THE DEVELOPMENT OF FILTERING EQUIPMENT FOR HAZARDOUS MATERIALS

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The analysis showed that today a new direction in filter designing was formed besides the development of traditional types on filtering equipment. Here the filters are considered as a unit of flexible technology for treatment of not great volumes of hazardous sludges. Complete analysis of three perspective tendencies in designing of the filtering equipment is done.

1. Outlines of an apparatus which combine processes of heat and mass transfer and filtration are considered.

2. The application of robotic principles to the automatic operation of filtering equipment will allow qualitative changes to be made in solving the problem of the use of filters in dangerous conditions, such as arise with explosive, radioactive, toxic and other hazardous substances.

3. The application of principles of rotational machines and conveyor systems in the filtration processes is discussed. The attention of experts on hazardous materials treatment must be fixed on the filtration systems when sludge treatment by filtration is based on the principle similar with rotational casting mold. The filter elements play the role of containers for solid phase of sludge. The filter elements pass in consecutive order different processing zones in the rotational machine. For instance: loading, filtration, expression or drying, fixation (sintering, impregnation, etc.) and packing (coating, encapsulation, spray coating, etc.). In some cases containers are impermeable when filter elements are punged into sludge and are extracted from sludge after filtration (before expression).

These three branches of design will permit in the future to make use of filtering equipment in treatment sludges with hazardous solid phase. The expansion of the functional possibility is achieved by new nontraditional construction of filters. For these types of filters it is important to determine exact sludge and cake properties and optimum operating conditions.

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INTRODUCTION

Today one of the vital problems among ecological problems is treatment of hazardous materials with the aim to reduce their negative influence on environment and maximum reduction of the volume of wastes which cannot be subjected to total liquidation.

There are many methods and technologies for hazardous waste treatment. Here attention will be paid to filtering equipment used (apparatus and machines) not only as a matter for filtration, but also for reaction, heat- and mass-transfer processes.

Now many regular filters are used for realization of consecutive technological processes complex, for example: filtration, washing (extraction), drying (for these purposes drum filters, filter presses, belt or tilting-pan filters etc. may be used); reaction, filtration, washing (extraction), drying (tank filters as filter-reactors, filter-dryers, etc.).

DISCUSSION

Basic waste treatment methods which are used or can be used in principle together with filtration or realized in equipment for filtration are named in Table 1.

Table 1: Processes which can be Combined with Filtration

PROCESSES	Examples of Filters Types or Processes with Filtration
Magnetic Separation	Magnetic Filters
Screening Classification	Filter-cyclones; Filter-vibrators
Solid/Liquid Separation: Sedimentation; Centrifugation; Flotation, etc.	Filter-flotators; Centrifugal filters; Filters with sedimentation chamber, etc.
Drying	Filter-dryers; Regular types of filters as belt, drum, disk, etc.
Stripping by steam, air, other gases	Desorption in filter-adsorbers; Stripping of slurry in tank filters (possible in principle)
Solid/Liquid Solvent Extraction	Belt filters; Tank filters with stirrer (filter-reactors)
Adsorption	Filter-adsorbers; Filter with sorbent layers; Filters with precoat layer of adsorbent
Membrane processes (MF, UF, RO)	Liquid filtration before membrane processes as a rule; Microfiltration; Combination of filtration with membrane processes in seat is possible
Chemical treatment (Neutralization, oxidation, etc.)	Before filtration or in filter-reactors
Precipitation	Before filtration; Deep bed filtration; Tank filter-reactors
Electrochemical processes	Electrofiltration (different aspects)
Miscellaneous chemicals, (for example, catalysis)	Catalysis filter-reactors (possible in principle)
Pyrolysis	Filter-reactors (filtration with the following pyrolysis in the same apparatus in fluidized bed, for instance). May be possible if ceramic or metal filter elements are used
Fixation by sorption	See adsorption. The main problem is: selecting filtering stabilizing materials suitable for further encapsulation or hardening at the same time.
Encapsulation	Special filters constructions or use of filtering materials capable of creating protecting coating on the solid phase surface under certain conditions (May be designed and developed in principle)
Crystallization	Filter-crystallizators

The filtration is put in the center of attention here but it does not mean the filtration exclusiveness in comparison with other processes. As we can see from Table 1, processes of the same group as filtration (physical treatment method) are the most compatible ones with filtration.

