

A GAS FLOW SYSTEM

The invention is directed to a gas flow system.

5 A modular manifold as a gas flow system is described in US2011/0220224. This publication describes a manifold composed of modules which are connected in a straight row to each other using a coupler and an elongated cladding. At the side of the manifold connectors are present to connect to valves and gas inlet or gas outlet conduits. Modular manifolds are advantageous because, as explained in this
10 publication, they can be easily modified to change capacity and/or flow paths and allow repair or removal of a single valve. A disadvantage of the modular manifold described in US2011/0220224 is that the modules require multiple parts such as couplers and cladding to hold the modules together. Next the manifold can only be extended in one direction while for some applications more design freedom is
15 required.

WO2016206714 describes a building provided with a central air drying system and a number of locally positioned evaporative cooling units. The evaporative cooling units are gas flow systems using plate heat exchangers. Because the
20 evaporative cooling units are placed in the spaces of the building it may be envisaged that different sizes of the cooling unit will be required for different sizes spaces in the building. Plate heat exchangers of different capacity may be easily be obtained by using more or less plates in the plate heat exchanger. This however results in different dimensions of the stack and thus also of the headers for supplying
25 and discharging air to the stack of plates.

The present invention aims at providing a gas flow system, exemplary for use as a header of a plate heat exchanger, which can be easily manufactured in different dimensions.

30 This aim is achieved by the following gas flow system. A gas flow system comprising at least a first and a second hollow cuboid shaped gas flow element, each gas flow element having an interior space, six open faces, eight vertices and twelve edges interconnecting the eight vertices,

wherein the four edges of at least one open face of the first gas flow element is connected in a gas tight manner to four edges of an open face of the second hollow cuboid shaped gas flow element at their respective connecting open faces and

- 5 wherein a valve is present at the connecting open faces which has an open position or positions thereby fluidly connecting the interior space of the first hollow cuboid shaped gas flow element with the interior space of the second hollow cuboid shaped gas flow element to enable a first gas flow to flow from a hollow cuboid shaped gas flow element to the other hollow cuboid shaped gas
- 10 flow element of the system and wherein the valve has a closed position thereby fluidly disconnecting the interior space of the first hollow cuboid shaped gas flow element with the interior space of the second hollow cuboid shaped gas flow element to disable a first gas flow to flow from first hollow cuboid shaped gas flow element to the other hollow cuboid shaped gas flow element, or
- 15 wherein a partition is present at the connecting open faces thereby fluidly disconnecting the interior space of the first hollow cuboid shaped gas flow element with the interior space of the second hollow cuboid shaped gas flow element enabling a second gas flow through the first hollow cuboid shaped gas flow element and a fluidly disconnected third gas flow through the second
- 20 hollow cuboid shaped gas flow element.

Applicants found that with the modular system according to the invention headers for differently sized plate heat exchangers can be manufactured using the

25 same hollow cuboid shaped gas flow elements. This is advantageous because only one type of a single sized hollow cuboid shaped gas flow elements may then be required to be manufactured. Further the hollow cuboid shaped gas flow element allows one to make gas flow passage which makes a 90° turn and to split one gas flow passage to more than one gas flow passage. This is not possible with the

30 modular manifold of the earlier described US2011/0220224.

The cuboid may be a rectangular cuboid and is preferably a square cuboid, also known as a cube. The cube is preferred because other second cubes can be

connected to all open faces of the cube using all open faces of the second cube.
This provides more design freedom than the rectangular cuboid.

5 The hollow cuboid has an interior space for passage of gas. The open space fluidly connects the six open faces of the cuboid. The shape and dimensions of the edges is suitably the same. The cross-section of the edges is relatively small resulting in a relatively large open space. The open space suitably comprises for more than 70%, preferably more than 80% of the total area of a side of the cuboid.

10 The four edges of at least one open face of the first gas flow element is connected in a gas tight manner to four edges of an open face of the second hollow cuboid shaped gas flow element at their respective connecting open faces. Such a connection may be achieved by welding, adhesives or by separate connecting means which engage with the edges at the connecting open face. Suitably the four
15 edges of the connecting open face is provided with connecting means to connect to the four edges of the connecting open face of the second hollow cuboid shaped gas flow element. Such means may be a stud-and-tube coupling system using an interference fit. An example of such connection is the well-known Lego building blocks. Such connecting means may also be extensions from the edges of the first
20 hollow cuboid shaped gas flow element which extension can form a snap-fit connection with the edges of the second hollow cuboid shaped gas flow element.

