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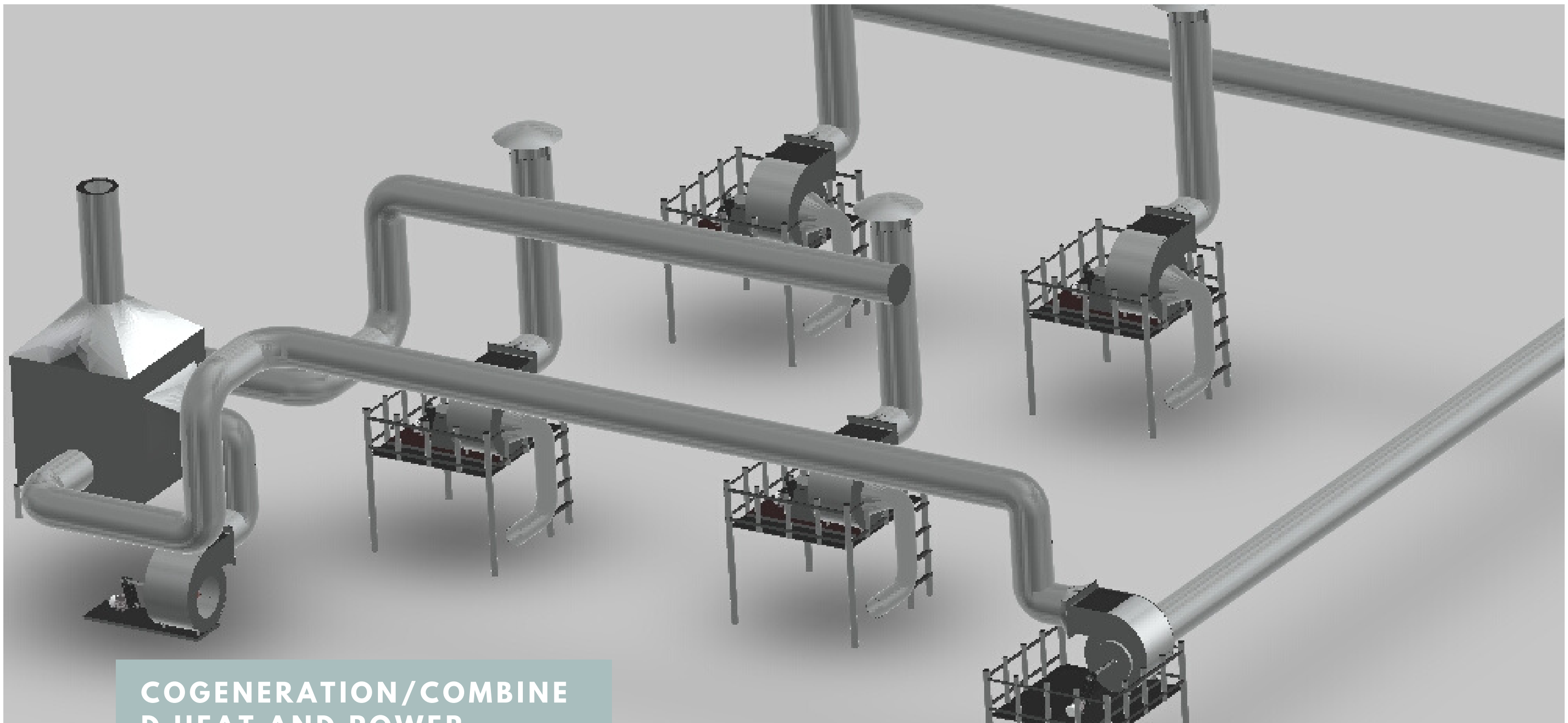
HEAT RECOVERY FOR PROCESS EFFICIENCY



COGENERATION/COMBINED HEAT AND POWER PLANTS HAVE BEEN DEVELOPED AND APPLIED TO CERAMIC MANUFACTURING (SEE FIG. 2). THE HEAT GENERATED BY THE COGENERATION GAS ENGINE IS FED INTO A MIXING CHAMBER WITH THE KILN FLUE GAS. IF THE HOT AIR TEMPERATURES IS NOT SUFFICIENT, A GAS BURNER IS USED. THE RADIATION HEATING CAUSED BY THE KILN GO THROUGH A HEAT EXCHANGER HEATED BY THE COOLING WATER OF THE COGENERATION GAS ENGINE. THIS HOT AIR IS THEN FED INTO THE MIXING CHAMBER .

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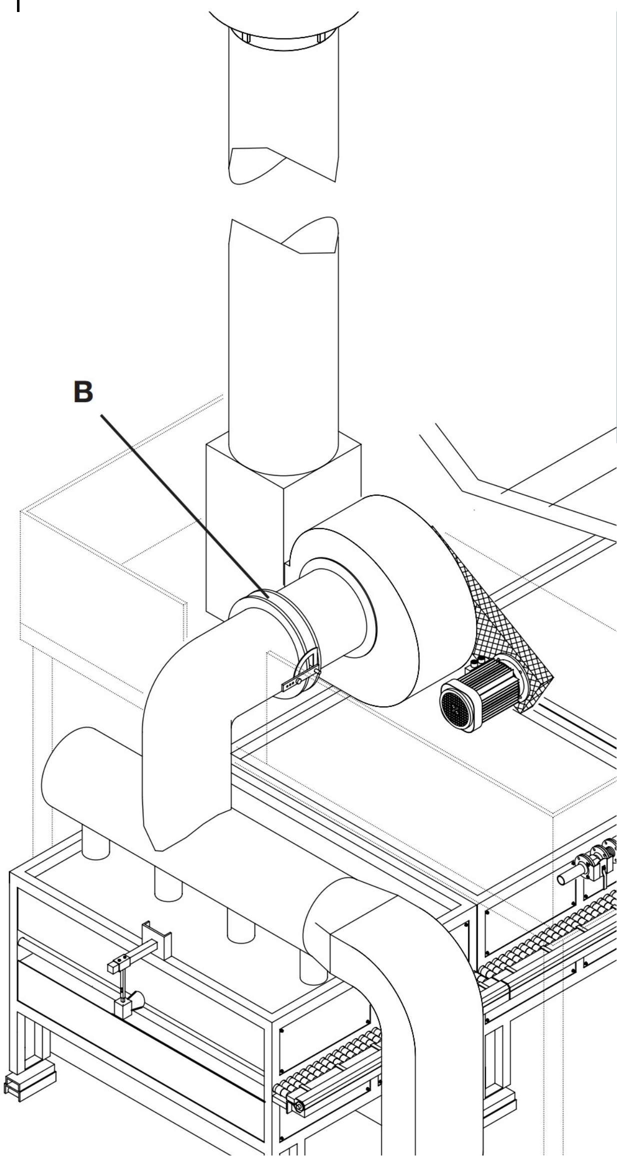
ABSTRACT

