Diatomite Filtration Of Salt Water And Related Streams

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INTRODUCTION

The past decade has witnessed the advent of an accelerated growth in our industrial system related to petroleum and chemical processing. The complexity of our new processes has created new problems in waste disposal in the case of industrial and oil field wastes. Conversely, some of the same methods developed for combatting surface polution in some areas are also being utilized advantageously to acquire additional or more efficient oil production in other areas, such as secondary recovery.

The following discussion will be mainly concerned with diatomite filtration of salt water and industrial waste streams and subsequent subsurface injection. Filtration usually follows other treatment methods that may be used. Diatomite filtration is one of the most versatile, reliable and economical methods available to remove undissolved solids from liquids. Expenditures of several million dollars have gone into the careful design of filtration equipment and proper selection of filter aids. New ideas and techniques are continuously being developed to aid adequately in insuring safe and troublefree underground injection.

What follows is a brief description of diatomite, the principal types of diatomite filters and filter aids available, and some factors determining the proper selection of the correct filter aid.

Marine diatomite is the skeletal remains of single-celled marine life that existed several million years ago. It is composed primarily of amorphous silica. Upheavals in the earth's crust caused these deposits to rise above the ocean level where they were leached clean of organic and other water soluble matter by countless rains. Today, they are processed into different particle-sized powders which are used as filter aids.

OBJECT OF DIATOMITE FILTRATION

Many industrial wastes cannot be filtered economically without the use of filter aid. The finer particles to be filtered pass through the filter cloth; the coarser and slimier particles tend to plug off the cloth or septum causing a decrease in flow and a rapid increase in pressure. Also, these solids make cleaning of the septum difficult or impossible. The use of diatomite to alleviate the above difficulties is a two-step operation. Diatomite filter aids are extremely fine, highly porous powders. Consequently, the first step in achieving improved filtration conditions is to form a precoat of diatomite on the permeable septum.

This can be accomplished by circulating a slurry of the correct grade of diatomite in clear filtrate from the system, preferably at the same conditions that will be encountered during the filtration cycle. This leaves a surface covering of 1/16 in. to 1/8 in. thickness on the filter septum. As an illustration, a 60 x 60 mesh wire filter cloth contains 3600 openings per square inch, a precoat of diatomite presents about 2,500,000 capillary channels per square inch, which permit the passage of liquids and filter out extremely fine solids. Besides removing fine solids, the precoat serves to protect the filter septum from impurities, thus making it possible to remove all the filter cake and leave the filter septum clean for the next cycle.

Naturally, with removal of turbidity, the impurities will form on the surface of the precoat and the flow will be sharply reduced. Therefore, the second step is the continuous addition of filter aid to the liquid being filtered prior to entering the filter. When filtered out on the precoat, this so called body feed maintains the high permeability of the cake as filtration proceeds. The correct amount of body aid can easily be controlled with correctly designed equipment to meet changing quality of influent.

Diatomite Filter Aids

In attacking any filtration problem, the nature and amount of solids to be removed are highly important criteria that will affect the grade and consumption of filter aid and design cost of the filter. Diatomite filter aids are produced in a number of different grades giving different flow capacities and clarity. Filter aids are available for removing particles ranging from 10 microns down to 0.1 micron.

The filter aids differ mainly in particle size distribution. The proper grade for a given application is that which provides optimum flow rate for the degree of clarification required. A fundamental characteristic of filter aids is that as they increase in particle size, the flow capacity increases, but the clarity decreases. Medium grades are most commonly used, based on experienced economic studies. Once the correct filter aid has been ascertained, the other most important variable in controlling the filter cycle is the amount of body feed added. There is an optimum amount of body feed addition beyond which very little is gained by increased amounts.

Filter cycles are also dependent upon the flow rate through the filter. Flow rate is usually expressed as gallons per square foot of filter area per minute. The higher the flow rate, the less filter area required. This in turn reduces initial capital investment. But, conversely, by doubling the rate, the cycles are decreased by more than a factor of two. This means more filter down-time, higher labor costs and higher filter aid costs. The optimum rate should give a proper balance in the factors affecting overall costs such as capital investment, operating costs and scheduling. It is generally true that the faster the flow rate, the shorter the cycle. This is not a linear relationship, however.

The primary reason for decreased flow through a filter cake is a decrease in cake porosity as pressure builds up during the cycle. Theoretically a porosity decrease of only 27 per cent causes a ten-fold decrease in flow. This decrease in porosity is controlled by the following factors respectively:

1. Consolidation due to a rearrangement of particles into a more close packed array.
2. Consolidation due to floc breakdown.

3. Consolidation due to deformation of the particles in the filter cake.
4. Consolidation due to the solution and consequent disappearance of particle solids being removed by filtration.
5. Consolidation due to the actual crushing of hard particles.