The above connection may also be achieved by using a connecting frame. Such a connecting frame is preferably provided with means to connect to the four
25 edges of the open face of the first gas flow element and is provided with connecting means to connect to the four edges of the open face of the second hollow cuboid shaped gas flow element. In this way the four edges of the open face of the first gas flow element is connected in a gas tight manner to four edges of the open face of the second hollow cuboid shaped gas flow element.

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The connecting frame may be used for only fluidly connecting two hollow cuboid shaped gas flow elements. When used for this purpose the connecting frame may be relatively thin. Preferably the connecting frame itself, defining the distance between two connected hollow cuboid shaped gas flow elements, is between 0.1

and 0.6 cm. The frame will then be provided with an opening for the gas flow between the connected gas flow elements.

5 The connecting frame may also comprise the valve or the partition according to the invention. A suitable valve is a rotating valve. The rotating valve may be connected to a means to operate the rotation of the valve. Such means may be positioned on the connecting frame or at the exterior of the hollow cuboid shaped gas flow elements. The partition may be a connecting frame which is closed, not having an opening for an gas flow between the connected gas flow elements.

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The connecting frame may also be combined with other functional devices, for example air filters, such as a dust catcher, water injector, a clamp holding a wire, wire-feed through elements, heating elements, cooling elements, sensors, such as temperature sensor, pressure sensor, humidity sensor, a silencing device or a flow meter. When such added functionalities are present on the connecting fame the frame itself may be thicker than when the frame is solely used to connect or is provided with a partition.

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The above functionalities do not necessarily have to be part of the connecting frame. Also in case no connecting frame is used the hollow cuboid shaped gas flow elements may be comprised of such means having these functionalities. The means may be connected to the edges of the hollow cuboid shaped gas flow elements, for example using frames, using similar connecting means as the connecting means described above.

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25 When the gas flow elements are directly coupled, in the absence of a connecting frame, the valve may be a rotating valve as present in a rectangular shaped frame. This rectangular shaped frame is connected to the edges of the connecting face of the first or the second hollow cuboid shaped gas flow element. For this connection connecting means like as described above may be present.

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When the gas flow elements are directly coupled, in the absence of a connecting frame, the partition may be a rectangular shaped closed frame and wherein the rectangular shaped frame is connected to the edges of the connecting

face of the first and/or the second hollow cuboid shaped gas flow element. For this connection connecting means like as described above may be present.

The hollow cuboid shaped gas flow element is suitably made of a polymer.

- 5 Preferably the hollow cuboid shaped gas flow element is a single injected moulded work product. The connecting frame is also preferably made of a polymer and is preferably a single injected moulded work product.

- 10 The dimensions of the hollow cuboid shaped gas flow element may vary. When they are used in combination with a plate heat exchanger it is preferred to use elements having a minimal dimension of an edge of 0.1 m and a maximum dimension for an edge of 0.3 m being the distance along the edge between two vertices.

- 15 The hollow cuboid shaped gas flow element, the connecting frame, the rectangular shaped frame and/or the rectangular shaped closed frame may be made of a polymer. Preferably a polymer which may be used in injection moulding. Suitable polymers are polypropylene (PP) and/or polyoxymethylene (POM).

- 20 The connecting frame preferably has about the same dimensions as the sides of the hollow cuboid shaped gas flow element. The connecting frame is either closed to provide for the partition or provided with an opening at its centre to allow a fluid communication between the first and second hollow cuboid shaped gas flow element. This open space is preferably about the same shape as the open face of
25 the hollow cuboid shaped gas flow element. The remaining edges of the frame are provided with the means to connect to the four edges of the open face of the first gas flow element and provided with connecting means to connect to the four edges of the open face of the second hollow cuboid shaped gas flow element.