This paper investigates the application of heat-pipe based heat exchanger for improving the energy efficiency of industrial processes. In particular, the case of the ceramic industry is addressed and the potential heat recovery and reduction of fuel consumption is determined. A theoretical model is constructed based on the established, proven performance characteristics of heat-pipe technologies and the performance of the ceramic process are calculated using numerical simulation. The results of the kiln numerical model are then combined to the theoretical model of the heat-pipe based heat exchanger and the heat recovery potential is evaluated as well as the reduction of fuel consumption. The combined theoretical and numerical approach demonstrates that the application of the heat pipes based heat exchanger to the cooling stack of the ceramic kiln enables to recover more than 863 MWh of thermal energy that can be used for heating up the hot air stream of the pre-kiln dryer. Thus, approximately 110,600 Sm3 per year of natural gas can be saved from the burners powering the dryer and the emission of 164 tonnes per year of carbon dioxide can be avoided. Additionally, the avoided cost due to the fuel consumption reduction amounts to more than 22,000 Euro per year. These figures support the application of the heat pipes based heat recovery to the ceramic process from the viewpoint of the improvement the energy efficiency and environmental impact and also of the economic investment.

INTRODUCTION

The use of heat pipe heat exchangers to recover waste heat from industrial exhaust streams has been investigated and applied in many sectors such as: steel, food and transportation. Heat pipes are defined as a passive heat transfer technology capable of transferring large amount of heat with no moving parts. A heat pipe is composed of a sealed tube with working fluid acting as the heat carrier. The working fluid is condensed at the top section of the tube and evaporating at the bottom, this will create a two phase heat transfer cycle [1]. Heat pipe heat exchangers are composed of rows of heat pipes exposed to an exhaust stream at the bottom and a cooling fluid (Air, water, etc ...) on the condenser section. Heat pipe units have been tested in different conditions (temperatures, cooling fluid, evaporator fluid, working fluid). En Tian developed a heat pipe heat exchanger to recover the heat in a high temperature and challenging exhaust to transfer the heat to a clean air stream. The top part of the heat pipe is composed of a tube bundle with the air going through tube while the bottom part is composed of finned pipe. The system was able to save up to 15% of natural gas without any blockage on the exhaust side [2]. Jouhara and Meskimmon investigated the application of heat pipe heat exchanger technology in data centre cooling system. The amount of heat produce by computing can be substantial. This work developed a heat pipe heat exchanger to cool down data centre chamber using none pure air from the outside. The heat exchanger had a potential of 75% of energy savings by utilising heat pipe technology [3]. A.R.Lukitobudi designed a heat pipe based heat exchanger to recover heat from a bakery oven to recover hot air. The effectiveness of the designed heat pipe heat exchanger was 65% and was able to recover between 20 kW and 35 kW [4].

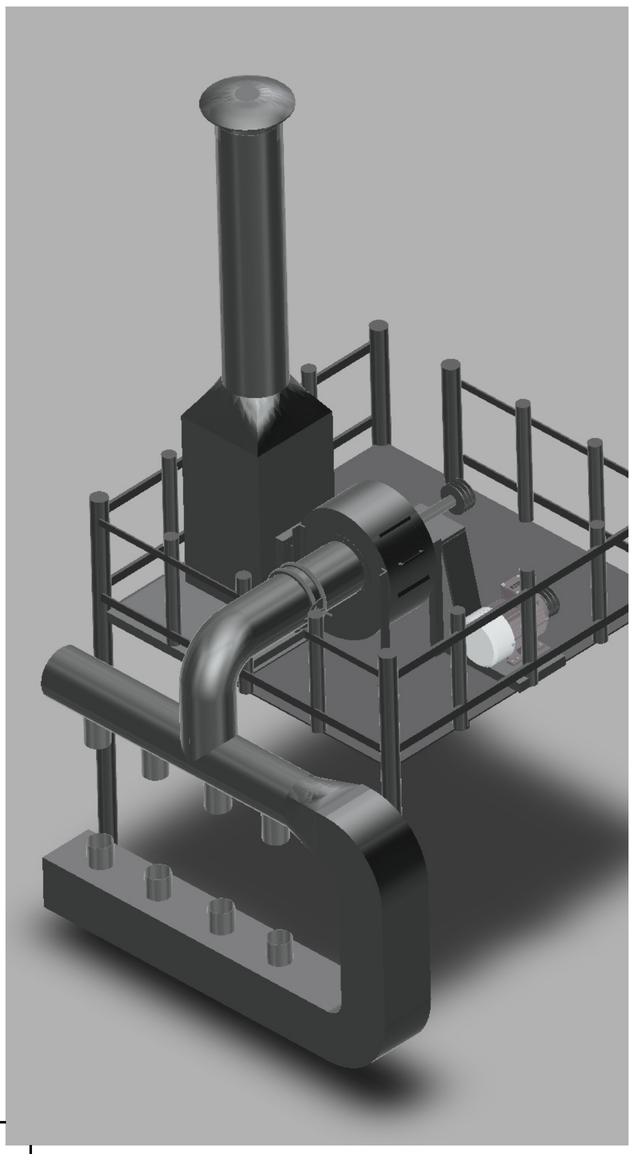
Many investigations have been conducted regarding the waste heat recovery from the cooling stage of ceramic kilns. Most of the innovative techniques have been summarized by Refs. [5] and [6] (see Fig. 1). The main waste heat recovery technique developed was the recovery of excess heat from the kiln. The hot air recovered from the cooling zone of the kiln is used to warm up the air for the drying stage. Due to the corrosion issue, standard heat exchangers are used to transfer the heat from the flue gas of the cooling zone to clean hot air which will be then sent to the dryer. The excess heat is also used to feed the burner with hot air as well as the central heating of the plant.



HOT AIR SUCTION IN FINAL COOLING

The system consists of a series of air intakes in the kiln crown by means of adjustable hoods with butterfly valves
, which are connected with piping to the suction inlet of the fan. The hot air is vented out of the factory through
a stack.
A connection can be pre-arranged to draw hot air for other utilities.
The discharge of the hot air into the atmosphere must always be free, without choking.

