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INTRODUCTION

During the flow of fluids through process pipelines and equipment, solid particles of dirt, rust, scale.. etc, may be picked up by the fluids. These solids can cause damage to equipment by erosion and blockage. In order to minimize this problem, Filters or Strainers are installed in piping, upstream of equipment in which solid particles are undesirable.

As an example, strainers are installed upstream of some steam-traps which, if solid particles were to enter the trap, its operation would be affected adversely.

Filters are constructed according to the duty they are to perform - a good example is the air filter in the intake to a car engine. It is made of very fine material in order to remove very tiny particles of dust which would cause problems in the carburettor where the air is mixed with the fuel. The fuel is also filtered before mixing.

To protect the engine bearings, shafts, gears and pistons …etc, the car lube oil is also filtered. In all cases where filters or strainers are used, they must be cleaned or the dirty elements changed for clean ones as soon as the filtration process becomes poor and fluid flow decreases.

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1. FILTERS (Figure: 24)

Filters are generally constructed as cylinders containing some type of screening element through which the fluids are forced to flow. The elements are made up of various types of materials depending on the degree of filtration required. Some filter elements consist of special paper which will collect solid particles while allowing the fluid to pass through.

Filters used in process operations to remove solid particles, are constructed of a number of elements made up of wire frames or perforated metal tubes encased by finely woven cloth or metal wires (screens).

Other types contain fibre-glass elements which adsorb the particles of dirt, scale and rust. Still further types consist of 'basket' type elements which can easily be removed, cleaned and replaced. The filter elements are placed in a cylindrical vessel which is connected into the pipe-work carrying the fluid.

In continuous processes, two filter units may be installed, where one is in use while the other is on 'standby'. A total filter bypass is also usually fitted for use should both units become fouled due to excess solids in the system not allowing cleaning or element replacement to take place. However, in such a case, the filters must be re-commissioned as soon as possible.

The system will have a means of measuring the pressure drop across the filter and, when this D.P. reaches a certain point, an alarm switch may be activated. The filters must then be changed over, the dirty filter is then isolated, de-pressured, drained and opened up to remove the dirty elements. New elements are then installed and the unit 'boxed up'.

The clean filter is then refilled and/or re-pressurized by using the small lines and valves provided. While refilling, air is vented to ensure that the filter is liquid/gas full. It is then placed on 'standby'. Where a single filter unit is installed, again, the bypass is used while cleaning is carried out.

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Figure: 24

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2. STRAINERS

Strainers are generally constructed of finely perforated metal tubes or cones or of woven wire mesh. They are often used temporarily after new piping has been installed or maintenance carried out on a process system. Their purpose in this case is to remove debris such as welding dross or pieces of solid material which entered the system while the work was being done.

Where small piping like fuel supplies, air to instruments and steam / condensate systems are concerned, strainers are installed to ensure the smooth operation of instruments and steam traps by removing solid particles.

The main types of strainer used in such systems are :

1. THE 'Y' STRAINER.
2. THE 'T' STRAINER
3. THE 'CONE' STRAINER.

The following diagrams show the application of strainers in process operations.

(See Figures : 25, 26 & 27)

THE 'Y' STRAINER
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Figure : 25

'T' TYPE STRAINERS
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'CONE' TYPE STRAINERS
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3. STEAM TRAPS

In operations involving the use of steam for heating process fluids in exchangers, vaporizers, reboilers … etc, much of the steam condenses back to water as it gives up its latent heat to the process fluids. The water, if allowed to remain in the system, would cause problems leading to loss of efficiency and would cause 'Water Hammer' in the piping.

Water hammer is caused when water in steam pipes is allowed to build up. The steam travelling at high velocity pushes slugs of water along the pipe until it slams up against a bend or fitting in the system. The force of the water striking the bend causes a noise like a hammer blow and, at the same time the force of the impact produces a heavy shaking and vibration of the pipe-work. The power of this hammering can result in damage to piping and equipment. The slugs of water in the piping also cause 'steam-lock' in the system giving rise to pressure surges as steam flow is temporarily blocked. Another effect, is the rapid condensation of steam and re-vaporization of water which also causes pressure surges within the system.

The only way to prevent water problems in steam systems is to ensure that the water is continuously drained away. To have an operator standing by each steam system to drain off water would be very uneconomical and a waste of manpower.

To deal with the problem, 'STEAM TRAPS' are installed at strategic points in a steam system.

The steam traps are automatic in operation and, when properly maintained will perform the job of water removal continuously and efficiently.

There are various types of steam trap. The main types are listed and explained as follows :

1. MECHANICAL TRAP
2. THERMOSTATIC TYPE
3. THERMO-DYNAMIC TYPE

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1. THE MECHANICAL STEAM TRAP (Float Type)

The Float type steam trap consists of a chamber having inlet and outlet ports. The chamber contains a stainless steel ball-float connected by a lever to the inside of the chamber wall. In the body of the trap, the outlet port has valve seats fitted to accommodate a valve plug which is fitted to the lever between the float and the chamber wall.

When the trap is empty, the ball float is down and the outlet valve is closed. As condensate (water) enters the trap and forms a level, the ball begins to float and rise with the rising level.

At a pre-set level the rising lever actuates the valve plug and opens the valve. Condensate passes out of the trap, the level falls and the valve closes down. In this way, the level of condensate is controlled and no steam loss is incurred. This type of trap works well with heavy or light condensate loads.

