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APPARATUS FOR INTRODUCING FLUID INTO A PROCESS STREAM

The present invention relates to an apparatus for introducing a fluid into a process stream. In particular, though not exclusively, the present invention relates to an apparatus for introducing a fluid into a vinyl acetate reactor.

Vinyl acetate may be produced by reacting acetic acid, oxygen and
5 ethylene in the presence of a catalyst. The activity of the catalyst may be enhanced by using a promoter such as aqueous potassium acetate. Typically, the reaction is carried out in a fixed bed reactor containing the catalyst. A reactant process stream comprising acetic acid vapour, ethylene and oxygen is fed into the reactor through an inlet. The inlet comprises a pipe having a bend of an angle of between 45 to 90°
10 upstream of the reactor. As reactant molecules flow past the bend in the pipe, they accelerate by varying amounts. This distorts the velocity distribution of the reactant molecules and, as a result, the velocity profile of the process stream is asymmetric.

The catalyst promoter is also introduced into the reactor through the pipe.
15 Conventionally, this is achieved using a spray nozzle which is mounted to an end of a rigid support arm. The support arm is positioned downstream of the bend, and extends perpendicularly into the pipe from the pipe wall. The promoter is introduced into the pipe as liquid droplets from the nozzle; which partially evaporate whilst in the pipe. The promoter is carried by the reactant process
20 stream into the reactor for distribution over the catalyst bed. However, because of

the distorted velocity profile of the reactant process stream, the promoter is not deposited evenly over the catalyst. The problem is compounded by the support arm, which, by being configured at right angles to the direction of flow, further distorts the velocity profile of the reactant process stream.

5 We have alleviated the problem by providing a new apparatus for introducing fluid into a process stream.

According to the present invention, there is provided apparatus for introducing a fluid into a process stream which apparatus comprises :

- (a) a pipe for conducting said process stream, said pipe having a bend; and
- 10 (b) a nozzle for introducing said fluid into said process stream downstream of said bend characterised in that said pipe has a flow-correction device downstream of said bend and said nozzle is mounted downstream of said flow-correction device to an end of a support arm which extends into said pipe in a direction substantially parallel to the direction of said pipe downstream of said
- 15 bend.

The pipe bend may have an angle of 40 to 120° preferably, of about 45 to 100°. In a preferred embodiment, the pipe bend has an angle of about 90°.

In use, a process stream is fed into the pipe at a location upstream of the pipe bend. This process stream flows through the pipe, and past the pipe bend.

- 20 Fluid is also introduced into the pipe through the nozzle. The nozzle fluid is introduced at a location downstream of the bend, and is carried along by the flow of the process stream. The nozzle is mounted on a support arm which extends into the interior of the pipe in a direction substantially parallel to the direction of the pipe downstream of the bend. Thus, the support arm causes minimal disturbance
- 25 to the flow of process stream as it flows past the bend. Preferably, the support arm takes the form of a tube, which is coupled to a supply of nozzle fluid.

Preferably, the nozzle fluid is a liquid.

- As the process stream flows past the bend, the molecules accelerate by varying amounts. This distorts the velocity distribution of the process stream and,
- 30 as a result, the process stream velocity profile is non-uniformly asymmetric. The

bend may also cause the process stream to swirl. At least one of these disadvantages may be alleviated by mounting a flow-correction device in the pipe of the present invention.

5 In one embodiment, the flow-correction device comprises a body having a plurality of longitudinal channels. In use, the body is positioned downstream of the pipe bend and configured such that the channels are substantially parallel with the direction (longitudinal axis) of the pipe downstream of the bend. As the process stream flows through the channels, any swirl in the flow pattern is reduced. The velocity distribution of the process stream, however, remains unchanged.

10 In a preferred embodiment of the invention, the flow-correction device comprises a plate having perforations. The perforations may take the form of pores or apertures which, preferably, are evenly spaced apart from one another. For example, the plate may comprise a plurality of holes with diameters of 5 to 30 mm, preferably, 8 to 12 mm. These holes may be spaced apart by about 5 to 30
15 mm, preferably, 12 to 17 mm. In a preferred embodiment, the plate has a plurality of 10 mm diameter holes spaced 14.7 mm apart. In use, the plate reduces the free area of flow through the pipe such that process stream passing through the perforations experiences a drop in pressure. The pressure drop may be equivalent to about 5 to 20 velocity heads based on the pipe inlet flow. The pressure drop
20 causes an increase in turbulence and a near equal flux through the holes of the plate. As a result, distortions in the velocity profile of the process stream are reduced or eliminated.

