Tech Sheet #ST 103

Steam: Yesterday, Today and Tomorrow
The Use of Steam as an Efficient Heat Source

The mention of steam conjures up the thought of days gone by when steam was used to power engines, to pump water for mines and replace the muscle power of men and animals. In reality, steam, which powered the industrial revolution of yesterday, is still the most popular heat transfer medium in many industries. Steam continues to be an efficient heat source for industry throughout the world.

AN EFFICIENT HEATING MEDIUM

Steam is an excellent heat transfer medium. Plant engineers depend on steam systems for a wide range of applications. Steam is often chosen over other energy sources (i.e., natural gas and fuel oil) because of its unique advantages. Examination of Table 1 shows the properties of steam as a heat carrier and suggests the following points which describe the advantages of steam as an efficient heat source:

- **High Heat Content**

Steam has a high latent heat content, which is given up during the process of condensing to provide heat. If we compare this to the usable heat available from hot water (sensible heat), steam can provide over five times the heat by mass (see Table 1). Large amounts of heat energy can be distributed economically through a given pipe size using steam instead of water.

- **Heat Transfer – Advantage Of Steam**

Steam offers significant advantages at the point of use. For example, if we compare the heat transfer rate for steam as compared to hot water, we find that steam can provide significantly higher heat than water. For a submerged coil heating application supplied with steam, the coils would only be a fraction of the length of coils fed with hot water. This is because the heat transfer rate from steam to water is about six times that of the rate of heat transfer from water to water. A steam coil can reduce the heating surface by up to 50% as compared to a hot water coil with cost savings on initial purchase price of up to 35%.

- **Pumping**

Steam flows in response to pressure drop along the distribution line and, therefore, eliminates large and expensive circulating pumps. The steam system requires only a boiler feed pump and sometimes a condensate return pump, but these are insignificant compared to circulating pumps, which are required in hot water systems.

- **Control And Flexibility**

The pressure-temperature relationship of steam, as shown in Table 1 provides for simple control. Lower temperatures can be obtained readily by using a pressure reducing valve to lower the steam pressure. The pressure reducing valve allows the end user to customize the steam pressure for each application. Another characteristic of steam is that it maintains a constant temperature as it condenses and gives up heat. This can be valuable for certain process applications.

- **Highly Responsive**

Steam is a gas and is highly responsive as a heat transfer medium. It can respond more quickly to changes in demand than a liquid because a vapor flows far more rapidly in a pipe than a liquid does.

- **Ease Of Distribution**

Steam's unique features allow steam lines to be relatively lightweight. Steam is a gaseous form and contains high heat content that can be delivered through distribution lines to points of use far more efficiently than any other medium. At the point of use steam gives up its heat when it condenses. Approximately 900 Btu's per pound of steam is released when condensation occurs with heat transfer coefficients ten to one hundred times higher than those of hot water when heating air. In hot water systems, for example, pipe sizes may need to be two times larger than steam systems to deliver the same amount of heat. Steam lines can also be readily shut down when steam is not required.

STEAM: YESTERDAY, TODAY, and TOMORROW

Steam was harnessed to drive the steam engines which triggered the industrial revolution. Engineers and designers realized that steam could be used not only to power engines, but also to provide an efficient heat transfer medium. While electricity eliminated the need for steam engines, it did not eliminate steam's other advantages . Ironically, today, most electricity is still generated using steam turbines for driving power.

Today, steam remains an excellent heat transfer medium, as indicated by all the advantages that we have discussed, e.g., high heat content, heat transfer advantages, ability to be circulated without pumps, flexibility, and ease of control and distribution. In many industries, including, for example, the chemical processing industry, it is the most popular heat transfer medium.

Due to all of its advantages, steam will continue to be the most effective and convenient way to convey heat. This superior heat transfer medium powered the industrial revolution of yesterday, continues to work for us today, and will always be an efficient heat source

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TABLE 1.0

Properties of Saturated Steam
(Abstracted from Keenan and Keyes, THERMODYNAMIC PROPERTIES OF STEAM, by permission of John Wiley & Sons, Inc.)