There is however, one point to mention, steam contains small amounts of uncondensible gases and these can build up in the trap and cause loss of efficiency. The trap is therefore fitted with a vent valve at the top to periodically release these gases. This type of steam trap has the disadvantage of possible freezing in winter conditions and can be damaged by water hammer (previously mentioned).
(See Figure : 28)

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2. THE THERMOSTATIC STEAM TRAP (Balanced Pressure Trap)

This type of steam trap has a sealed, internal bellows element filled with a liquid which has a boiling point about 25°C below that of water. Heating or cooling of the element causes it to expand or contract. The bottom of the element is connected to a valve which fits into a seat in the trap body.

When the trap contains steam, the bellows is expanded by boiling the liquid inside and the valve is closed. As condensate fills the trap, it cools and the bellows begins to contract as its internal liquid stops boiling. This opens the valve and the liquid is drained off and then replaced by steam. Once again the bellows expands and closes the valve.

For the brief time taken for the expansion of the bellows to take place, a small amount of steam escapes from the trap. Variations in steam system pressure will cause a change in the boiling point of the liquid in the bellows thereby automatically adjusting the internal pressure compared to the steam pressure. Hence the trap being called a 'Balanced Pressure Trap'.

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3. THE THERMO-DYNAMIC STEAM TRAP

This type of steam trap, when installed, has a strainer fitted into the line upstream of it, to remove solid particles of scale ..etc. As condensate enters the trap, through the inlet pipe with the steam pressure behind it, a metal disc is forced upwards into a small chamber and the condensate passes under the disc into the outlet pipe.

The velocity of the water passing through the trap is low, even when the pressure is high. This is due to the density of the water being high compared to that of steam and the fact that, within the trap, the fluids pass through an angle of 180°.

When all of the water has been displaced, steam begins to flow. The greater velocity of the steam below the disc and the sudden change of direction, causes a pressure drop under the disc which pulls it down onto its seat and stops the steam flow.

The steam pressure in the chamber above the disc will be the same as the line pressure thereby holding the disc on its seat. When the steam above the disc cools and condenses, the chamber pressure falls and the disc is forced upwards again by the line pressure.

If only steam passes into the trap, the above process is repeated with a small release of steam until the disc drops again.

This type of trap is recognized by the quick hiss of escaping steam every few seconds.

(See Figure : 30)

THE THERMO-DYNAMIC STEAM TRAP

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EJECTOR SYSTEMS INTRODUCTION

In many processes, VACUUM is a required condition for the operations involved. In some smaller applications, 'Vacuum Pumps' are used to fulfil the requirements.

Some distillation processes for example, are carried out under vacuum (at pressures below that of the atmosphere). The application of vacuum, decreases the boiling points of the liquids being separated, thereby reducing the amount of heat energy needed for the operation.

Atmospheric pressure, as we know, is expressed as 14.7 psia. However, in modern industry, the S.I. units of pressure in use are 'kilopascals' (kPa), where atmospheric pressure is expressed as 101,000 Pa (Pascals) or 101 kPa.

One Pascal is equal to One Newton per Square Meter :
$1 \text{ Pa} = 1 \text{ N/m}^2$

Using the Imperial System, vacuum is generally measured in Inches of Mercury ("Hg) or in Inches of Water ("H2O). In this system, Atmospheric pressure is equal to 30 "Hg. The Metric System (S.I.) uses ' Millimetres of Mercury ' (mmHg), where atmospheric pressure is equal to 760 mmHg, or 1 atmosphere or about 1 bar.

EJECTORS & EDUCTORS

Where process equipment is to be operated under vacuum, a popular method of creating the vacuum is by the use of Ejector Systems. An ejector uses the Bernoulli Principle of creating vacuum in that a high pressure fluid (often steam) is passed through a 'Venturi' tube. The narrow section of the tube causes an increase in the fluid velocity which produces a pressure drop in the system.

A 'suction' line from the equipment to be put under vacuum is connected into the ejector and, depending on the operation to be performed, gases and maybe liquids will be pulled out by the ejector action.

In a vacuum distillation unit, steam jet ejectors are used to pull the overhead vapours from the column through the overhead condenser. The process of condensation of vapour also causes a vacuum to be created. The ejectors improve and maintain the vacuum by removing the uncondensible gases. (See Figure : 31)

STEAM EJECTOR SYSTEM
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Figure : 31

In a condensing steam turbine unit, the same principle is used to maintain a high vacuum in the exhaust steam surface condenser. Its purpose is to obtain maximum power from the steam driving the turbine.

In this system, the steam exhaust is first condensed in the surface condenser by cooling water coils. The process of condensation causes a very large decrease in volume - (changing high pressure, superheated steam to water decreases volume by about 1800 times - i.e. 1800 ft^3 of steam will condense to 1 ft^3 of water). This huge volume decrease creates a vacuum.

However, in such systems, uncondensible gases are also present and, if they aren't removed, they will build up and destroy the vacuum. To remove these gases, steam ejectors and ejector condensers are used. The gases are pulled from the surface condenser by a set of steam ejectors.

The ejector steam is then condensed in a separate exchanger which again helps to maintain the vacuum. The condensed steam (water) is piped away from the ejector condenser to the surface condenser.

Again however, the uncondensibles will tend to build up in the ejector condenser. These are pulled out by a second stage ejector system and the process repeated. The gases are allowed to build up in the second ejector condenser until they reach a pressure which will open a check valve and go to atmosphere. (See Figure : 32)

An 'EDUCTOR' is similar in operation to the ejector and can use any high pressure fluid as its motive force. They are used to cause a flow of air through a tank or vessel inside of which men are to work. An eductor can also be used to 'pump out' liquids from pits and vessels.

SURFACE CONDENSER
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Figure : 32