Heat recovery ventilation



Heat recovery ventilation (HRV), also known as mechanical ventilati heat recovery (MVHR), is an energy recovery ventilation system whi works between two sources at different temperatures. Heat recover is a method which is increasingly used to reduce the heating and cooling demands (and thus energy costs) of buildings. By recovering the residual heat in the exhaust gas, the fresh air introduced into the air conditioning system is pre-heated (pre-cooled), and the fresh air enthalpy is increased (reduced) before the fresh air enters the room the air cooler of the air conditioning unit performs heat and moisture treatment.[1] A typical heat recovery system in buildings consists of a core unit, channels for fresh air and exhaust air, and blower fans. Building exhaust air is used as either a heat source or heat sink depending on the climate conditions, time of year and requirements the building. Heat recovery systems typically recover about 60–95% of the heat in exhaust air and have significantly improved the energy efficiency of buildings

INDUSTRIAL CHIMNEY (STACK)

A FLUE-GAS STACK, ALSO KNOWN AS A SMOKE STACK, CHIMNEY STACK OR SIMPLY AS A STACK

An industrial chimney (stack) is an important subset of an aeraulic network, since it must guide fluids as varied as air, water vapor, fumes or gases from combustion eg wood, natural gas or city gas, fuel oil. It is often a mixture of oxygen, nitrogen, water vapor with other effluents such as carbon dioxide, carbon monoxide and various other oxides. Backed by a construction or self-stable (which is the general case), an industrial chimney (stack) must resist to the mechanical stresses due to wind, snow, earthquakes and must therefore be the subject of a careful structural study , for which it is sometimes necessary to take into account the additional load related to the insertion of soundproofing devices (silencers), platforms and means of access.

When transporting fluids at high temperatures (e.g. in the case of power plants based on combustion engines or on gas turbines), an industrial chimney (stack) must withstand the thermal stresses associated with the temperature gradient between the foot and the outlet, the thermal shocks during the commissioning or shutdown of equipment located upstream, which can be accompanied by sudden temperature variations, and in most cases have a high performance thermal insulation.

Taking into account the speed of the transported fluid is fundamental when studying an industrial chimney (stack).

This speed must be sufficiently low on the one hand to not be at the origin of an nappropriate total pressure loss due to the friction phenomena (it is often expected from a chimney - stack - a draugh effect related to the negative pressure loss resulting from the difference in the density of the fluid between the foot and the outlet); and on the other hand not to cause undesirable flow noise, especially if the chimney contains noise reduction devices such as absorbent separators, between which the velocity of the gases can be considerably increased , which can generate self noise.

However, in many cases, a low ejection speed limit is imposed, in relation to fumes plumes dispersion requirements.

Thus, often using a technology based on the implementation of a double envelope, the design, construction and installation of industrial chimneys (stacks) - sometimes: very high - are often an opportunity to take up major multidisciplinary challenges (mechanical, thermal, aerodynamic, acoustic), and still constitute a particular challenge of a project (the choice of appropriate cosntruction materials, and the quality of construction are, as often, fundamental with respect to robustness and durability).

CENTRIFUGAL FAN

CENTRIFUGAL

Most centrifugal motorized impellers use backward curved (BC) blades because they generate significant static pressure, operate silently, and provide the highest efficiency of all centrifugal fan designs. Airfoil designs (BCA blades) can deliver even higher performance. In order to achieve optimal performance, inlet cones should be used with centrifugal impellers. Depending on the application, a motorized centrifugal impeller may be pre-installed in a fan housing.

Common housing options for motorized centrifugal impellers

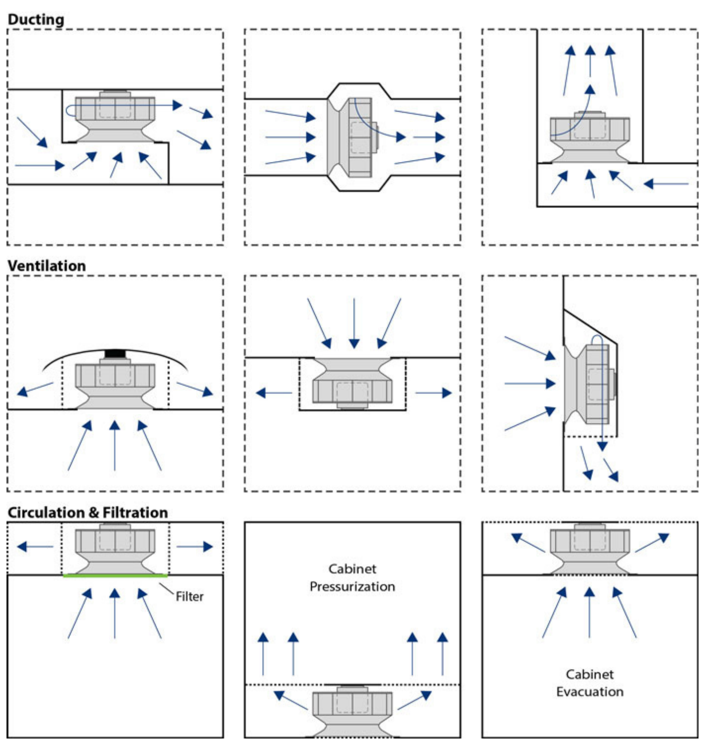
AXIAL

Axial motorized impellers are typically used to move high volumes of air at relatively low static pressure. For this reason, they are primarily used in non-ducted systems that require high airflow rates. Highest efficiency is obtained when using airfoil blades in these systems. Axial motorized impellers are often used for supply or exhaust applications, and they can also be pre-installed in a fan housing.

Common housing options for motorized axial impellers

INSTALLATION TYPE

The space-saving design of motorized impellers allows them to fit into smaller enclosures, making them especially attractive for applications with tight space constraints. Figure 1 below displays some typical installation arrangements for motorized centrifugal impellers.