Gauge Pressure (psig)	Absolute Pressure (psia)	Steam Temp. (°F)	Heat of Saturated Liquid (Btu/lb)	Latent Heat (Btu/lb)	Total Heat of Steam (Btu/lb)	Specific Volume of Saturated Liquid (cu ft/lb)	Specific Volume of Saturated Steam (cu ft/lb)
0.0	14.696	212.00	180.07	970.3	1150.4	0.016715	26.80
15.3	30.0	250.33	218.82	945.3	1164.1	0.017004	13.75
50.3	65.0	297.97	267.50	911.6	1179.1	0.017429	6.66
125.3	140.0	353.02	324.82	868.2	1193.0	0.018024	3.22

APPENDIX

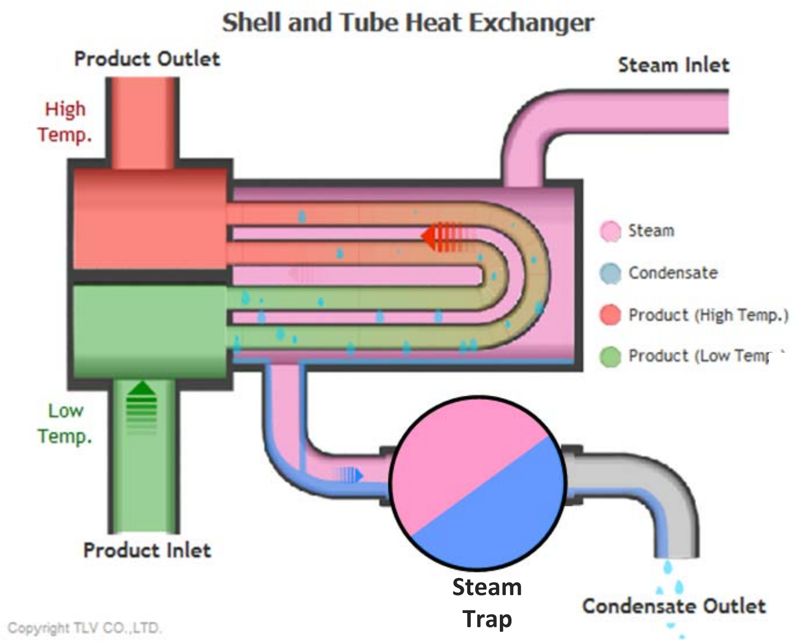
TYPICAL INDUSTRIAL APPLICATIONS & USES OF STEAM