Hazardous slurries and liquids which contain or produce a solid phase after treatment, for example by neutralization or precipitation, can be classified into three groups:

1. Slurry which contains main hazardous components in liquid phase, while solid phase is inactive or relatively innocuous.
2. Slurry which contains main hazardous contaminants in solid phase when liquid is inactive or relatively innocuos.
3. Slurry which contains hazardous components both in liquid and solid phases.

We consider it to be unimportant whether the solid phase was in the liquid before treatment or whether it was produced during wastes treatment.

The following problems can arise when treating the slurries:

- methods of treatment of liquid and solid phases of slurry are often contrary.
- in certain cases during liquid treatment the solid phase presents serious problems which can be produced by adsorption, catalysis, chemical reactions with reagents used for liquid treatment or due to fouling of equipment, etc.
- chemical treatment of solids (for example neutralization, precipitation, oxidation, etc.) demands a lot of chemical reagents, because in spite of possible small solid phases volume in the slurry, the solid phase particles can contain major part of hazardous materials. If in the liquid the contaminants concentration is as a rule up to some percents then in solid phase the hazardous contaminants concentration can reach up to 100% per all solid phases.
- despite comparatively small solids volume in the total volume of waste liquid, processes of solid separation and treatment are complicated and their cost reaches up to 40 - 50% of the total cost of hazardous waste liquid treatment as estimated by experts.

So, new ways of searching for hazardous slurry treatment particularly by filtration are actual.

In the first approach versions of slurry separation and treatment operations can be presented in the following groups.

The first group of slurries with main contaminants in liquid phase can be separated by filtration on filters which necessarily accomplish cake washing and dewatering. After that the cake is disposed and the liquid passes to subsequent treatment. Some versions of treatment schemes are presented in Fig. 1. These schemes can include the direct slurry filtration or slurry filtration after pretreatment, as well as filtration of the treated liquid phase after primary filtration if the solid phase is created in the liquid as a result of further treatment. Sometimes, if the coarse particles with good filterability are created at the primary stage of treatment, they can be used as filter aids for filtration in the next stage (scheme 4, Fig. 1).

The second group of slurries (hazardous contaminants located in the solid phase) can be separated by filtration immediately. For reducing hazards of solids, the cake undergoes treatment by chemical reagents, solvents, isolation.

