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For Reference

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Distillation plant with a column and a heat pump

The invention relates to a distillation plant with a column and a heat pump in accordance with the preamble of claim 1 and to a use of the plant.

In a distillation column heat is supplied to a sump for the production of a vapour, whereas in a column head a corresponding amount of heat is conveyed off for the liquefaction of vapours (often called exhaust vapours). The supply of heat in the sump and the conveying off of heat in the head are advantageously coupled via a heat pump process by means of which a heat transport as well as a heat conversion (i.e. temperature increase of the transported heat) can be carried out. A preferred method, the "direct exhaust vapour compression", can in many products not be used due to polymerisation, decomposition, corrosion, low vapour density etc. In such cases one distils conventionally without heat pumps or with a heat pump of which the working medium is a separate material which is conducted in an auxiliary circulation. In this the heat supply and the conveyance off of heat are carried out via indirect heat exchange in a sump vaporiser or in an exhaust vapour compressor respectively. Various materials come under consideration as working medium of the heat pump. For thermodynamic reasons and thanks to its lack of hazard to the environment, water is more advantageous in comparison with other possible materials and is therefore to be preferred.

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This Sheet Has Been Replaced

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A disadvantage of the use of heat pumps is that a compressor failure results in a long standstill time in practice since the compression must be done with machines for which as a rule no rapid replacement is available. The object of the invention is thus to provide a distillation plant in which this disadvantage with respect to a compressor failure is eliminated by means of suitable measures. This object is satisfied by a plant in accordance with claim 1.

The distillation plant comprises a column and a heat pump which operates between the sump vaporiser and an exhaust vapour compressor. The heat pump is substitutable by devices which can be switched to the sump vaporiser and the exhaust vapour compressor when required. These substituting devices comprise devices for the production of vapour or the provision of a coolant respectively as well as connection means. The coolants can be liquids (water) or gases (air).

The subordinate claims 2 to 6 relate to advantageous embodiments of the distillation plant in accordance with the invention. The subject of claims 7 to 10 is the use of this plant.

The invention will be described in the following with reference to the drawings. Shown are:

Fig. 1 a schematic illustration of a first distillation plant in accordance with the invention and

Fig. 2 a corresponding illustration of a second plant.

The components of the plant shown in Fig. 1 are:

- a column 1 for the carrying out of a distillation, comprising a distributor 10 for a raw product F (namely the material mixture to be treated), a sump 11, a column head 12 and installations 110 and 120;
- an exhaust vapour compressor 2 (compressor for the head vapours) comprising a sump 21 and a tube bundle 200 which is the vaporiser of a heat pump;
- a pump 41 for the circulation of condensed working medium 40 of the named heat pump which is vaporised in the exhaust vapour compressor 2;
- a sump vaporiser 3 comprising tube bundles 300, the sump 11 of the column 1 and a circulation pump 13, which is the compressor of the heat pump;
- a compressor 4 and a restrictor member 5 of the heat pump;
- a partial plant 20 for the removal of inert gases and of an excess heat which largely corresponds to the energy which is introduced into the process through the compressor operation;
- a tank 14 for the head product P", from where condensed product P" is fed back into the column via a circulation pump 13 and a return line 16;
- furthermore, a heat sink 7, i.e. a device 7 for the provision of a coolant (in particular cooling water or else air) and a heat source 6, i.e. a device 6 for the production of vapour (in particular water vapour).

Heat from a sump product P' which is won in the distillation is further supplied in a heat exchanger 100 to the raw product F, which can already be preheated through a heat supply in the partial plant 20 before it is fed into the column 1.

In the event of a failure of the compressor 4 its connection lines are closed by means of closure members (not illustrated), a further closure member 22 in the vaporiser circulation of the exhaust vapour compressor 2 is likewise closed and at the same time the heat source 6 is connected to the sump vaporiser 3 via connection means 63, 63', which are indicated in broken lines, and the heat sink 9 is connected to the exhaust vapour compressor 2 via connection means 72, 72'. Thus during a failure of the compressor 4 the operation of the distillation column 1 can now be continued in a conventional manner by means of non coupled heat exchange operations, namely with the substituting devices 6, 7 for the production of vapour and for the provision of a coolant respectively.

