



US 20120199310A1

(19) **United States**(12) **Patent Application Publication****Koenig et al.**(10) **Pub. No.: US 2012/0199310 A1**(43) **Pub. Date: Aug. 9, 2012**(54) **HEAT EXCHANGE SYSTEM, AS WELL AS A METHOD FOR THE OPERATION OF A HEAT EXCHANGE SYSTEM****Publication Classification**(51) **Int. Cl.**
F28F 27/00

(2006.01)

(52) **U.S. Cl.** **165/11.1**(57) **ABSTRACT**

The invention relates to a heat exchange system (1) including a heat exchanger (2) with a flow passage (210) arranged in a flow segment (21). For the exchange of heat between a transport fluid (3) and a heat transfer medium (4) flowing through the flow passage (210) in the operating state, the transport fluid (3) can be brought into flowing contact with the heat exchanger (2) via an inlet area (201) and can be led away again from the heat exchanger (2) via an outlet area (202). In accordance with the invention, for the determination of a degree of contamination (V) of the heat exchanger (2), a contamination sensor (5) in the form of a pressure sensor (5) and/or of a speed sensor (5) is provided with which a transport parameter (TK) can be determined which is characteristic for the flow of the transport fluid (3) from the inlet area (201) via the outlet area (202). Furthermore, the invention relates to a method for the operation of a heat exchange system (1).

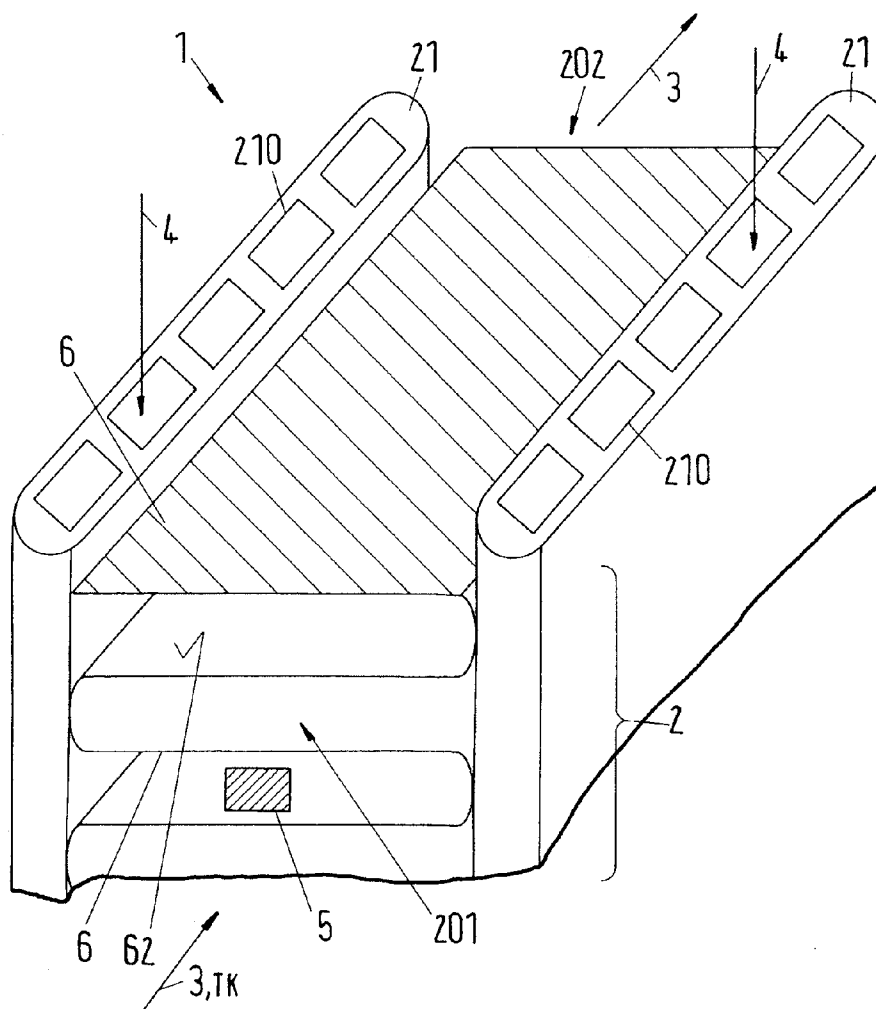
(75) **Inventors:** **Holger Koenig**, Kressbronn (DE);
Franz Summerer, Kottgeisering (DE)(73) **Assignee:** **A-Heat Allied Heat Exchange Technology AG**, Wien (AT)(21) **Appl. No.:** **13/382,635**(22) **PCT Filed:** **Jul. 7, 2009**(86) **PCT No.:** **PCT/EP09/58632**§ 371 (c)(1),
(2), (4) Date:**Apr. 24, 2012**