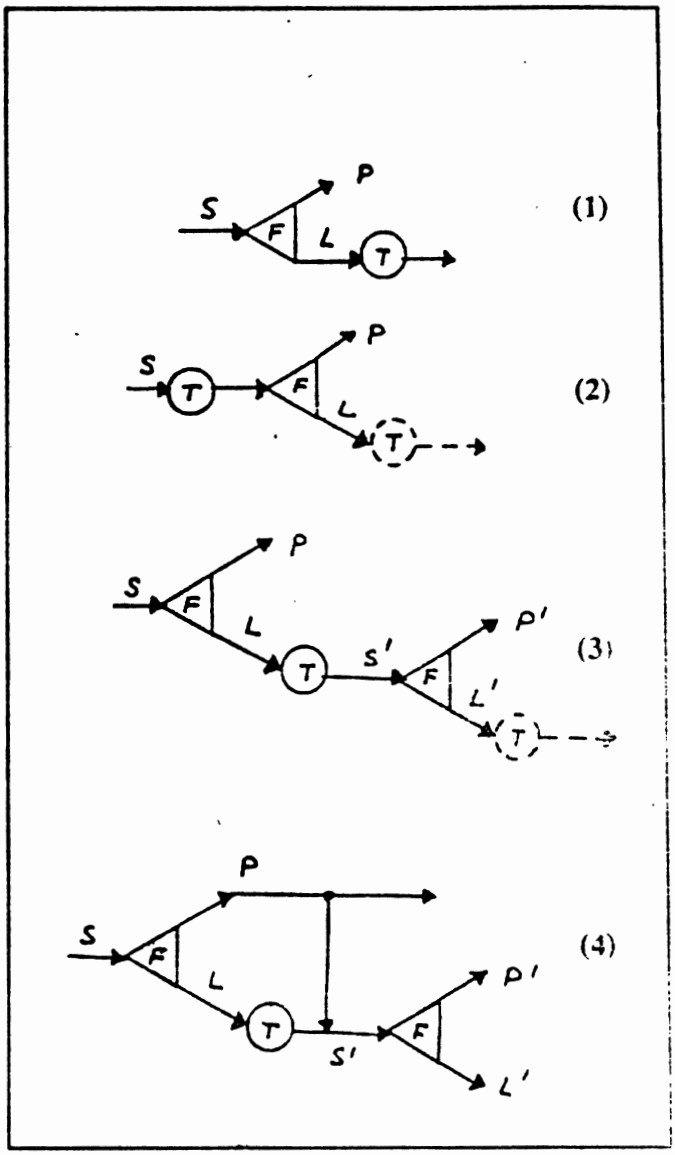

Fig. 1. Schemes of Slurries Separation of the First Group
S - slurry; F - filtration; T - treatment; P - solid phase; L - liquid phase

destruction, etc. (Fig. 2). Here direct slurry filtration directly (scheme 1) or preliminary thickening by filtration (scheme 2) with following treatment of concentrated slurry can be possible. If hazardous contamination in the solid phase occupies only a part of it, solvent extraction of contaminants can be done with the filtration followed. Combination of filtration with extraction, thermal processing (drying, etc.) or with suitable chemical operations is possible (scheme 2).

The third group of slurries supposes a great variety of possible sequences of treatment operations and filtration. Treatment of these slurries presents different combinations of technological schemes for groups 1 and 2.

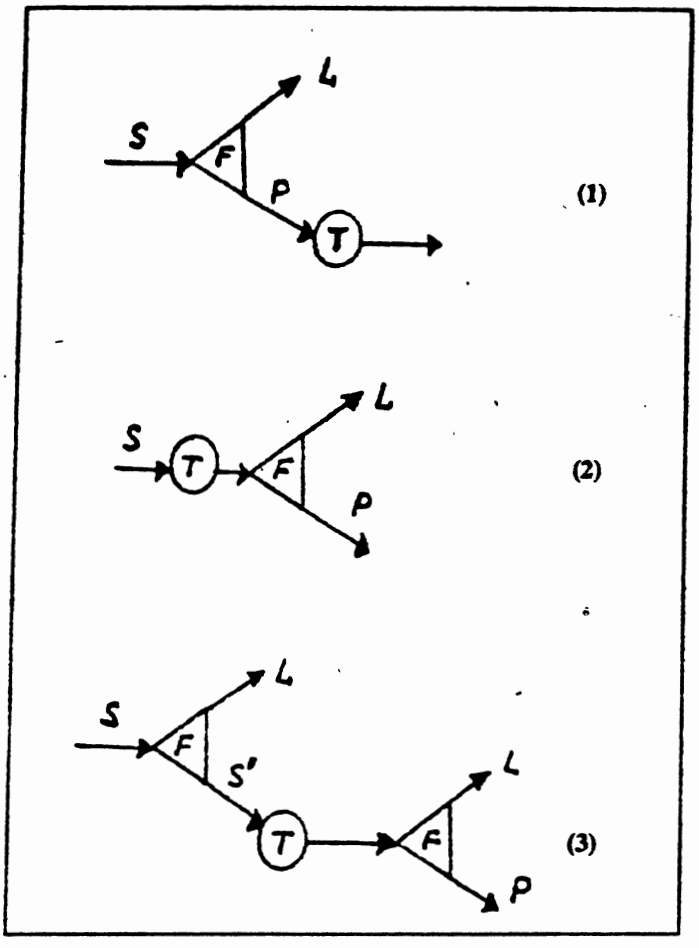

Fig. 2. Scheme of Slurries Separation, the Second Group

The main problem of filtration of hazardous slurry is environmental safety. Only three trends of non-conventional types of filtering equipment for treatment of hazardous slurries and sludges will be considered here: hermetic filtering equipment intended for processes of heat and mass transfer in one place; (combined filters); filtering equipment with robotic principles of automatic operations; rotational machines and rotary-conveyor systems for filtration. All three trends can be developed both as independent, and interdependent like it is shown in Fig. 3 for instance.