With the plant in Fig. 1 for example styrene can be won from a mixture which contains the more volatile ethyl benzene and, in smaller amounts, toluene and benzene. The hardly volatile styrene can be heated in the vaporiser 3 with water vapour at 104°C (pressure 1170 mbar) so that it can be vaporised in the sump 11 at a temperature of 100°C. The exhaust vapours in the head 12 with a temperature of 82°C can be liquefied in the compressor 2 with condensed water at 77°C (vapour pressure 416 mbar). The compressor 4 must compress water vapour from the sump 21 of the exhaust vapour compressor 2 from 416 to 1170 mbar.

For the conducting off of excess heat in the partial plant 20 it is as a rule advantageous to provide a cooler which is connected to a cooling water network 7. In the event of a compressor failure this cooling water

network can be used in the sense of the invention as the substituting device for the provision of coolant.

A control unit (not illustrated) is advantageously provided by means of which a switching over from the heat pump to the substituting devices can be carried out as soon as a failure of the compressor 4 takes place.

The unit 6 for the production of vapour is as a rule a boiler which gives off vapour at for example 6 or 16 bar. Thus a pressure relaxation member is to be arranged in the connection means 63' between the boiler 6 and the sump vaporiser 3. It is possible to use a pressure relaxation member of this kind as part of the device 7 for the provision of coolant so that exergy which is available with the vapour can be converted into a cooling power with this member. This will be illustrated subsequently with reference to Fig. 2 in which the pressure relaxation member is a vapour jet compressor 8.

In Fig. 2 the connections 63, 63', 72, 72', which are drawn in broken lines, are connection means by means of which substituting devices 6, 7 can be brought into effective contact with the distillation column 1 via non-illustrated closure members (cf. Fig. 1). The cooling device 7 comprises a preliminary cooler 71 and a main cooler 70. In a substitution of the heat pump 4, 5 cooling water which has been warmed in the exhaust vapour compressor 2 is cooled down by several degrees Celsius in the preliminary cooler 71 through evaporation before it is further cooled to the required first running temperature for the compressor 2 in the cooler 70. The vapour given off in the evaporation in the preliminary cooler 71 is sucked off via a line 76 and through the auxiliary compressor 8 which is formed as a vapour jet compressor. If

the drive vapour (supply line 61) of the boiler 6 has a pressure of 16 bar, then in the example given above (styrene distillation) with the auxiliary compressor 8 and high pressure vapour which comprises a proportion of about 60%, 40% low pressure vapour (about 400 mbar) can be correspondingly sucked in so that in the line 63 100% vapour (1170 mbar) is available as a heat source for the sump vaporiser 3. The water which is condensed in the giving off of the heat is conducted back into the boiler 6 via the line 63'. An excess of condensate, which corresponds to the sucked in low pressure vapour, can be given back via a line 67 into the cooling device 7 (and indeed into the cooler 70, as illustrated, or, better still, into the preliminary cooler 71).

The exhaust vapour compressor 2 can be formed as a device with tube bundles, at the tube surfaces of which the exhaust vapours condense in the form of falling films. Instead of a tube bundle compressor a plate compressor (an apparatus containing a plate stack) can also be used. The corresponding holds for the further heat exchangers, in which phase transitions take place.

A cooler 9 for the conveying off of excess heat is arranged in the plant of Fig. 2 parallel to the exhaust vapour compressor 2. In this the coolant can be air or water.

The plant in accordance with the invention can advantageously be used for the distillation of mixtures F of organic materials, with exhaust vapours being formed in this separation process at a temperature between 40 and 120°C and a sump product being vaporised at a temperature between 60 and 160°C. The heat pump process, through which the condensation of the exhaust vapours is coupled with the

vaporisation of the sump product, can be carried out with a compressor 4, which can be driven by an electric motor M, a gas motor, a steam turbine or a gas turbine. In the use of water as a working medium 40 a one-stage turbo-compressor, the blade wheel of which is advantageously manufactured of titanium, can be employed for the compressor 4.