Fig.1

Fig. 2

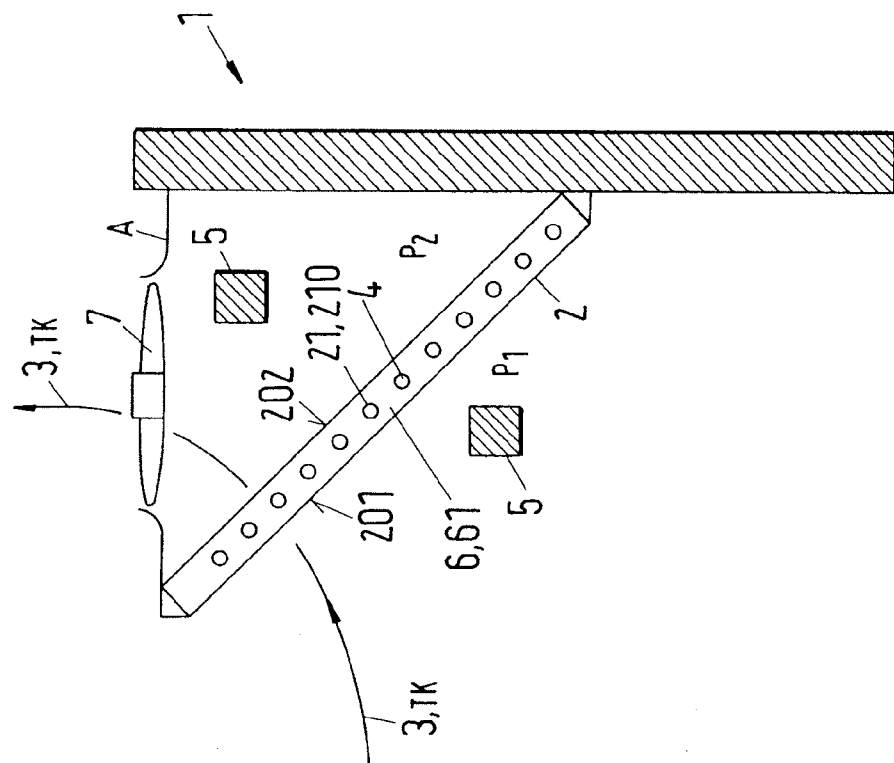


Fig. 3

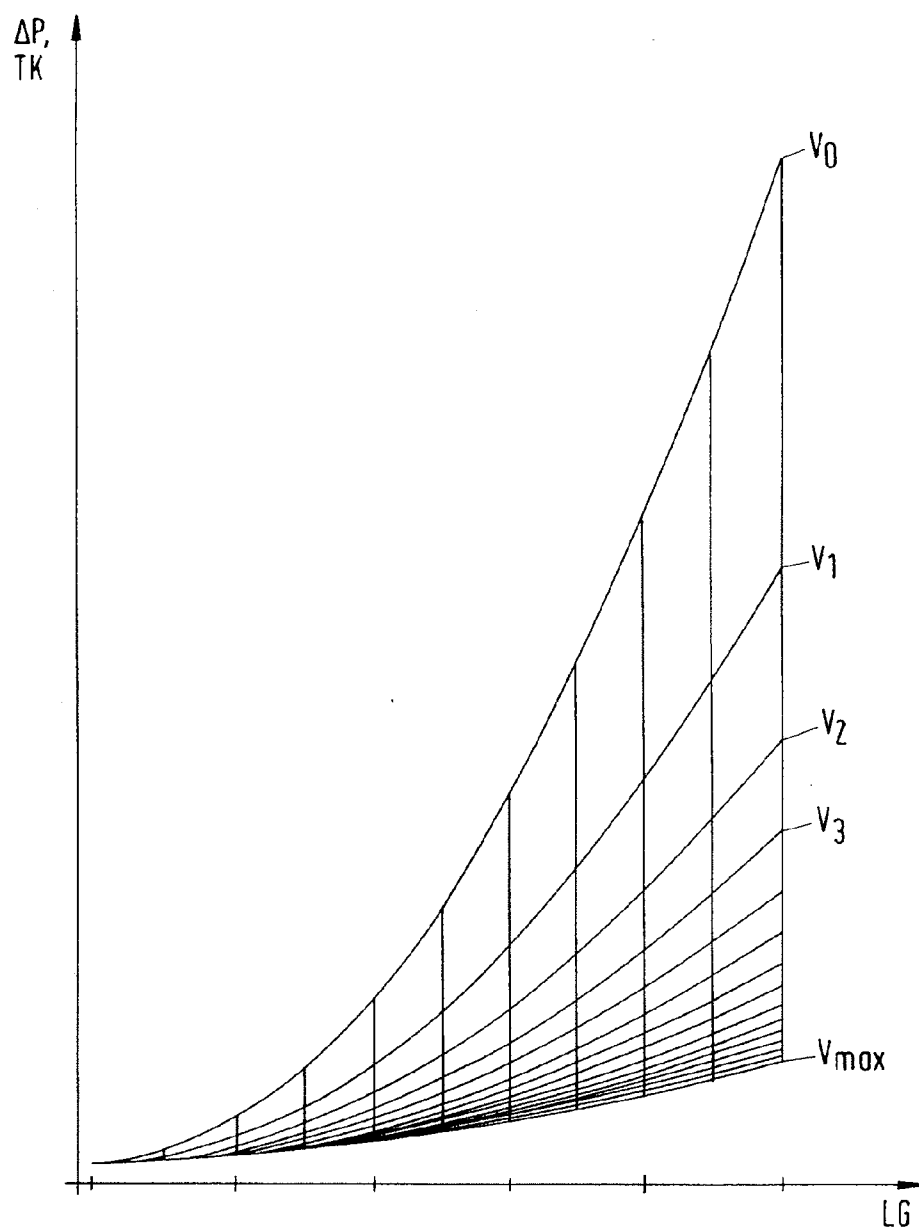


Fig.4

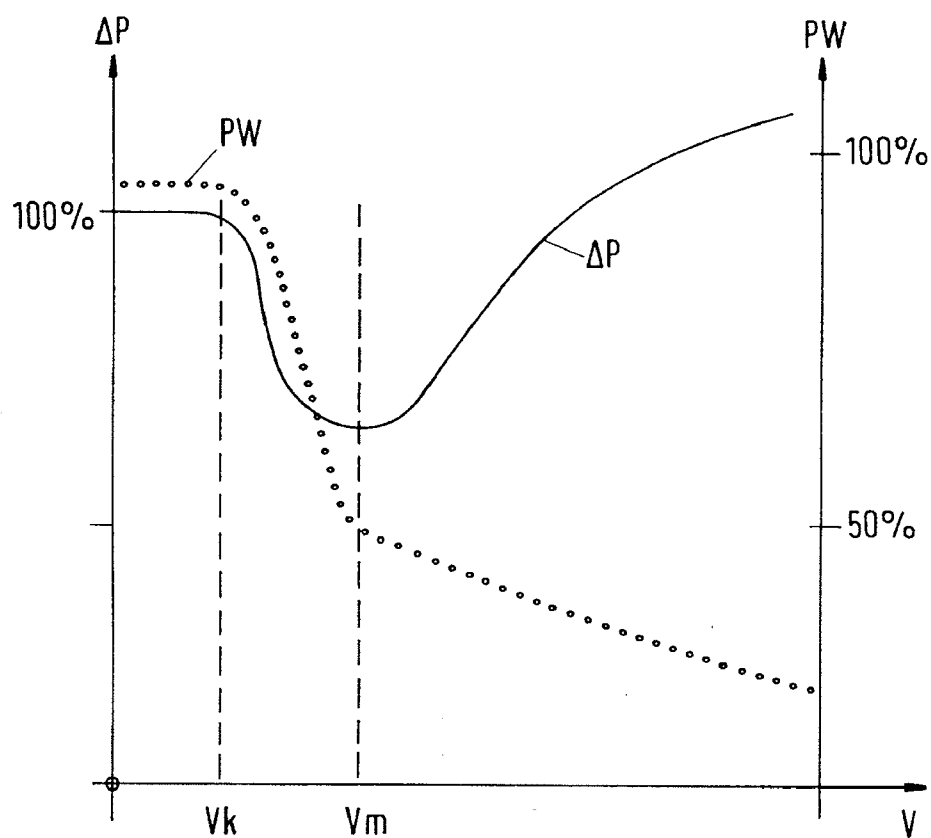


Fig.5

HEAT EXCHANGE SYSTEM, AS WELL AS A METHOD FOR THE OPERATION OF A HEAT EXCHANGE SYSTEM

[0001] The invention relates to a heat exchange system as well as to a method for the operation and determination of a degree of contamination of a heat exchange system in accordance with the pre-characterising part of the independent claims 1 and 11.

[0002] The use of heat exchange systems is known from the prior art in an overwhelmingly large number of applications. Heat exchangers are used in refrigeration plants, such as in normal household refrigerators, in air conditioning plants for buildings or in vehicles of all kinds, above all in motor vehicles, aircraft and ships, as water or oil radiators in combustion engines, as condensers or vaporisers in coolant circuits, such as for example in heat pumps and in further countless different applications which indeed are all well-known to the person averagely skilled in the art.

[0003] In this respect there are different ways of meaningfully classifying the heat exchanger from completely different areas of use. One attempt is to undertake a differentiation according to the construction and/or the manufacture of the different types of heat exchangers.