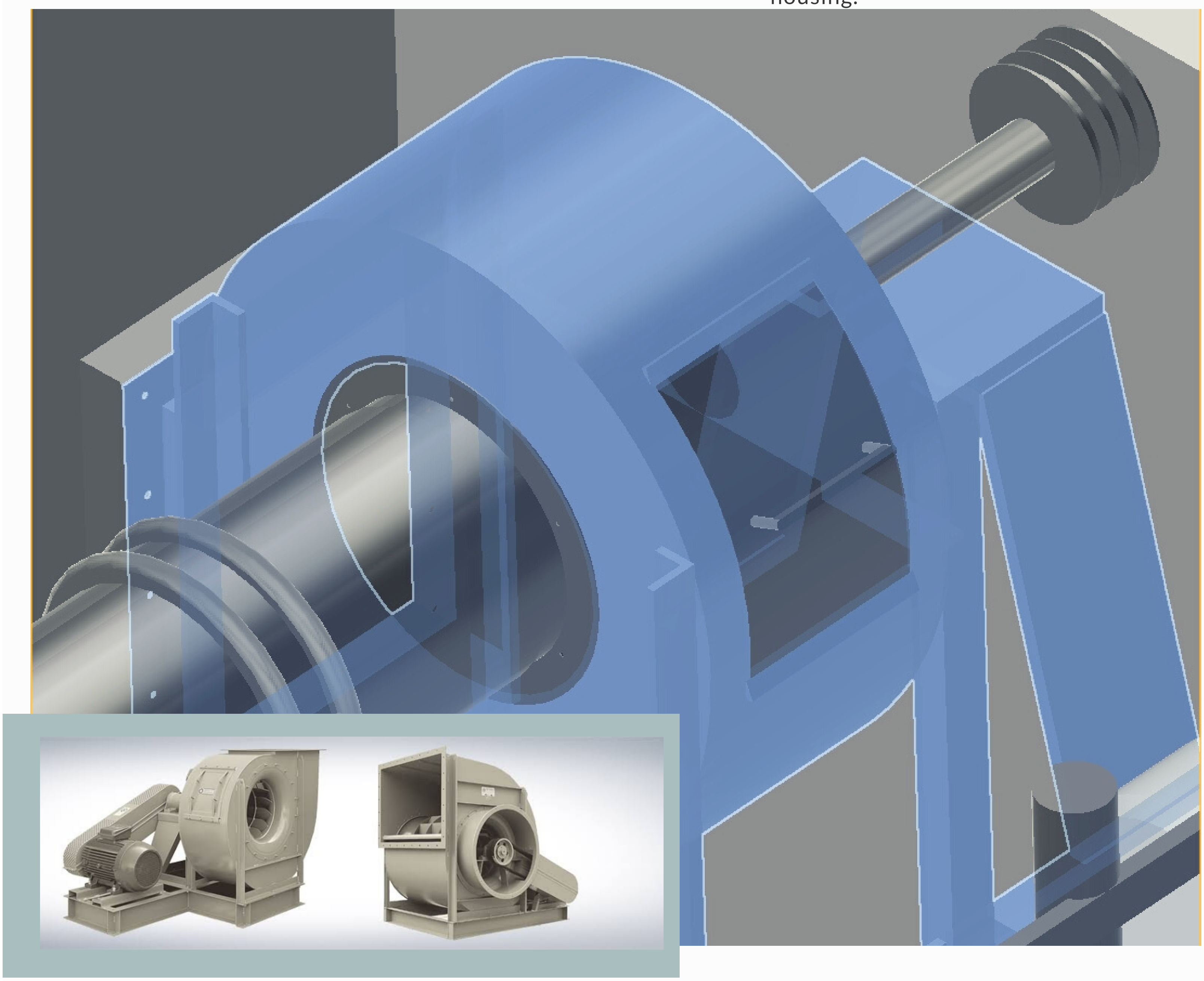
CENTRIFUGAL FAN

A centrifugal fan is a mechanical device for moving air or other gases in a direction at an angle to the incoming fluid. Centrifugal fans often contain a ducted housing to direct out going air in a specific direction or across a heat sink; such a fan is also called a blower, blower fan, biscuit blower[citation needed], or squirrel-cage fan (because it looks like a hamster wheel). These fans increase the speed and volume of an air stream with the rotating impellers. Centrifugal fans use the kinetic energy of the impellers to increase the volume of the air stream, which in turn moves against the resistance caused by ducts, dampers and other components. Centrifugal fans displace air radially, changing the direction (typically by 90°) of the airflow. They are sturdy, quiet, reliable, and capable of operating over a wide range of conditions

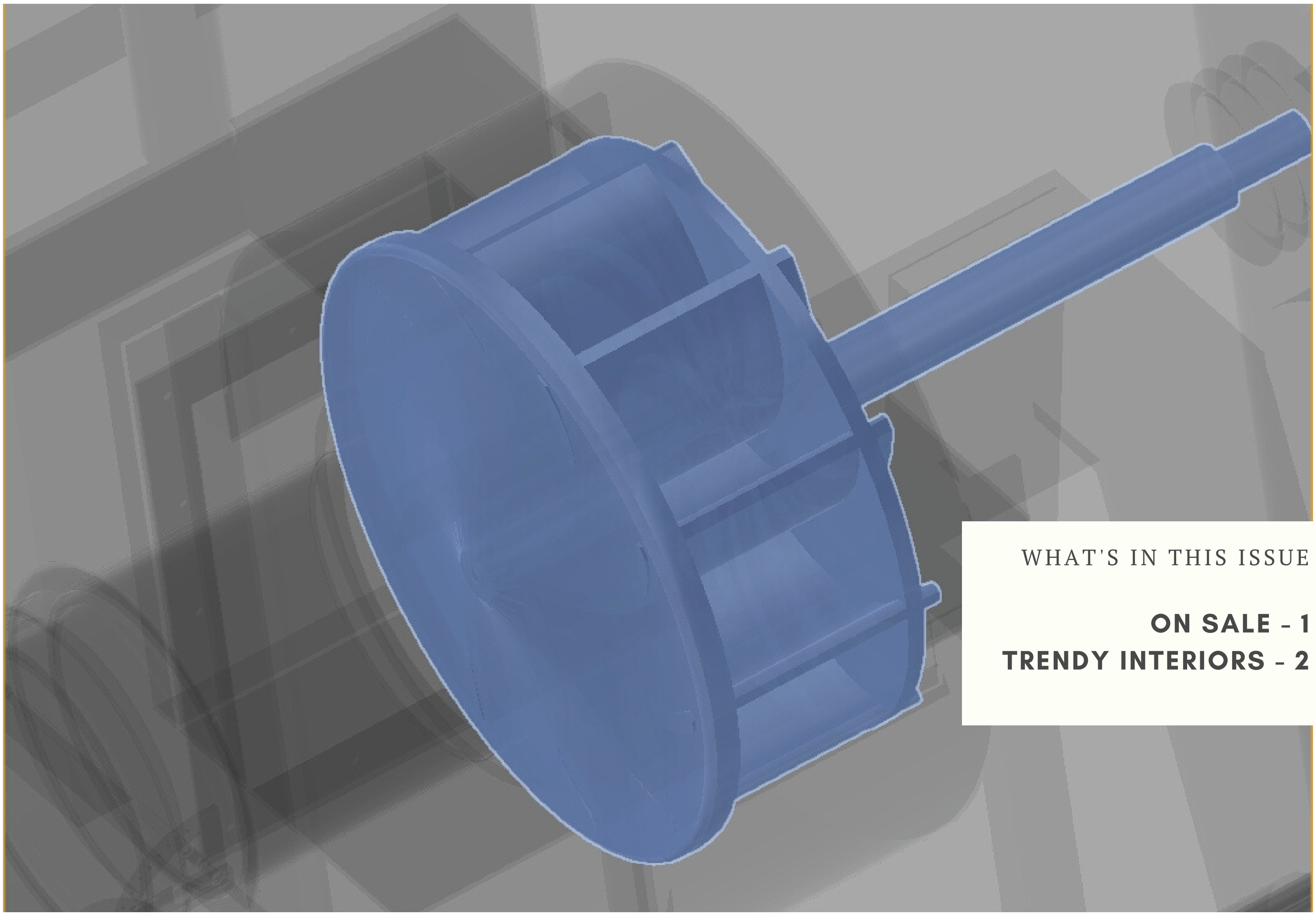
Centrifugal fans are constant-displacement or constant-volume devices, meaning that, at a constant fan speed, a centrifugal fan moves a relatively constant volume of air rather than a constant mass. This means that the air velocity in a system is fixed even though the mass flow rate through the fan is not.