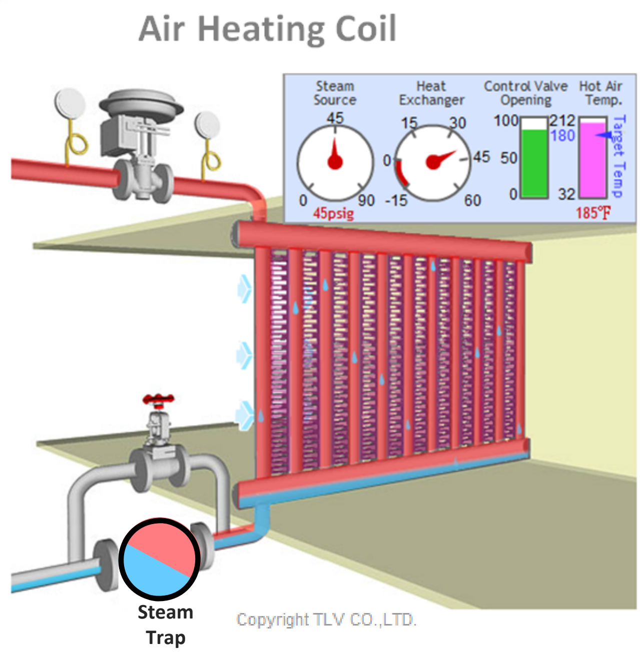
Steam for Heating

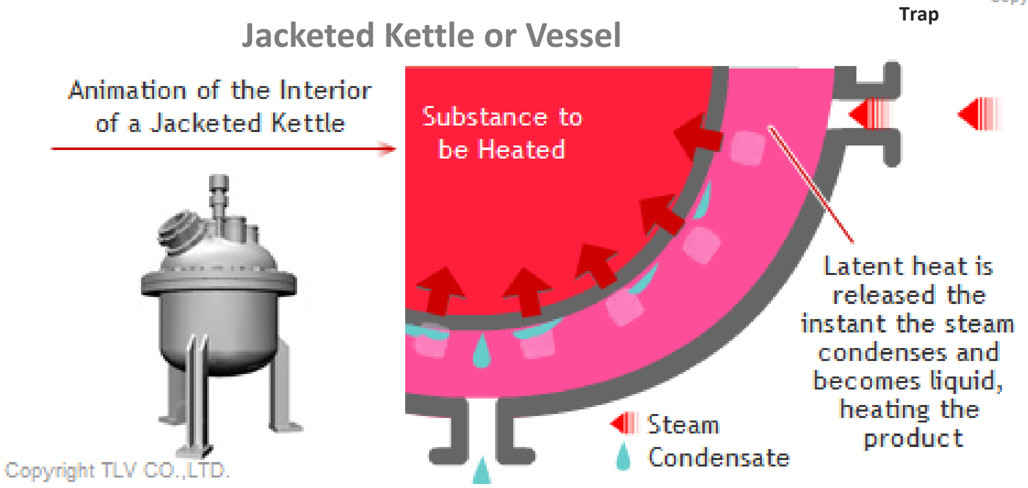
Positive Pressure Steam

Steam is typically generated and distributed at a positive pressure. In most cases, this means that it is supplied to equipment at pressures above 0 MPaG (0 psig) and temperatures higher than 100°C (212°F).

Heating applications for positive pressure steam can be found in food processing factories, refineries, and chemical plants to name a few. Saturated steam is used as the heating source for process fluid heat exchangers, reboilers, reactors, combustion air preheaters, and other types of heat transfer equipment.







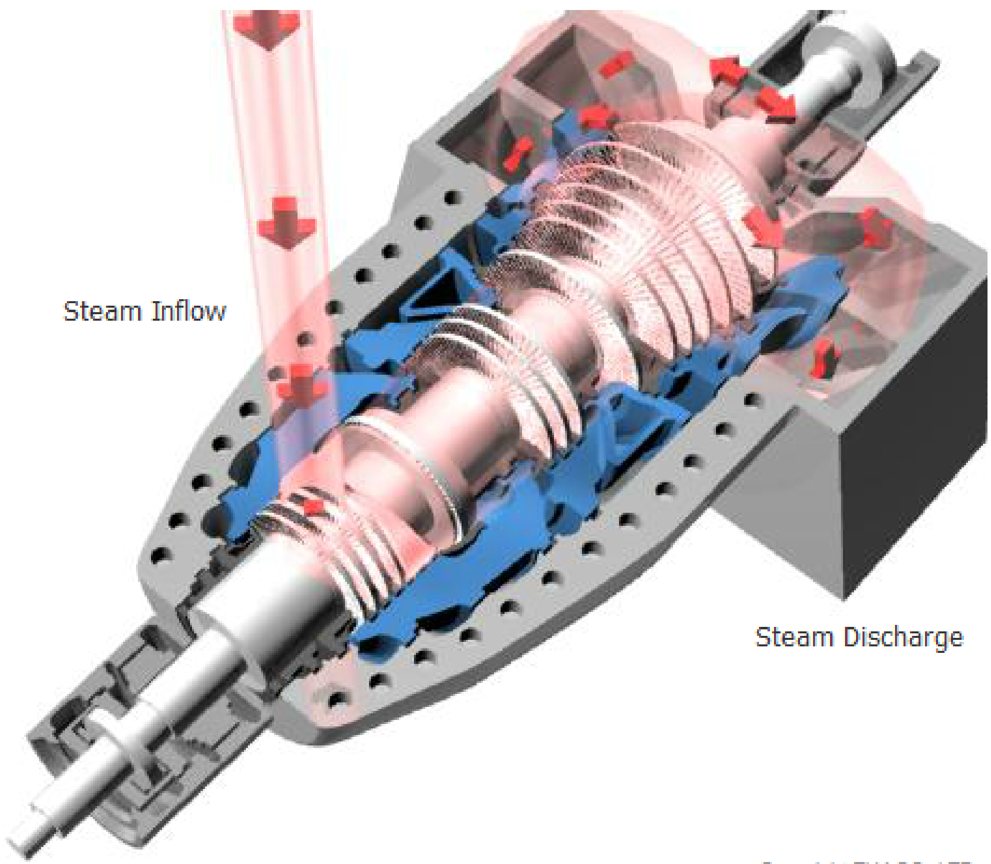
Steam for Propulsion/Drive

Steam is regularly used for propulsion (as a driving force) in applications such as steam turbines. The steam turbine is a piece of equipment that is essential for the generation of electricity in thermal electric power plants. In an effort to improve efficiency, progress is being made toward the use of steam at ever-higher pressures and temperatures. There are some thermal electric power plants that use 25 MPa abs (3625 psia), 610°C (1130°F) superheated, supercritical pressure steam in their turbines.