[0004] Thus, on the one hand, a division into so-called “fin heat exchangers” which can also be referred to as “tube heat exchangers” and, on the other hand into “mini passage heat exchangers” or “micro-passage heat exchangers”.

[0005] The fin tube heat exchangers, which have been well-known for a very long time serve, as do all types of heat exchangers, for the transfer of heat between two media, for example but not just, for the transfer of one cooling medium to air or vice versa, such as is known from a classic household refrigerator for example, in which heat is given off to the environmental air via the heat exchanger for the production of a refrigeration capacity in the interior of the refrigerator.

[0006] The environmental medium outside the heat exchanger, i.e. for example water, oil, or frequently simply the atmosphere which, for example receives the heat or which transfers heat to the heat exchanger is in this respect either correspondingly cooled or heated. The second medium can be a liquid cold or heat transfer medium or a vaporising or condensing “heat transfer medium”. In this respect within the scope of this application, the term “heat transfer medium” is to be understood to mean any fluid, which can be used advantageously in a heat exchanger. The term “heat transfer medium” thus includes not only the classical refrigerants known in technology, but also any other suitable heat transfer medium or cooling means. If, for example, in a certain application the heat exchanger is a simple radiator, for example a radiator in a combustion engine, then the heat transfer medium can more specifically naturally also be simple water or oil which circulates through the heat exchanger as coolant.

[0007] In any case the environmental medium, in other words for example, the air, has a considerably lower heat transfer coefficient than the second medium, in other words for example the coolant, which is circulating in the heat exchange system. This is compensated by very different heat transfer surfaces for the two media: The medium with the high heat transfer coefficient, in other words the heat transfer means, flows in the tube, which due to thin sheet metal parts (ribs, fins) has a greatly enlarged surface on the outside, at which the heat transfer takes place with the air for example.

[0008] FIG. 2 shows a heat exchange system in accordance with the invention with a fin tube heat exchanger known per se. In this regard the heat exchange system is formed in practice by a plurality of such elements.