The nozzle is positioned downstream of the flow-correction device. Thus, the nozzle fluid introduced into the pipe is carried along the pipe by a flow of
25 process stream whose flow pattern has been corrected either for swirling and/or non-uniformity in the velocity distribution profile.

Where a plate having perforations is employed as a flow-correction device, the nozzle may be coupled to the plate. In one embodiment, the plate having perforations is provided with a hole. In use, the nozzle is inserted through the hole
30 and held in place, for example, by retaining means. The retaining means may take

the form of a guide sleeve which is coupled to the plate. The guide sleeve can be used to ensure that the nozzle is placed in the same position every time it is used. Preferably, the guide sleeve ensures that the tip of the nozzle just protrudes from the underside of the plate. This allows nozzle fluid to be introduced into the
5 optimum mixing zone of the pipe.

The present invention may be employed as an inlet for a fixed bed reactor, for example, to contact process stream and nozzle fluid with a catalyst bed positioned therein. In one embodiment, the present inlet is coupled to a fixed bed reactor for the production of vinyl acetate. In this embodiment, a process stream
10 comprising acetic acid vapour, ethylene and oxygen is fed into the reactor, whilst a promoter of, for example, potassium acetate solution, is introduced into the reactor as a nozzle fluid. The promoter may evaporate on entering the pipe and is carried by the flow of reactants into the reactor for deposition over the catalyst bed. It has been found that fluid deposits more evenly over the catalyst bed as a vapour rather
15 than a liquid. Thus, in a preferred embodiment, the distance between the nozzle and catalyst bed is adjusted to maximise the residence time of the nozzle fluid in the inlet. This ensures that the a relatively large proportion of the nozzle fluid is evaporated before entering the reactor.

The present invention may further comprise a distributor, for example, in
20 the form of a plate. The plate is preferably circular and, when mounted over a portion of a catalyst bed, provides a bluff surface which is substantially perpendicular to the direction of the pipe downstream of the bend. The plate removes some of the dynamic pressure of the incoming process stream/nozzle fluid mixture through turbulent eddies and promotes back-mixing of the process
25 stream/nozzle fluid mixture by setting up recirculation within the reactor head-space. This ensures that the nozzle fluid is adequately dispersed in the process fluid, and can be deposited onto the catalyst bed in an even manner. The plate may be mounted on support members which may be secured to the surface of the catalyst bed, for example, by embedding the members to a predetermined depth

beneath the surface of the catalyst bed. Preferably, the plate is mounted over a central region of the catalyst bed.

According to a further aspect of the present invention, there is provided a process for the production of vinyl acetate in a fixed bed reactor, said process

5 comprising the steps of :

providing a pipe having a bend and a flow-correction device downstream of said bend,

coupling the pipe to a fixed bed reactor,

providing a nozzle which is mounted to an end of a support arm,

10 positioning the nozzle in the pipe such that the nozzle is located downstream of the bend and downstream of the flow-correction device, and the support arm extends into the pipe in a direction substantially parallel to the direction of the pipe downstream of the bend,

feeding a reactant process stream comprising acetic acid, ethylene and
15 oxygen into the reactor along the pipe,

feeding a catalyst promoter fluid into the reactant process stream through the nozzle to deposit the promoter over the catalyst bed, and

reacting the ethylene, acetic acid and oxygen containing gas in the reactor to produce vinyl acetate.

20 These and other aspects of the present invention will now be described, by way of example, with reference to Figure 1 which is a schematic view of apparatus for introducing a fluid into a process stream in accordance with an embodiment of the present invention.

In Figure 1, an inlet (10) is shown mounted to a fixed bed reactor (12)
25 which houses a catalyst bed (13). The inlet (10) comprises a pipe (14), a spray nozzle (16), a support arm (18) and flow-correction device (20). The pipe (14) has a bend (15) of an angle of about 90° upstream of the reactor (12). The nozzle (16) is located downstream of the bend, and is mounted to an end of the support arm (18) which is a tube coupled to a supply (28) of nozzle fluid. As shown in the

drawing, the support arm (18) extends into the pipe (14) in a direction "D" which is parallel to the direction of the pipe (14) downstream of the bend(15).