Superheated steam is often used in steam turbines to prevent damage to equipment caused by the inflow of condensate. In certain types of nuclear power plants, however, the use of high temperature steam must be avoided, as it would cause problems with the material used in the turbine equipment. Instead, high pressure saturated steam is typically used. Where saturated steam must be used, separators are often installed in the supply piping to remove entrained condensate from the steam flow.

Besides power generation, other typical propulsion/drive applications are usually for either turbine-driven compressors or pumps, ex. gas compressors, cooling tower pumps, etc.

Generator Turbine

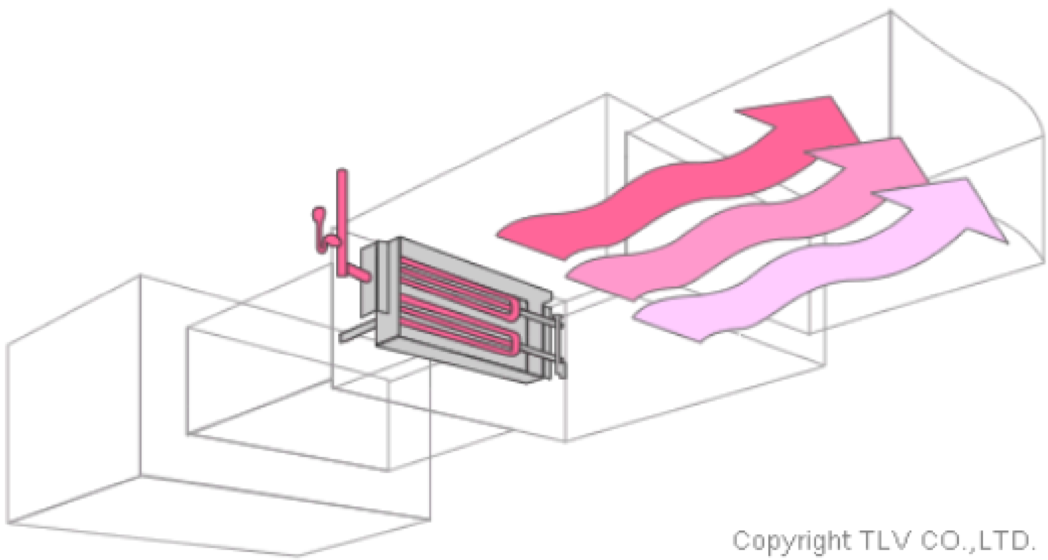


The driving force from the steam causes the fins to turn, which then causes the rotor on the attached power generator to rotate, and this rotation generates electricity.

Steam for Humidification

Many large commercial and industrial facilities, especially in colder climates, use low pressure saturated steam as the predominant heat source for indoor seasonal heating. HVAC coils, often combined with steam humidifiers, are the equipment used for conditioning the air for indoor comfort, preservation of books and records, and infection control. When the cold air is heated by the steam coils, the relative humidity of the air drops, and it must then be adjusted to normal levels with addition of a controlled injection of dry saturated steam into the downstream air flow.