[0009] In this respect the proportion of external surface to internal surface depends on the geometry of the fins (=tube diameter, tube arrangement and tube spacing) and also on the spacing of the fins. The spacing of the fins is selected differently for different uses. However, from a purely thermodynamic point of view it should be as small as possible, but not so small such that the pressure loss on the air side is too great. An economical ideal is approximately 2 mm, which is a typical value for liquefiers and heat exchangers.

[0010] The manufacture of these so-called fin tube heat exchangers takes place according to a standardized procedure which has been known for a long time. The fins are punched using a press and a special tool and placed together in packs. Subsequently the tubes are pushed in and dilated, either mechanically or hydraulically, so that a very good contact and thus a good heat transfer arise between tube and fin. The individual tubes are then connected with one another by bows and collecting and distributing tubes, often being soldered together.

[0011] The degree of efficiency in this regard is essentially determined by the fact that the heat, which is transferred between the fin surface and the air, has to be transferred by means of heat conduction through the fins to the tube. This heat transfer is all the more effective, the higher the conductivity or the thickness of the fin is, but also the smaller the space is between the pipes. One speaks of the degree of fin efficiency in this regard. For this reason aluminium is predominantly used as material for the fin nowadays, which aluminium has a high thermal conductivity (approximately 220 W/mK) at economic conditions. The tube spacing should be as small as possible which, however, leads to the problem that a lot of tubes are required. A high number of tubes mean high costs, because the tubes (as a rule are made of copper) are considerably more expensive than the thin aluminium fins. These material costs could be reduced in that one reduces the tube diameter and the wall strength, i.e. by building a heat exchanger with a plurality of small tubes rather than with a few large tubes. Thermodynamically this solution would be ideal: very many tubes spaced closely together with small diameters. However, also the working time for dilating and soldering the tubes is a crucial cost factor. This would rise dramatically in such a scenario.

[0012] For this reason a new class of heat exchangers, so-called mini-passage or micro-passage heat exchangers or also micro-channel heat exchangers were developed several years ago, which are manufactured by means of a completely different process and which almost correspond to the ideal image of a fin tube heat exchanger: a plurality of small tubes with narrow spacings therebetween.

[0013] Aluminium extrusions are used instead of small tubes in micro-passage heat exchangers however, which have very many small passages with a diameter of approximately 1 mm for example. An extruded section such as this, likewise known per se, is used and schematically illustrated in the embodiment of FIG. 1 in accordance with the invention, for example. In this respect a heat exchanger, depending on the heat output required can in practice make do with a single extruded section as a central heat exchange element. In order to achieve higher heat transfer performances, it goes without saying that a plurality of extruded sections can also be pro-

vided simultaneously, which for example are connected with one another or soldered to one another in appropriate combinations, via inlet pipes and outlet pipes.

[0014] Sections such as these can be manufactured simply and in various shapes and from a plurality of materials in suitable extrusion procedures for example. However, other manufacturing methods are also known for the manufacture of mini-passage heat exchangers, such as the putting together of appropriately shaped sheet metal parts or other appropriate methods.

[0015] These sections cannot and do not need to be dilated and they are also not pushed into punched fin packs. Instead sheet metal strips, in particular aluminium strips are, for example laid between two profiled sheet metal parts lying close together (typical spacing for example <1 cm), so that a heat exchange pack arises by means of the alternate placing of sheet metal strips and sections. This pack is then soldered in its entirety in a soldering oven.

[0016] This means that even when using the mini-passage heat exchangers, fins are often likewise used in the same way as the fin tube heat exchangers to increase the surface and for the improvement of the heat transfer between the heat transfer medium, which flows into the interior of the mini-passage heat exchanger and the air, into which heat for example is to be released.

[0017] In this respect it is known in both types of heat exchangers to provide the fin with slits, so-called "louvers". As the person averagely skilled in the art certainly knows, these louvers are mostly roof-shaped protrusions formed in the fin surface, through which, on the one hand, air can flow for example, at which, on the other hand, turbulences of the air can also form, so that an effective contact time or an effective contact surface is additionally increased between the air, with which heat is to be exchanged and the fin, so that the efficiency of the heat exchange can be increased further. This measure has also been known for a long time, wherein the specific geometric design of the louver can vary greatly, depending on the application. In the simplest case a louver is simply a slit, in other words an elongated narrow groove in the fin or an aperture in the fin.