In use, a reactant process stream comprising acetic acid vapour, ethylene and oxygen is introduced into the reactor (12) via the pipe (14). As the process stream travels round the bend (15), the reactant molecules accelerate by varying amounts. This distorts the velocity profile of the stream. The velocity profile is subsequently corrected using the flow-correction device (20).

The flow-correction device (20) comprises a perforate plate which is mounted to the pipe (14) at position "P". The plate comprises a plurality of 10 mm diameter holes (21) which are spaced apart from one another by 14.7 mm. In use, the plate reduces the free area of flow through the pipe such that process stream passing through the perforations experiences a drop in pressure. This causes an increase in turbulence, and a near equal flux through the perforations. As a result, distortions in the velocity profile of the stream are reduced or eliminated.

A promoter of potassium acetate solution is introduced into the process stream in the pipe (14) using the spray nozzle (16), and is carried into the reactor (12) by the "corrected" flow of reactants. The nozzle (16) is inserted in a hole in the perforate plate such that the tip of the nozzle just protrudes from the underside of the plate. The nozzle (16) is held in this position by a guide sleeve (not shown).

On entering the reactor (12), at least a portion of the promoter/reactant stream comes into contact with a distributor (22). The distributor (22) takes the form of a plate which is mounted over the catalyst bed (13) on support members (24). The plate provides a bluff surface substantially perpendicular to the direction "D". Thus, when fluid comes into contact with the plate, some of the dynamic pressure of the incoming fluid is removed through turbulent eddies. This promotes back-mixing of the reactant/promoter mixture in the reactor head-space (26), ensuring that the promoter is fully dispersed in the reactant stream. The homogenous reactant/promoter mixture can thus be used to deposit the promoter evenly over the catalyst bed (13).

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Claims :

1. Apparatus for introducing a fluid into a process stream which apparatus comprises :
 - (a) a pipe for conducting said process stream, said pipe having a bend; and
 - (b) a nozzle for introducing said fluid into said process stream downstream of
5 said bend

characterised in that said pipe has a flow-correction device downstream of said bend and said nozzle is mounted downstream of said flow-correction device to an end of a support arm which extends into said pipe in a direction substantially parallel to the direction of said pipe downstream of said bend.
- 10 2. Apparatus as claimed in claim 1 in which the pipe bend has an angle of about 40 to 120°, preferably about 45 to 100°.
3. Apparatus as claimed in claim 1 in which said pipe bend has an angle of about 90°.
4. Apparatus as claimed in any one of the preceding claims in which the support
15 arm comprises a tube coupled to a supply of nozzle fluid.
5. Apparatus as claimed in any one of the preceding claims in which the flow-correction device comprises a body having a plurality of longitudinal channels substantially parallel with the direction of the pipe downstream of the bend.
6. Apparatus as claimed in any one of claims 1 to 4 in which the flow-correction
20 device comprises a plate having perforations.
7. A fixed bed reactor for the production of vinyl acetate comprising a reactor with a catalyst bed therein having an inlet for a process stream comprising acetic acid vapour, ethylene and an oxygen containing gas and for a nozzle fluid



comprising potassium acetate solution, said inlet comprising apparatus as claimed in any one of the preceding claims.

8. A reactor as claimed in claim 7 in which there is mounted a distributor plate over a portion of the catalyst bed substantially perpendicular to the direction of the pipe downstream of the bend.

9. A process for the production of vinyl acetate in a fixed bed reactor, said process comprising the steps of :

- (i) providing a pipe having a bend and a flow-correction device downstream of the bend,
- 10 (ii) coupling the pipe to a fixed bed reactor,
- (iii) providing a nozzle which is mounted to an end of a support arm,
- (iv) positioning the nozzle in the pipe such that the nozzle is located downstream of the bend and downstream of the flow-correction device, and the support arm extends into the pipe in a direction substantially parallel to the direction of the pipe downstream of the bend,
- 15 (v) feeding a reactant process stream comprising acetic acid, ethylene and oxygen into the reactor along the pipe,
- (vi) feeding a catalyst promoter fluid into the reactant process stream through the nozzle to deposit the promoter over the catalyst bed, and
- 20 (vii) reacting the ethylene, acetic acid and oxygen containing gas in the reactor to produce vinyl acetate.

10. A process as claimed in claim 9 wherein said fixed bed reactor comprises a fixed bed reactor as claimed in claim 7 or claim 8.



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