Steam Humidifier in Air Duct

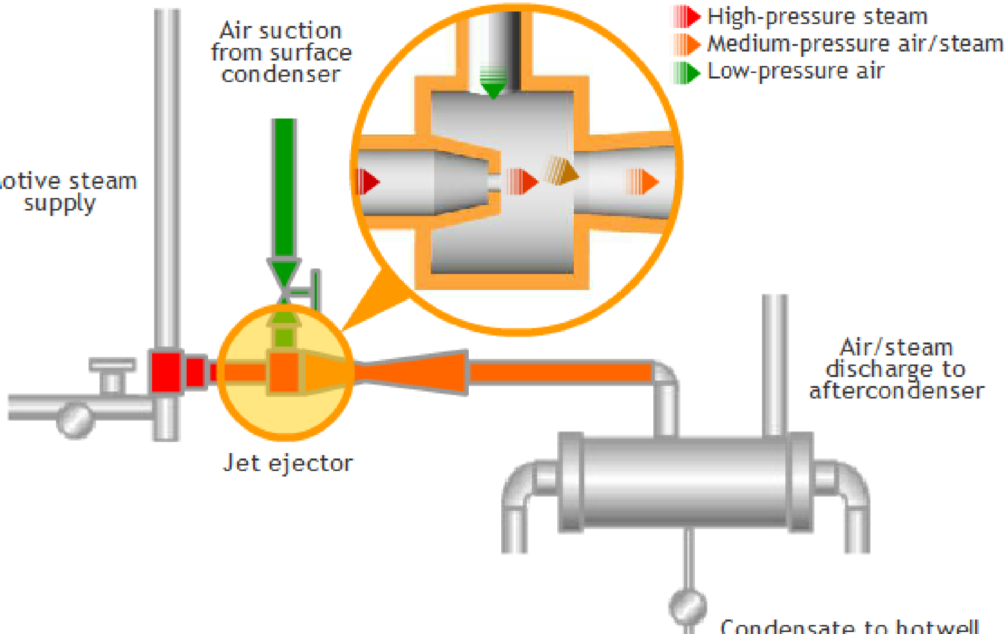


Steam is used to humidify air within an air duct before the air is distributed to other regions of a building.

Steam as Motive Fluid

Steam can also be used as a direct "motive" force to move liquid and gas streams in piping. Steam jet ejectors are used to pull vacuum on process equipment such as distillation towers to separate and purify process vapor streams. They are also used for continuous removal of air from surface condensers, in order to maintain desired vacuum pressure on condensing (vacuum) turbines.

Ejector for Surface Condenser



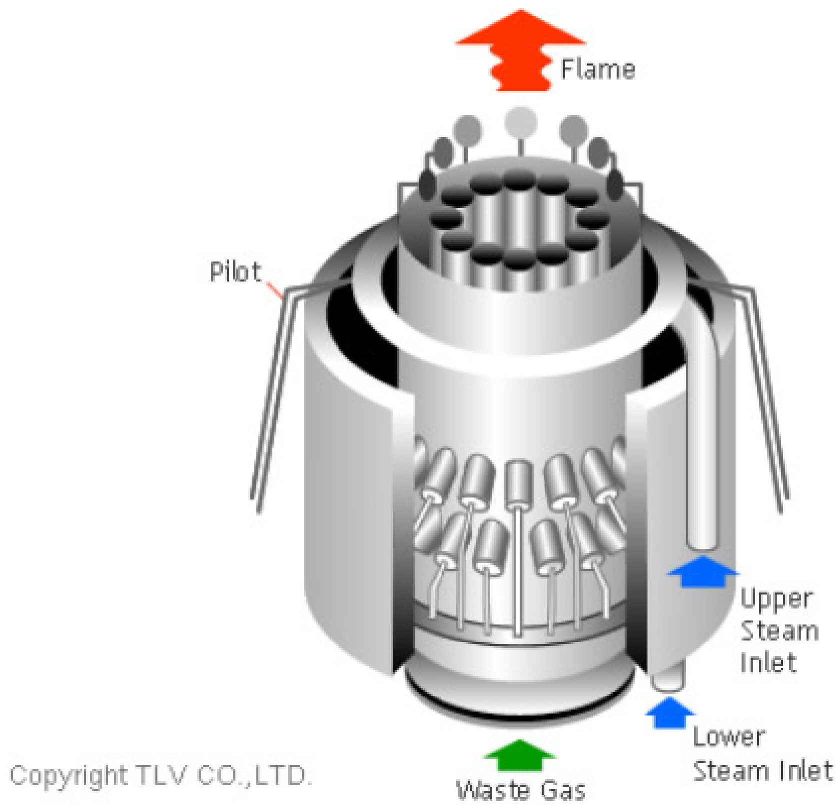
High pressure motive steam enters the jet ejector through the inlet nozzle and is then diffused. This creates a low pressure zone which entrains air from the surface condenser.

In a similar type of application, steam is also the primary motive fluid for secondary pressure drainers, which are used for pumping condensate from vented receiver tanks, flash vessels, or steam equipment that experiences stall conditions.

Steam for Atomization

Steam atomization is a process where steam is used to mechanically separate a fluid. In some burners, for example, steam is injected into the fuel in order to maximize combustion efficiency and minimize the production of hydrocarbons (soot). Steam boilers and generators that use fuel oil will use this method to break up the viscous oil into smaller droplets to allow for more efficient combustion. Flares also commonly use steam atomization to reduce pollutants in the exhaust.