[0018] Due to the narrow spaces and the small passage diameters in the micro-passage heat exchangers a heat exchanger arises with a very high degree of fin efficiency and with a very low filled volume (inner side of the passage). The further advantages of this technique are the avoidance of material pairings (corrosion), the low weight (no copper), the high pressure stability (approximately 100 bar) as well as the compact type of construction (typical depth of a heat exchanger for example, 20 mm).

[0019] Mini-passage heat exchangers have established themselves in mobile use during the 1990's. The low weight, the low block depth as well as the limited dimensions which are required here are the ideal pre-requisites for this. Car radiators as well as liquefiers and vaporizers for vehicle air conditioning units are almost exclusively realized using mini-passage heat exchangers nowadays.

[0020] On the one hand, larger heat exchangers are mostly required for use in the stationary position, on the other hand it is not so much the weight and the compactness which are foremost here but rather far more the ideal value for money. Mini passage heat exchangers were so-far limited in their dimensions to be suitable for this application. A plurality of small modules would have had to be connected in a complex and costly manner. Moreover, the use of aluminium for

extruded sections is relatively high, so that hardly any cost advantage was to be expected through this use of material.

[0021] Above all however the price of copper, which has risen sharply in comparison with aluminium means that this technology is also becoming increasingly interesting for stationary use.

[0022] In this regard a problem in all the previously known heat exchange systems is the contamination of the system components of the heat exchange system, in particular of the heat exchanger itself, i.e. above all the fins of the heat exchanger, something which is fundamentally unavoidable in the operating state.

[0023] Air-cooled heat exchangers, such as liquefiers or return exchangers often work in contaminated environments. The contamination of the air can be of a natural kind (pollen, insects, dust, leaves etc.) or of an industrial kind (grinding dust, tire abrasions, flour dust, cardboard dust etc.). Many contaminants stick to the aircooled heat exchanger and clog it up over time.

[0024] The heat exchangers past which the cooling air is led for example with the assistance of corresponding fans, can in time be contaminated more and more by such contaminants and by other contaminants of all kinds which are contained in the cooling air, which can lead for example to the fact that the heat transfer coefficient of the surface of the heat exchanger is reduced, so that the heat transfer performance is considerably reduced. This can lead to increased operating costs or in extreme cases the heat exchange system is no longer able to produce the required heat exchange performance at all, which can, in the worst cases lead to serious damage.

[0025] In this regard the above-mentioned louvers are particularly susceptible to contamination. These in particular offer a good support for contaminations of all kinds. The contaminations collect on the edges of the louvers in the fins and thus lead to a deterioration in the heat transfer of the fin and thus to a loss of performance of the heat exchanger, which as a result can lead to an increase in the consumption of energy and even to a ceasing to function.

[0026] The result of the contaminations is thus very often that the resistance on the air side increases and as a result the volume of air flow is reduced and the heat transfer is also reduced. This can result in the fact that an engine which is to be cooled, such as a data processing unit or a combustion engine or another engine overheats and is damaged. Damage to goods, such as food for example, which is stored in cold storage, can also perish due to lack of cooling.

[0027] In this respect these problems arise both in fin tube heat exchangers and also in micro-passage heat exchangers provided with fins.

[0028] In order to prevent serious damage of this kind and to act against contaminations such as these, the heat exchanger must either be expensively cleaned regularly or else provided with a corresponding filter. The filters must, however also be cleaned regularly.

[0029] In this respect in the known systems the cleaning of the heat exchanger is laborious and thus complicated and expensive, for a start for reasons of construction, for example because in the operating state the heat exchanger is not easily accessible. In many known heat exchange systems it is necessary for example to open a housing, in order to clean the heat exchanger itself or other crucial components in the interior of the housing of the heat exchange system, for example, or even just to check whether cleaning is necessary or whether it may still be postponed. In this respect the opening of the

housing is not just time-consuming and complicated. However, in this case as has already been mentioned, the correspondingly connected heat engines have to be shut down, since otherwise an opening of the housing of the heat exchange system is not permitted for reasons of safety or is not possible at all for technical reasons in the operating condition.

