suited. Experienee has shown that an increase in temperature facilitates dispersion. A drawback is the unavoidable increase in freeness.

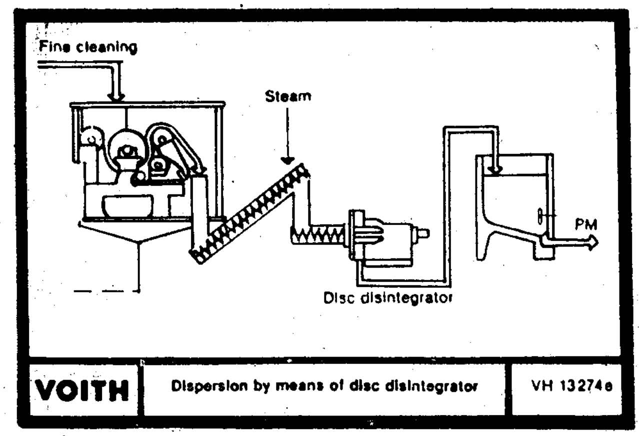


Fig.18

In return, however, the risk of a possible drop in strength at high temperature due to the refining effect, which this machine produces to a greater or less extent depending on the refining tackle used, is more than compensated for.

De - ashing

The extraction of fillers (Fig. 19), especially in the production of tissue, is an important requirement. In principle, any thickener which does not build up any filtering layer of fibre is suitable for de-ashing.

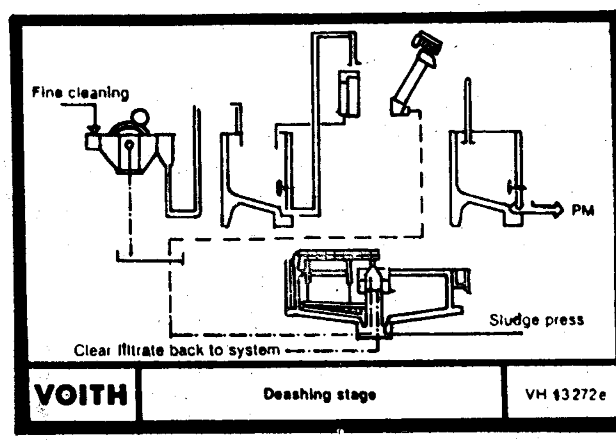


Fig.19

Depending on ingoing stock consistency, different designs of machines are used, e.g. cylinder-mould or disc-thickeners or even Duo-Formers at 0.8 to 1%, and inclined screws at 3 to 4% ingoing stock consistency. The final selection of the most suitable de-ashing equipment is based on characteristics of the raw material and the desired final product.

Bleaching

In closing we should like to draw your attention to the various bleaching methods (Fig. 20) for the sake of co npleteness. This process stage has been gaining importance in recent times with the increasing use of dyed waste papers in high-quality paper grades.

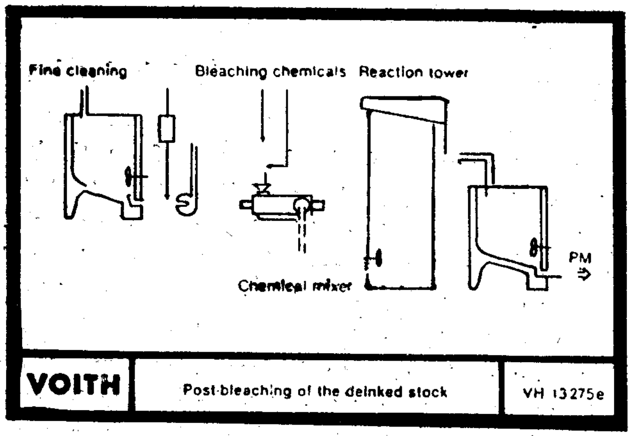


Fig.20

There has been an enormous development in deinking technology over the past few years. More than half of the machines described in this account did not exist at all 4 years ago, and the process technology, too, has been improved to a decisive degree. All these steps were necessary to produce, in spite of the increasing contamination of waste papers, a fibrous stock which meets the high demands of modern paper machines.

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