Centrifugal fans are not positive-displacement devices and centrifugal fans have certain advantages and disadvantages when contrasted with positive-displacement blowers: centrifugal fans are more efficient, whereas positive-displacement blowers may have a lower capital cost.

The centrifugal fan has a drum shape composed of a number of fan blades mounted around a hub. As shown in the animated figure, the hub turns on a driveshaft mounted in bearings in the fan housing.



FAN IMPELLER

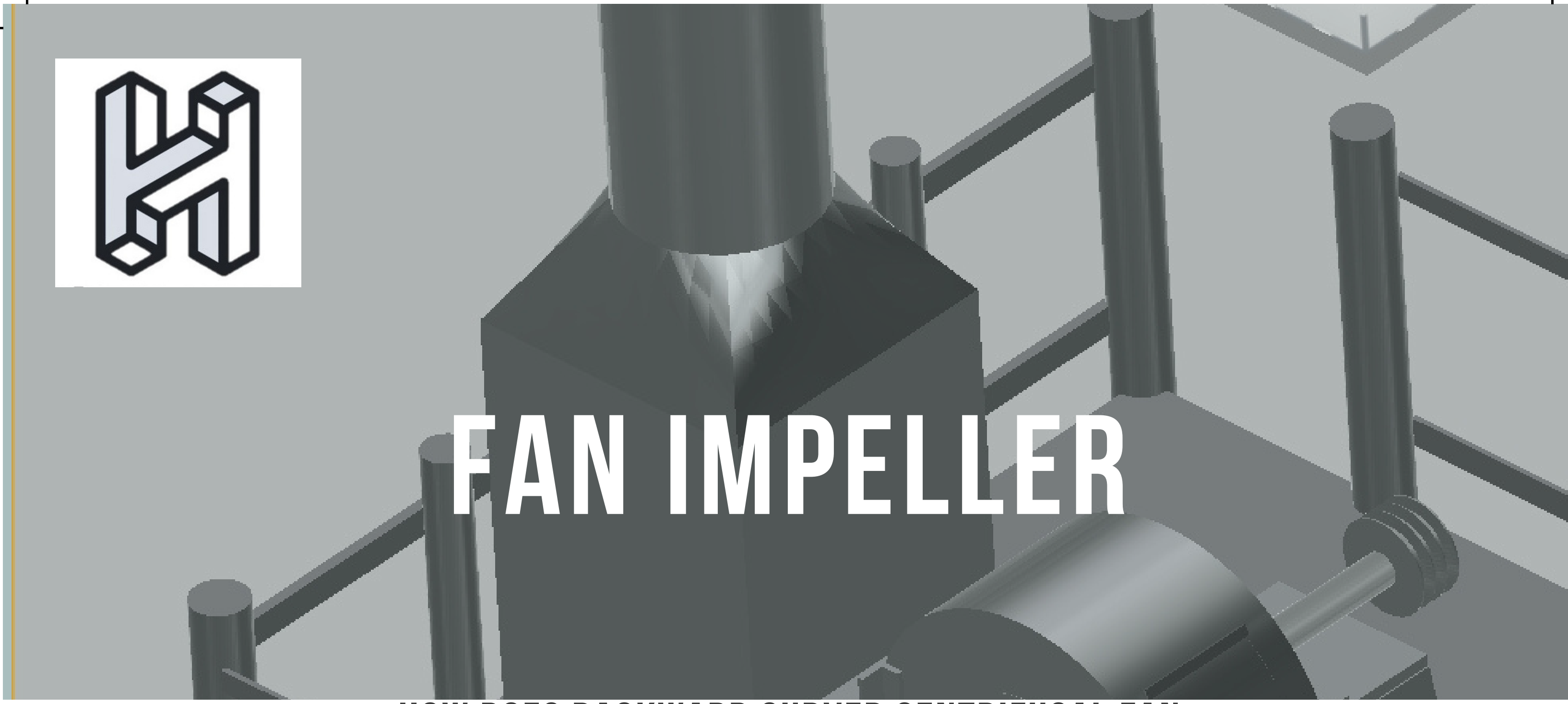


WHAT'S IN THIS ISSUE

Backward Curved Motorised Impeller

When we have defined the volume flow rate that we require, whether this is to provide fresh air or process cooling, we need to combine this with the resistance to flow that the fan will encounter in the application. The volume flow rate, (in m3/hr) and the pressure (in Pascals - Pa), are combined to become the duty point against which the fan must operate.

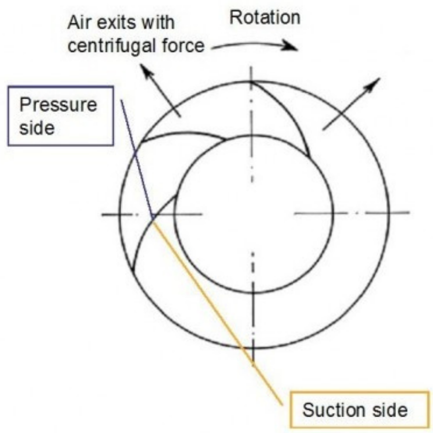
It is important that we select a fan whose performance characteristic meets the required duty point on or near the point of peak efficiency. Using the fan at its peak efficiency minimises the power consumption and noise emitted from the fan whilst delivering the required performance.