Some of the above factors do not begin to exert an influence until the pressure across the cake has reached a definite point. Consequently, a typical pressure vs. time filtration curve will tend to show a relatively slow increase in pressure with time and then an abrupt break will occur with pressure increasing very rapidly. This sudden break can occur anywhere between 15-40 pounds, depending upon compressibility of the cake.

Prior discussion has been limited mainly to the use of diatomite without delving into various types of filters. Diatomite filters have been in use for a variety of industrial filtrations for over 40 years. In the last decade, an increasing number of filter manufacturers have introduced entirely new types of units or complete redesigns of older units. These new units can be designed for specific systems and most manufacturers have representatives available for discussing specific applications and to work on engineering design details.

Pressure Filters

Generally speaking, diatomite filters for waste streams and subsurface injection fall into two main classifications: pressure filters and rotary vacuum precoat filters. In most pressure filters the element, or septum, consists of either a cylinder or a metal leaf. The cylinder type is usually a series of vertically mounted tubes fabricated of a suitable framework of either metal, plastic or porous stone. The tubes can be covered with wire or cloth septums.

A general design of tubular element filter consists of one closed end with an open end attached to a tube sheet. Tubes and tube sheet are mounted in a pressure vessel and flow during filtration is into the vessel, through the tubes from outside to inside, out the top of the tubes into an open space above the tube sheet and then out the discharge line. This type of filter should be constructed so that it has a dome in which air is trapped for backwashing purposes at the end of a cycle. A quick opening valve in the drain line is tripped and the air cushion expands rapidly, forcing filtered liquid backward through the tubes in an explosive bump. This cleans off the accumulated cake which is then carried out as filter drains.

A second type of pressure filter consists of metal leaves covered with wire screen, or synthetic or natural cloth. These leaves can be of various geometric configurations, mounted either in a horizontal or vertical pressure vessel. Several designs are utilized for mounting, manifolding, securing in place or each can have individual outlets. Flow is into the vessel, through the septum and into the discharge manifold.

These filters can be cleaned by sluices mounted inside the shell. A refinement of the sluicing method is a pressure leaf which rotates during sluicing so that each section of leaf receives the full force of the sluicing jet. Another cleaning method consists of draining the filter, after which the leaves are removed or retracted from the filter shell with the cake in place. The cake is then dropped in dry form into a hopper or collecting device. Leaves in these filters are usually spaced from one to four inches apart, depending on thickness of filter cake.

Pressure filters are primarily used where a relatively porous filter cake can accumulate and the amount of solid in the liquid being filtered is small. This will insure obtaining cycles of reasonable length of from eight to twenty-four hours. It ordinarily takes 30 minutes to clean and precoat an adequately designed pressure filter, which makes operating utility quite high.

Rotary Vacuum Precoat Filter

The rotary vacuum precoat filter consists of a horizontal drum covered with cloth or wire and submerged in a tank according to individual design, but in general vacuum is applied to panels under the cloth running lengthwise on the inside of the drum. By means of internal piping and a suitable rotary vacuum tight valve, liquid is withdrawn and the cake dried in one continuous operation. A cutting blade is mounted on the tank and is geared to advance towards the drum as it rotates. In the operation of the rotary vacuum precoat filter, the drum is first precoated while rotating at about three minutes/rev by circulating a one to two per cent slurry of diatomite through the filter. A precoat of 2-1/2 inches is usually sufficient at which time the filter is ready for feed liquor.

When precoating is completed the raw charge is fed into the filter tank and a thin cake of solids forms on the precoat as the drum rotates. The liquid is drawn through the precoat and filter into a vacuum filtrate receiver. As the drum continues to rotate the cake emerges from the slurry and goes through a drying cycle. The cake then encounters the cutting; at this point, the cake and a thin layer of precoat is shaved off presenting a clean filtering surface for the next cycle. Cuts can be controlled from 0.005 to 0.0005 inches.

Rotary vacuum filters are especially adaptable for high solid content streams and cycle lengths of 100 hours are not uncommon. This all depends upon solid load and nature. Specific details on designs and applications of either pressure or rotary vacuum filters may be obtained from reputable filter representatives.

SUMMARY

In our modern technological era, where greater emphasis has been placed upon developing safe methods for subsurface injection of wastes and underground pressure maintenance, diatomite filtration has begun to play a major role. Superior quality injection streams can be obtained by diatomite filtration at competitive costs with other means. At the same time, the positive removal of practically 100 per cent of the solid particles and bacteria of certain sizes provides additional protection against substrata plugging and increased pressure which could cause fracturing and higher pumping costs. A large variety of filters and diatomaceous earths are available. With a well designed, correctly operated unit, many waste problems can be completely alleviated through diatomite filtration.