- 30 The means to connect the connecting frame to the edges of the open faces of the first and second hollow cuboid shaped gas flow element may be any connection which results in a gas tight connection between the open faces of the cuboid and the connecting frame. The means to connect may be a stud-and-tube coupling system using an interference fit. An example of such connection is the well-known Lego

building blocks. A preferred means of connection is a snap-fit connection. Preferably the connecting frame is provided with extensions having a cantilever snap-fit connector. Preferably the frame is provided with numerous protrusions in a perpendicular direction with respect to the plane of the frame. The protrusions are suitably provided with a sharp edge at its end. When the frame is placed over an open space of the hollow cuboid the protrusions will enter the open space and bend when they are moved along the edges of the open space. When frame reaches its gas tight position the sharp edge or tang snap around the edge of the hollow cuboid shaped gas flow element and the frame is tightly fitted.

In order to allow bordering faces of hollow cuboid shaped gas flow element to connect to a second hollow cuboid shaped gas flow element it is preferred that the cantilever snap-fit connections are not placed at the same positions along the edge of the connecting frame. Thus by providing a frame wherein the edges are different with respect to the position of the cantilever snap-fit connections it is possible to connect a connecting frame to neighbouring open face of the cuboid shaped gas flow element. Preferably the snap-fit connections on first parallel edges may equally be positioned while the snap-fit connections on the two remaining second parallel edges are positioned differently from the first parallel edges. In this manner the same connecting frames may be used for neighbouring open faces wherein one of the first parallel edges of one connecting frame and one of the second parallel edges of the other connecting frame connect to the same edge of the hollow cuboid shaped gas flow element.

The remaining open faces of the first and second hollow cuboid gas flow elements may be connected to other hollow cuboid gas flow elements of the same design and shape. In this manner a gas flow system comprising different conduits for different first, second and third gas flows can be provided. The open faces of the hollow cuboid shaped gas flow elements which are not connected to another gas flow element in such a system will be enclosed or fluidly connected to an upstream or downstream part of the gas flow flowing through the gas flow system. Preferably the remaining open faces of the first or the second hollow cuboid shaped gas flow element are enclosed in a gas tight manner by an enclosing wall element which is

connected to the four edges of the open face. Some open faces of some gas flow elements may be connected to a gas inlet or connected to a gas outlet.

The connection to a gas inlet and gas outlet may be by means of a transition
5 frame. Such a transition frame may be connected to the open face of the hollow
cuboid shaped gas flow element in the same manner as the connecting frame. The
transition frame may be provided with means to connect to a conduit or to other parts
of an apparatus. In case of use as part of a plate heat exchanger it may be
envisaged that certain standard parts are provided to connect to the transition frame,
10 wherein the standard part may be used for plate heat exchangers of different
dimensions.

The enclosing wall element may also be connected to the open face in the
same manner as the connecting frame or as the rectangular shaped closed frame.
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The gas flow system is preferably used as a header of a heat exchanger,
preferably a plate heat exchanger. The system comprises two parallel rows of fluidly
connected hollow cuboid shaped gas flow elements. The two rows are
interconnected via a number of connecting open faces provided with a partition. The
20 resulting second gas flow and third gas flow, which are fluidly disconnected, are the
gas flows exchanging heat in the heat exchanger.

The above plate heat exchanger is preferably used as part of an evaporative
cooling unit. More preferably the evaporative cooling unit is part of a system to cool a
25 building, wherein a building is provided with a central air drying system and a
number of locally positioned evaporative cooling units. An example of such a system
is described in WO2016206714.

The invention will be illustrated by the following non-limiting Figures.
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Figure 1 a hollow cube shaped gas flow element (3). The gas flow element has
an interior space (4), six open faces (5), eight vertices (6) and twelve edges (7)
interconnecting the eight vertices (6).

Figure 2 shows a connecting frame (8) provided with an opening (9) and four edges (10). Along the edges (10) extrusions are seen directed in both directions perpendicular to the plane of the frame. These extrusions are the cantilever snap-fit connections (11) which can connect to an edge (7) of the gas flow element (3) as
5 seen in Figure 3.

Figure 4 shows a detail of a gas flow element (1) at one of its vertices (6) wherein one open face is provided with a connecting frame (8) and a neighbouring open face is provided with an enclosing wall element (15). Both the connecting frame
10 (8) as the enclosing wall element (15) are provided with numerous protrusions (16) in a perpendicular direction with respect to the plane of the connecting frame (8) or plane of the enclosing wall element (15). The protrusions (16) are provided with a sharp edge (17) at its end which are dimensioned such that they form a cantilever snap fit connection with the edge (7). As shown the location of the protrusions (16) of
15 the connecting frame (8) and the enclosing wall element (15) are not at the same positions along the edges of these elements. This makes it possible that neighbouring open faces of a gas flow element (1) can be provided with connecting frames (8), enclosing wall elements (15) or other elements by a snap fit connection on its common edge (7).