In accordance with the fundamental object of the invention, a switching over from an operation with the heat pump 4, 5 to an operation with the substituting devices 6, 7 is carried out in the event of a compressor failure.

The substituting devices 6, 7 can also advantageously be used in the starting up of the distillation in that they are connected to the sump vaporiser 3 and to the exhaust vapour compressor 2 respectively prior to putting the compressor 4 into operation.

If the plant in accordance with Fig. 2 is also used with an electrically driven compressor 4, then an alternating operation with the heat pump and the substituting devices respectively can lead to an optimising of the energy costs. Namely in the case that for example during the day the costs of the electrical energy are substantially higher than during the night and the costs for the vapour production are relatively low, so that the increased energy requirement connected with the substituting devices causes lower costs as a whole as a result of the higher costs of the electrical energy. Thus for the saving of energy costs the operation can be carried out during the night with the heat pump 4, 5 and during the day with the substituting devices 6, 7, 8.

Patent Claims

1. Distillation plant comprising a column (1) and a heat pump (4, 5) which operates between a sump vaporiser (3) and an exhaust vapour compressor (2) of the column
characterised in that the heat pump is substitutable by devices (6, 7) which can be switched to the sump vaporiser and the exhaust vapour compressor when required; and in that these substituting devices comprise those (6 and 7 respectively) for the production of vapour and the provision of a coolant respectively, in particular of cool liquid or cool gas, and connection means (63, 63', 72, 72').

2. Distillation plant in accordance with claim 1 characterised in that water, which is subjected to phase transitions during the operation of the heat pump, serves as the working medium of the heat pump (4, 5).

3. Distillation plant in accordance with claim 2 characterised in that a cooler is provided for the removal of excess heat; in that this cooler (9) is connected to a cooling water network; and in that this cooling water network is the device (7) for the provision of coolant.

4. Distillation plant in accordance with claim 1 to 3 characterised in that a control unit is provided via which a switching over from the heat pump (4, 5) to the substituting devices (6, 7) can be carried out.

5. Distillation plant in accordance with claim 2 or claim 3 characterised in that the device (6) for the production of vapour is

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a boiler; and in that a pressure relaxation member is arranged in the connection means between the boiler and the sump vaporiser, with it being possible for the pressure relaxation member to be a part of the device for the provision of coolant, in particular a vapour jet compressor (8), and with said member making exploitable exergy which is available with the vapour.

6. Distillation plant in accordance with one of the claims 1 to 5 characterised in that the exhaust vapour compressor (2) is formed as an apparatus with tube bundles or plate stacks, at the surfaces of which the exhaust vapours condense in the form of falling films.

7. Use of a distillation plant in accordance with one of the claims 1 to 6 characterised in that a mixture (F) of organic materials is fed into the column (1) in liquid form; in that exhaust vapours with a temperature between 40 and 120°C and a sump product with a temperature between 60 and 160°C are formed in the distillatory separation; in that a heat pump (4, 5) is employed for a heat conversion and heat transport; in that a compressor (4) of the heat pump is driven by an electric motor (M), a gas motor, a steam turbine or a gas turbine, with the compressor in particular being a one-stage turbo-compressor and with water serving as a working medium (40).

8. Use of a distillation plant in accordance with claim 7 characterised in that in the event of a compressor failure a switching over from an operation with the heat pump (4, 5) to an operation with the substituting devices (6, 7) takes place.

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9. Use of a distillation plant in accordance with claim 7 or claim 8 characterised in that the substituting devices (6, 7) are connected up to the sump vaporiser (3) and to the exhaust vapour compressor (2) respectively when starting up the distillation.

10. Use of a distillation plant in accordance with one of the claims 7 to 9 characterised in that an operation with the heat pump (4, 5) and an operation with the substituting devices (6, 7, 8) is alternatingly provided for the optimisation of energy costs.

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