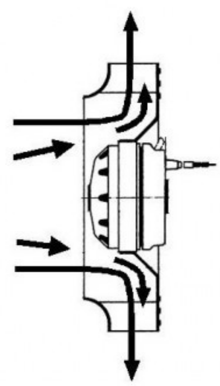


FAN IMPELLER

HOW DOES BACKWARD CURVED CENTRIFUGAL FAN WORK?

The name, 'Centrifugal Fan' is derived from the direction of flow and how the air exits the fan impeller radially from the outer circumference of the fan. A Backward curved centrifugal fan is characterised by its cylindrical shape, several large curved blades and a conical inlet nozzle. In the example shown below, the fan rotates in a clockwise direction.





FAN CHARACTERISTIC

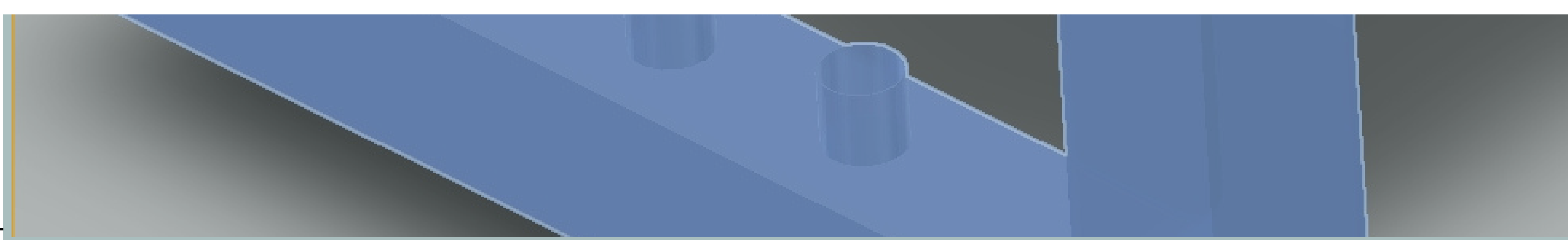
The optimum operating area for a backward curved centrifugal fan is an area in the middle of its performance characteristic. A backward curved centrifugal fan works best when medium pressures and medium volume flows are required. The graph below illustrates the optimum working area

MOUNTING OPTIONS

A non-overloading performance characteristic, high static efficiency and flexible installation options are reasons why a backward curved fan provides the best solution for match ing airflow requirements in systems with significant flow resistance. To ensure these benefits are delivered an inlet ring, (or nozzle), is required to ensure smooth laminar flow as the air enters the impeller.

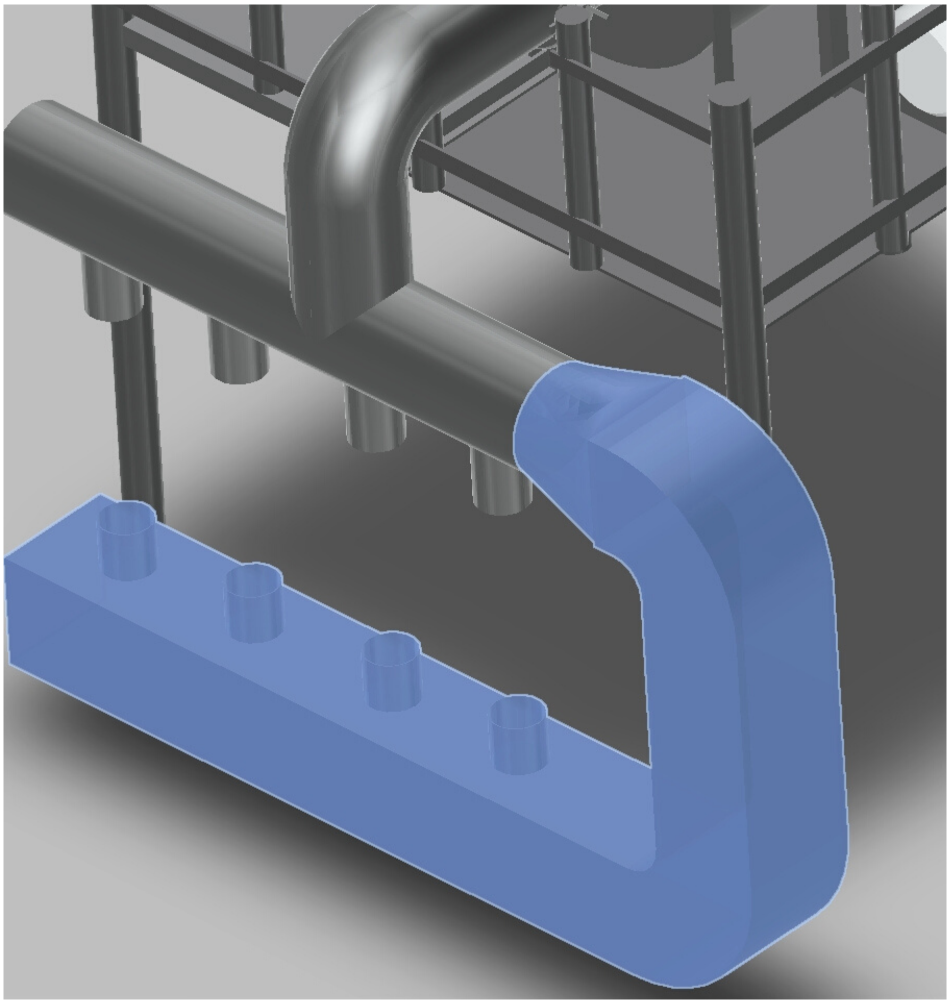
MOUNTING CONSIDERATIONS – CLEARANCES

It is important to ensure sufficient clearance on both the suction and exhaust sides of the fan.
Insufficient clearance on the suction side of the fan will increase the inlet velocity which will lead to turbulence.