Steam Assisted Flare

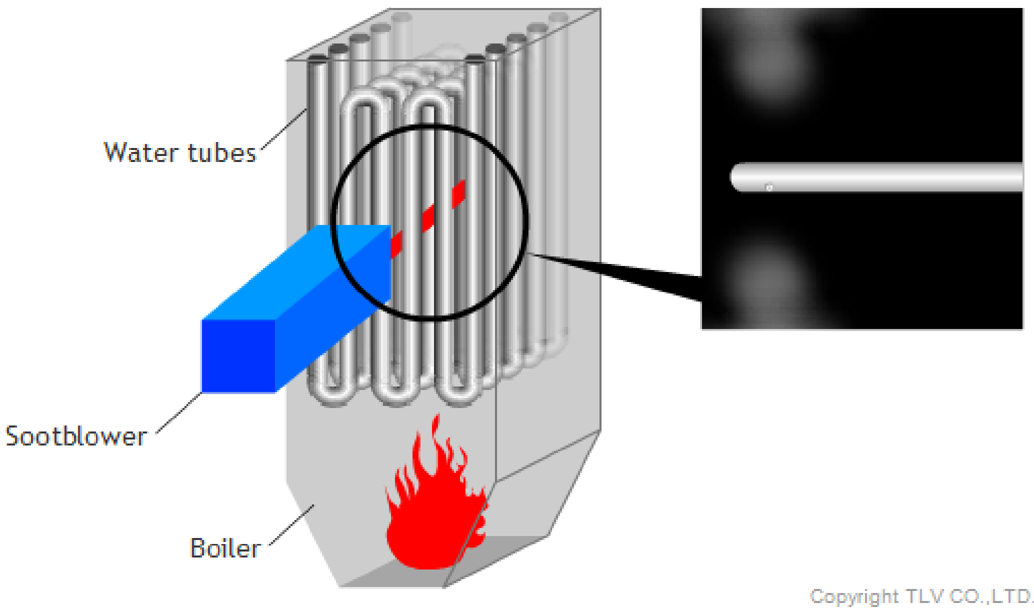


In flares, steam is often mixed in with the waste gas before combustion.

Steam for Cleaning

Steam is used to clean a wide range of surfaces. One such example from industry is the use of steam in soot blowers. Boilers that use oil or coal as the fuel source must be equipped with soot blowers for cyclic cleaning of the furnace walls and removing combusted deposits from convection surfaces to maintain boiler capacity, efficiency, and reliability.

Boiler Tube Cleaning with Soot Blower

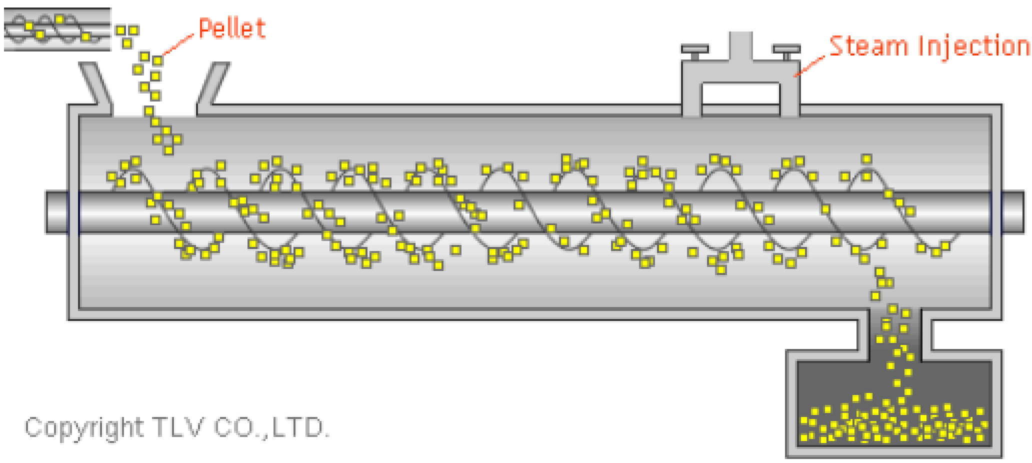


Steam released out of the soot blower nozzle dislodges the dry or sintered ash and slag, which then fall into hoppers or are carried out with the combusted gasses.

Steam for Moisturization

Steam is sometimes used to add moisture to a process while at the same time supplying heat. For example, steam is used for moisturization in the production of paper, so that paper moving over rolls at high speed does not suffer microscopic breaks or tears. Another example is pellet mills. Often mills that produce animal feed in pellet form use direct-injected steam to both heat and provide additional water content to the feed material in the conditioner section of the mill.

Pellet Mill Conditioner



The moisturizing of the feed softens the feed and partially gelatinizes the starch content of the ingredients, resulting in firmer pellets.