20 In Figure 5 a system (12) of two connected gas flow elements (3) are shown as a first (1) and a second (2) hollow cuboid shaped gas flow element. The four edges (7) of at least one open face (5) of the first gas flow element (1) is connected in a gas tight manner to four edges (7a) of an open face (5a) of the second hollow cuboid
25 shaped gas flow element (2) by means of a connecting frame (8). In this way the interior space (4) of the first hollow cuboid shaped gas flow element (1) is fluidly connected with the interior space (4a) of the second hollow cuboid shaped gas flow element (2).

30 In Figure 5 only a connecting frame (8) is shown. In a practical application of the gas flow system the remaining open faces (5) of the gas flow elements (2) and (3) may be enclosed in a gas tight manner by an enclosing wall element which is connected to the four edges of the open face or connected to a further cuboid shaped gas flow element by means of a connecting a frame or connected to a gas

inlet or connected to a gas outlet. A next gas flow element can be connected to gas flow elements (2) or (3) at their outer ends forming a linear flow path for the gas or may be connected to an open face at the side resulting in a flow path making a 90° turn.

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In Figure 5 the connecting frame (8) is provided with a rotating valve (13). The valve (13) can fluidly disconnect interior space (4) from interior space (4a) when in a closed position and can fluidly connect interior space (4) with interior space (4a) in an open position. The valve (13) rotates around an axis and can be operated from at the exterior of the gas flow elements (1) and (2) via axle (14) as the means to operate the rotation of the valve.

Figure 6 shows a system of two connected gas flow elements (3) are shown as a first (1) and a second (2) hollow cuboid shaped gas flow element. The four edges (7) of at least one open face (5) of the first gas flow element (1) is directly connected in a gas tight manner to four edges (7a) of an open face (5a) of the second hollow cuboid shaped gas flow element (2). A rotating valve (20) is present in a rectangular shaped frame (21). Frame (21) is connected to the edge (7) of the second hollow cuboid shaped gas flow element (2). The same edge (7) is connected to the edges of the first hollow cuboid shaped gas flow element (1) as shown.

Figure 7 shows a schematic cross-section of a plate heat exchanger (20) having hexagonal heat exchange surfaces (21) and wherein heat may be exchanged between a first gas flow (22) and a second gas flow (23). The first and second gas flows will flow via alternating spaces between stacked heat exchanges surfaces (21) from a header to a header. The first gas flow (22) will flow from a header (24) to a header (25). The second gas flow will flow from a header (26) to a header (27). Header (24) is fluidly connected to a gas inlet (28). Header (27) is fluidly connected to a gas outlet (29). Header (25) is fluidly connected to a gas outlet (30) via a valve (31) and header (26) is fluidly connected to a gas inlet (32) via a valve (33). Header (25) is connected via a valve (34) to header (26).

In Figure 8 the plate heat exchanger (20) of Figure 7 is shown in a three dimensional view. Some walls are not shown such to have a better view of the various components of the heat exchanger. A stack (35) of heat exchange surfaces (23) is shown. Header (25) is made of a row of 4 interconnected gas flow elements (1) as shown in Figures 1-6 connected by a connecting frame (8). Header (26) is also made of a row of 4 interconnected gas flow elements (1). Header (25) and header (26) are connected to each other by 4 interconnecting frames (8) provided with a rotating valve (13). The four rotating valves (13) are interconnected and are operated by an external positioned motor (36). For the headers not shown but present at the opposite side of the plate heat exchanger the connection of the two rows of gas flow elements may be by means of partitions as present in the connecting open faces, thereby fluidly disconnecting the gas flows through both headers.

Header (25) is at its far away end connected to a further gas flow element (37) via a connecting frame (8) provided with valve (31). This gas flow element connects header (25) with gas outlet (30). Gas outlet (30) is fluidly connected to gas flow element (37) via an adaptor wall element (38) which is connected to an open face of gas flow element (37) by a snap fit connection as shown in Figure 4.