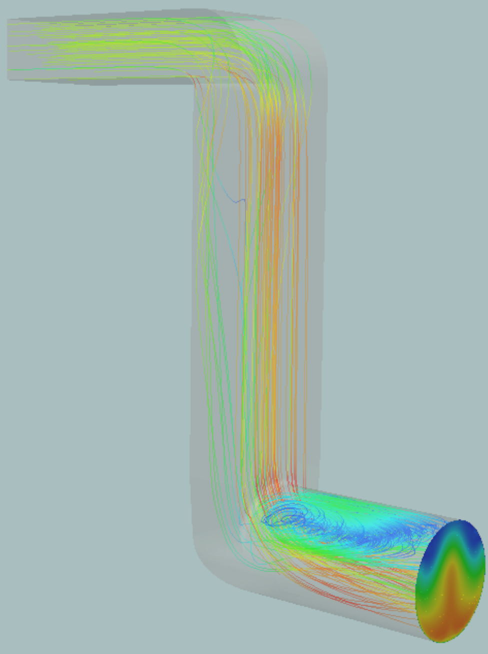


DUCT (FLOW)

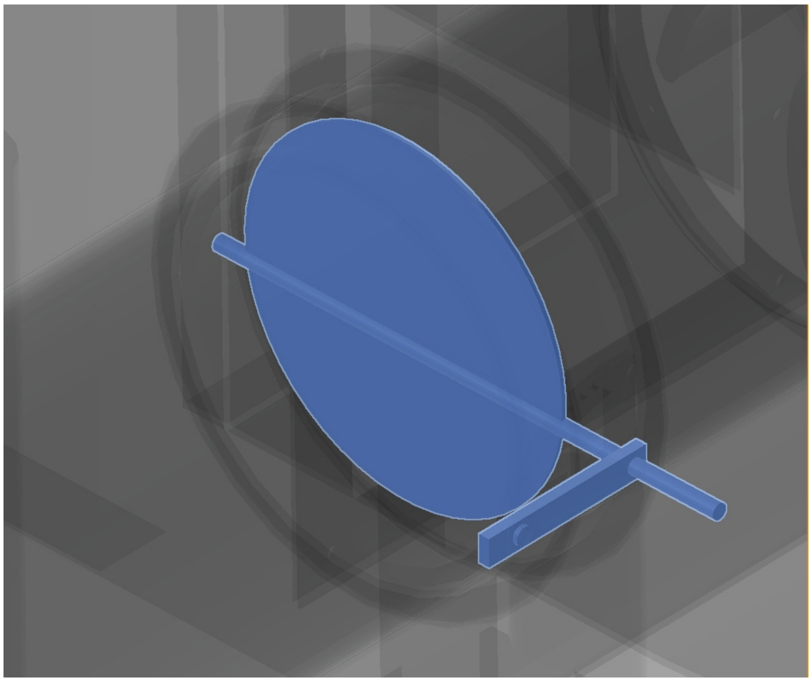
Ducts are conduits or passages used in heating, ventilation, and air conditioning (HVAC) to deliver and remove air. The needed airflows include, for example, supply air, return air, and exhaust air.[1] Ducts commonly also deliver ventilation air as part of the supply air. As such, air ducts are one method of ensuring acceptable indoor air quality as well as thermal comfort.
Ducts for air pollution control in a 17000 standard cubic feet per minute regenerative thermal oxidizer (RTO).
A round galvanized steel duct connecting to a typical diffuser
Fire-resistance rated mechanical shaft with HVAC sheet metal ducting and copper piping, as well as "HOW" (Head-Of-Wall) joint between top of concrete block wall and underside of concrete slab, firestopped with ceramic fibre-based firestop caulking on top of rockwool.
A duct system is also called ductwork. Planning (laying out), sizing, optimizing, detailing, and finding the pressure losses through a duct system is called duct design.[

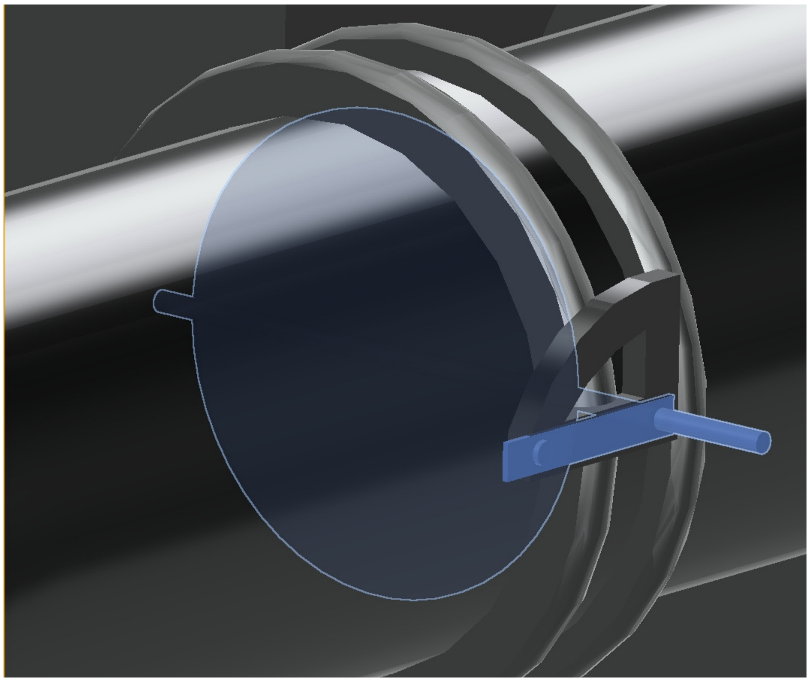


Besides the ducts themselves, complete ducting systems contain many other components.
An air handling unit with vibration isolator (3)
A duct system often begins at an air handler. The blowers in the air handler can create substantial vibration, and the large area of the duct system would transmit this noise and vibration to the inhabitants of the building. To avoid this, vibration isolators (flexible sections) are normally inserted into the duct immediately before and after the air handler. The rubberized canvas-like material of these sections allows the air handler to vibrate without transmit ting much vibration to the attached ducts. The same flexible section can reduce the noise that can occur when the blower engages and positive air pressure is introduced to the ductwork.



DAMPERS AND VALVES





Advantages:

Effective saving of energy

Prevents the process of cooling down of heat producers

Improvement of the effective ness of the fireplaces with a chimney in multiple usage