1. Combined filters. The minimization of possible contacts of hazardous slurries with environment is needed during their treatment. For this purpose some different processes can be realized in one apparatus including filtration.

Of course, different technological processes accomplished in one apparatus lead to complicating of the equipment constructions or to decreasing of the output of equipment. Nevertheless when treating moderate volumes of hazardous slurries, which needs are in safety control, the filtering equipment complication can be justified. So, combined filters are intensively developed.

In general the possibility of combined filters can be represented by scheme, Fig. 4, where

1 - chemical reaction;
2 - mass transfer processes (stripping, crystallization, drying, extraction, adsorption, etc.);
3 - heat transfer processes (heating, cooling etc.);
4 - mechanical processes (mixing, stirring, expression, grinding, etc.);
F - filtration.

The processes in the combined filters can be realized both in the layer and in the slurry volume. As examples multifunctional notch-filters ROSENMUND (filtration, washing and drying with stirring) (Avery, 1985), Reactor-filter-dryer NUTREX (Avery, 1985; Gromov, 1989), Filter-flotator unit (Patent 235868), Apparatus for extraction (solid/liquid) and separation (Patent 1524915) can be named.

2. Robots used for automation of the filtering equipment (robotic filters).

This type of equipment allows qualitative changes in solving problem of the use of filters in dangerous conditions such as hazardous slurries.

The robotic systems are the most effective ones for batch filters. Some aspects of robots used for batch filters were discussed (Yelshin, 1990).

The other application of robots can be periodic servicing functions to test the parameters or to take samples during filtration, dewatering, drying or filter media regeneration. Sensors accommodation inside the filtration zone for continuous watching of the slurry cake properties with the help of traditional automatic devices creates some problems which do not have any positive solutions as yet.

Measurable parameters can be: taking samples of the slurry and cake, cake thickness measuring, gas or liquid permeability of cake or regenerated filter media testing, cake moisture and cake washing quality testing; etc.

The control of the filtration with robots can be developed on the basis of experience of robotic systems which are used in analytical laboratories for automated samples control.

This branch of filtering equipment is on the stage of forming and is interesting for hazardous slurries treatment when besides solid phase dewatering, the packing or encapsulation of solids are necessary for further isolation. In these systems part of technological operations can be made by robots, too. Rotary filter-machines can be used on final stages of the hazardous slurry treatment when slurry is highly concentrated (paste). In this case, the slurry often needs the portion filtration for further fixation of solid phase, for example by sintering, impregnating, hardening, deposition of materials for fixation within a porous volume of cake, packing, etc.

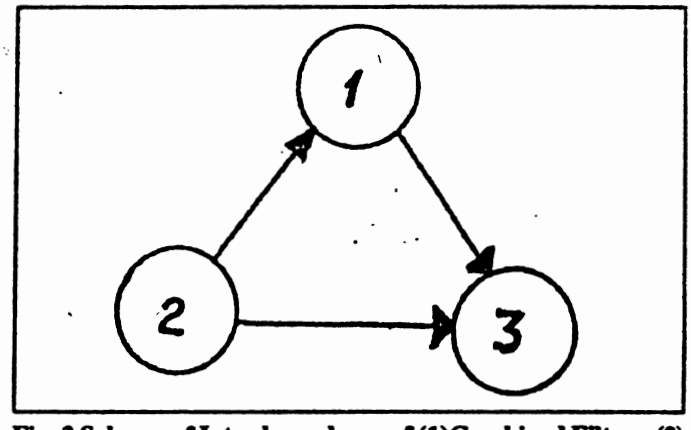

Fig. 3 Scheme of Interdependence of (1)Combined Filters, (2) Robotics Filters (3) and Rotational Filter-machines.