[0030] A further point is that a contamination which increases with time can be compensated within certain limits by means of appropriate control of the heat exchange system and/or regulation of the heat exchange system, for example by matching a performance of a fan, which conveys the air to the heat exchange through the heat exchanger in dependence on the degree of contamination. Or in that a throughflow or an operating pressure of a heat transfer medium is readjusted by the heat exchanger or another operating parameter is matched correspondingly.

[0031] However all these measures presuppose that the degree of contamination of the heat exchange system has to be known and, what is more, has preferably to be known not just qualitatively but also quantifiably and especially the change in the contamination has to be ascertainable.

[0032] It is therefore the object of the invention to make available an improved heat exchange system which overcomes the problems known from the prior art and which in particular permits the continuous monitoring of the degree of contamination of the heat exchange system, especially of the fin of the heat exchanger. In particular a heat exchange system is to be proposed, in which, within pre-determined limits, certain relevant operation parameters can be adapted to the intrinsically changing contamination of the heat exchange system, so that a heat transfer performance of the heat exchanger or of the entire heat exchange system can also be optimised over a long operating time, and a pre-determined heat transfer performance is also guaranteed for long operating times, even with increasing contamination. Furthermore, by means of the invention it is to be ensured that a pre-determined degree of contamination is automatically recognised, so that the ideal moment for necessary cleaning work can be automatically recognised without great expense.

[0033] The subject matter of the invention satisfying this object are characterised by the features of the independent claims 1 and 11.

[0034] The dependent claims relate to particularly advantageous embodiments of the invention.

[0035] The invention thus relates to a heat exchange system including a heat exchanger with a flow passage arranged in a flow segment. For the exchange of heat between a transport fluid and a heat transfer medium flowing through the flow passage in the operating state, the transport fluid can be brought into flowing contact with the heat exchanger via an inlet area and can be led away again from the heat exchanger via an outlet area. In accordance with the invention for the determination of the degree of contamination of the heat exchanger, a contamination sensor in the form of a pressure sensor and/or of a speed sensor is provided, with which a transport parameter can be determined which is characteristic for the flow of the transport fluid from the inlet area over the outlet area.

[0036] By means of the contamination sensor in accordance with the invention, which monitors the characteristic transport parameter, it is possible for the first time to automatically and continually monitor a contamination of the heat exchange system which is increasing with time, wherein a fall

in performance of the heat exchanger is already recognised by means of the contamination sensor in accordance with the invention before the pressure loss over the heat exchanger rises significantly. It is namely a crucial recognition of the invention, which massively uses the decrease in power of the heat exchanger, even at a degree of contamination at which the increasing contamination of the heat exchanger is not yet leading to an increase in the pressure loss over the heat exchanger. On the contrary, this leads to a decrease in the pressure loss over the heat exchanger at an earlier stage.

[0037] This means that it is possible for the first time, by means of the present invention, to gain reliable information about the performance or the change in performance of the heat exchanger from the characteristic transport parameters of the heat exchanger, for example from the fall in pressure over the heat exchanger or from a flow speed of the transport fluid, for example of the air flowing through the heat exchanger.

[0038] By this means an increasing contamination of the heat exchange system can for example be compensated within certain boundaries by suitable control and/or regulation of the heat exchange system, for example in that a performance of a fan, which conveys the air to the heat exchange by the heat exchanger, is adjusted in its performance in dependence on the degree of contamination. Or, however, in that a through flow of a heat transfer medium or an operating pressure of a heat transfer medium is appropriately readjusted by the heat exchanger or a different parameter is appropriately modified.

[0039] In this regard in an embodiment which is particularly relevant in practice, it is possible to continually determine the degree of the contamination of the heat exchange system and what is more, if necessary, not only quantitatively but also qualitatively, wherein the change in the contamination can also be especially determined in dependence on time. I.e. the degree of contamination of the heat exchange system, especially of the fin of the heat exchanger, can be continually monitored in the heat exchange system in accordance with the invention.