Sound insulation when mul tiple fireplaces are connected with one chimney

Durability through stainless steel components

Suitable flue gas dampers for different applications and situations

Dampers

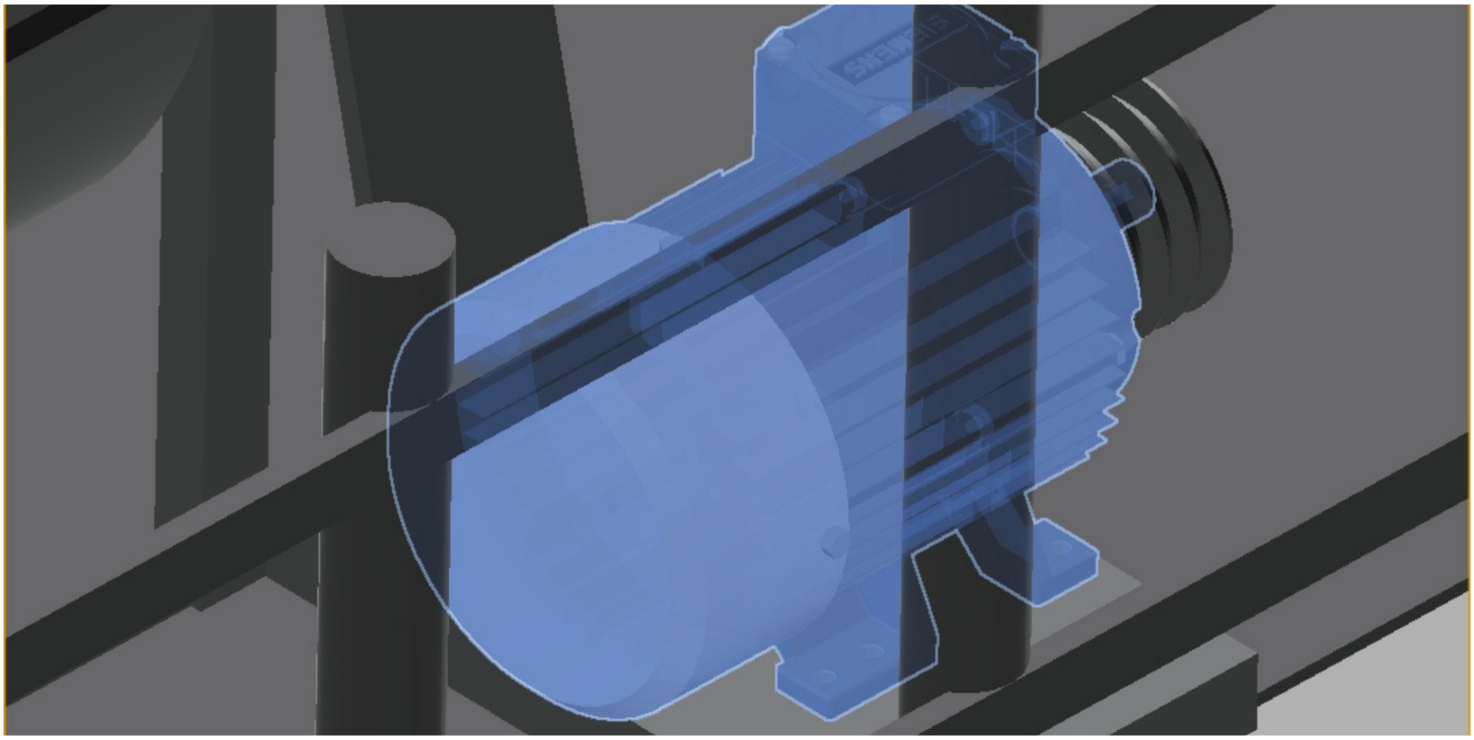
Flue gas dampers (butterfly valve) are installed in the connection pipe between a boiler and the chimney and close the flue gas path, if the chimney is no longer in use. This prevents the cooling down of the heat generator and the installation room, which helps to save energy.

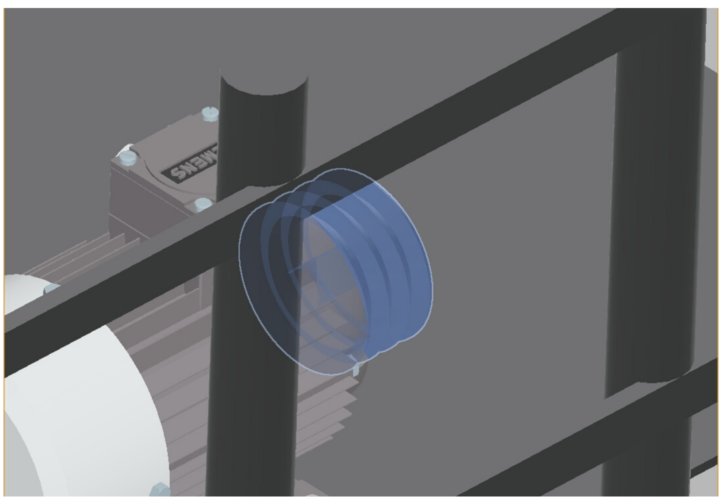
Furthermore in the case of cascade systems, you also avoid possible inflow of flue gases from other fireplaces connected to the chimney into the installation room and cause a certain amount of sound insulation (attenuation) in the case of multiple-use chimneys. We offer both manually closing dampers and automatically closing dampers with an electric servomotor, controlled by the boiler.

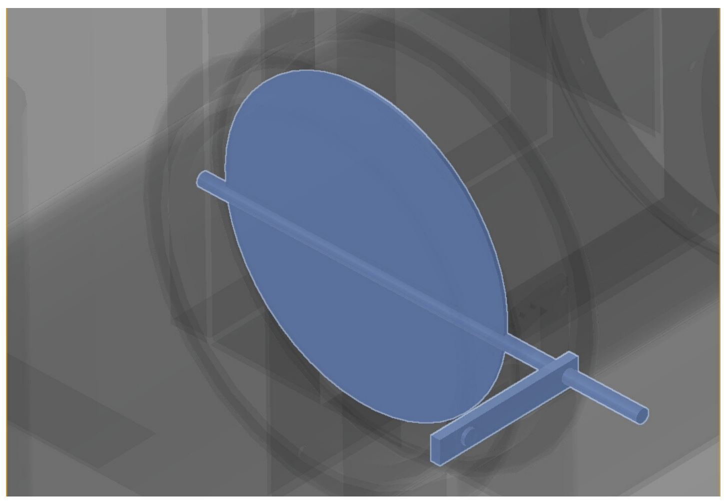
Valves

To compensate the undesired pressure fluctuations in the connection pipe we offer different relief valves. In case of implosion we recommend the use of Joukowsky implosion relief valve. For explosion we offer the pressure relief valve.

Stainless steel or black steel flue gas dampers made by Jeremias are used in combined heat and power plants, emergency power systems, exhaust air technologies and in over pressure operation engines.







INDUCTION MOTOR

An induction motor or asynchronous motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding.[1] An induction motor can therefore be made without electrical connections to the rotor.[a] An induction motor's rotor can be either wound type or squirrel-cage type.

Three-phase squirrel-cage induction motors are widely used as industrial drives because they are self-starting, reliable and economical. Single-phase induction motors are used extensively for smaller loads, such as household appliances like fans. Although traditionally used in fixed-speed service, induction motors are increasingly being used with variable-frequency drives (VFD) in variable-speed service. VFDs offer especially important energy savings opportunities for existing and prospective induction motors in variable-torque centrifugal fan, pump and compressor load applications. Squirrel-cage induction motors are very widely used in both fixed-speed and variable-frequency drive applications.

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