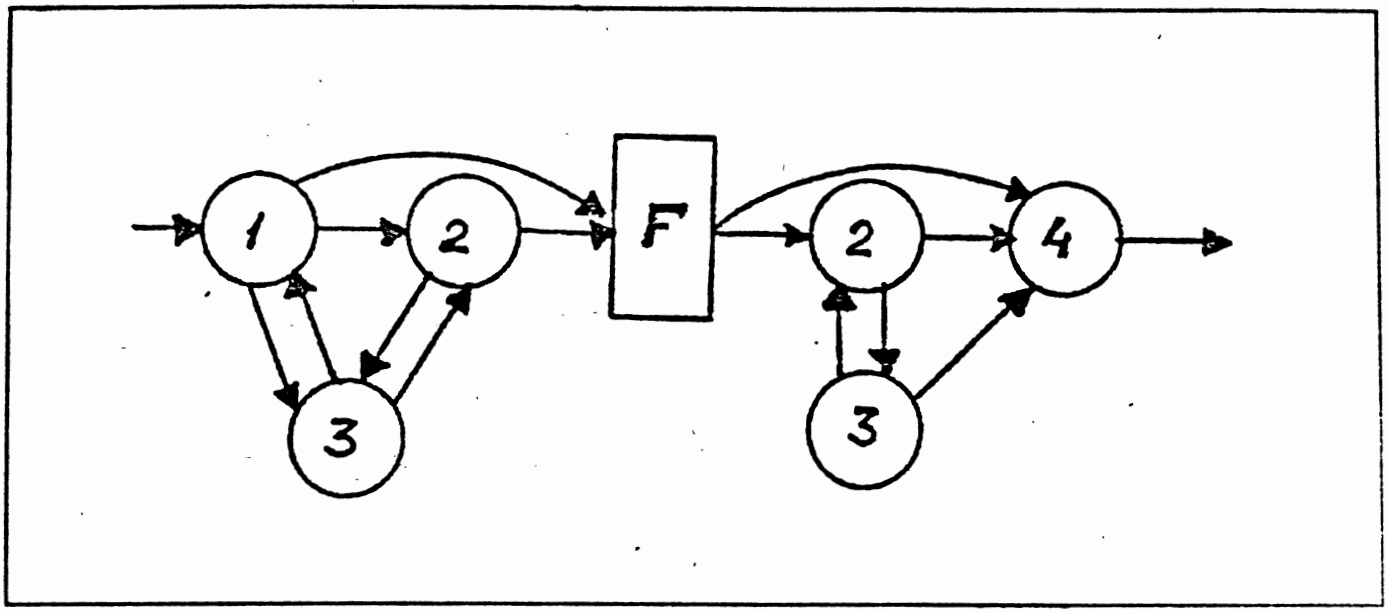

Fig. 4. General Processing Scheme of Combined Filters.

3. Development of principles of rotational machines and rotary-conveyor systems for filtration purposes (rotary filter-machines).

The following constructions of filters based on the elements on the rotary machines principle can be named.

Automatic device for filtration [App. 2164866] cake dewatering device (Patent 1131526); cartridge filter (Patent 816499), supplied with a rotary magazine of cartridges having the device for reload of filter elements; ISEP Systems which include the processes of adsorption, ion exchange and filtration (Bulletin, 1989). For instance ISEP System L100 (ADVANCED SEPARATION TECHNOLOGIES) for testing continuous sorption technology was designed on the basis of utilization of two rotary valves, each with 20 ports which define up to 20 fluid contact zones. The valves are mounted above and below a carousel assembly. The carousel, comprised of thirty individual media (or resin) containing chambers, slowly rotates through each contact zone. Fluid entering the valve is distributed to the media-filled chamber as each chamber rotates into position. The valve set is designed so that fluid from two adjacent zones will not be introduced into the same chamber, thereby maintaining process integrity.

However, existing equipment does not have devices for fixation of the solid phase and packing the cake or filter elements after treatment in the rotary filter-machine. So, for this group of filters there are a lot of possibilities for creative development of ideas discussed here.

CONCLUSION

Analysis of the development of some filtering equipment for treatment of hazardous slurries are as follows:

1. There are tendencies to complicate the filtering equipment to increase safety and quality of processes.

2. The most successful for this purpose are the combined filters, robotic filters and rotary filter-machines which can be used for treatment of moderate and small volumes of hazardous slurries.

3. The design of robotic filters and rotary filter-machines is now in the stage of initial research and development. These two types of equipment can give a variety of new nontraditional constructions of filters.

4. All three types of filtering equipment can be successfully combined in qualitatively new systems for filtration.

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