[0040] This makes it possible, to systematically adjust certain relevant parameters to the intrinsically changing contamination of the heat exchange system within pre-determined limits, so that a heat transfer performance of the heat exchanger or of the entire heat exchange system can also be continually optimized during a longer length of operation, as a result of which a pre-determined heat transfer performance remains guaranteed, even during long operating times. A pre-determined degree of contamination can be automatically recognised by means of the invention, so that the ideal point in time for necessary cleaning and maintenance can be recognised automatically, without significant cost and complexity.

[0041] In this regard the invention is based on the recognition, that a characteristic transport parameter of the transport fluid is dependent on the degree of contamination of the heat exchange system in a clear and reproducible manner, in particular on the degree of contamination of the heat exchanger.

[0042] In this connection the transport parameter can be a flow speed of the transport fluid for example, in other words for example a flow speed of the air through the heat exchanger. The transport parameter can, however, also be a pressure of the transport fluid, for example a pressure of the

air before it enters the heat exchanger via the inlet area, or a pressure during or after the flowing out over the outlet area of the heat exchanger.

[0043] The transport parameter is particularly preferably a pressure difference or a pressure loss over the heat exchanger. As will be explained in detail later with reference to FIG. 4 and FIG. 5, it has been shown in experiments, namely, that an increasing contamination of the heat exchanger influences the pressure loss of the flowing transport fluid in dependence on the degree of contamination in a characteristic manner.

[0044] For example, a look-up table or a mathematical function can be generated by means of corresponding calibration measurements, which reflects the degree of contamination of the heat exchange system, in dependence on the loss of pressure and/or of an absolute pressure value and/or of a characteristic flow speed of the transport fluid, wherein further parameters, such as for example the speed of rotation of a fan, a temperature or other parameters or operating parameters and condition parameters of the heat exchange system are possibly to be taken into account. The person averagely skilled in the art knows which particular parameters are to be taken into account for the determination of the degree of contamination and it goes without saying that it depends on the actual design of a corresponding heat exchange system.

[0045] The invention can be used particularly advantageously in heat exchangers, which include a fin for the increase of the effective heat transfer surface, with the fin being preferably equipped with the initially specified louvers.

[0046] In a completely surprising manner, the contamination of the louver initially leads, namely, to a reduced loss of pressure, as will be explained later with the help of FIG. 5. Here the loss of pressure as a function of the degree of the contamination initially falls to a minimum, in order to then rise again with progressive contamination. This means that the loss of pressure over the heat exchanger decreases initially with increasing contamination, not at all what was expected.

[0047] It is a crucial recognition of the invention, that the increasing contamination of the louver, in particular of the edges but also of the aperture slits of the louver, reduces the turbulence primarily at the edges of the louver or minimizes the turbulence at the edges of the louver or in the case of corresponding contamination, even prevented altogether, so that fewer turbulences arise and thus the overall loss of pressure through the flow passage formed by the fin is reduced. This means that the loss of performance of the heat exchanger associated therewith results from the reduction of the turbulence on the louver, because the effective contact time or the effective contact surface of the transport fluid with the heat exchanger is thus reduced.

[0048] By exploiting this recognition, in a special embodiment a very simple contamination sensor can be or is installed for the measurement of the pressure loss at a heat exchange system in accordance with the invention, which detects a reduction in the fall in pressure through the heat exchanger and thus can measure the degree of contamination, preferably in dependence on the time. It should hereby specially be ensured that the amounts of air, to which the respective loss of pressure over the heat exchanger is measured are respectively essentially the same in the clean and the contaminated condition. The speed of rotation of the fan and in further environmental conditions should in other words preferably be substantially the same between the clean and the contaminated condition. To this end, in speed-regulated ventilators

for example in accordance with EC technology the charging rate of the engine can be used as a signal, among other things.

[0049] As has already been mentioned more than once, in an embodiment which is particularly important in practice, a fin can be provided for the increase of a heat exchange rate at a flow segment, wherein a through flow aperture is preferably provided on the fin, in particular in the form of a louver.

[0050] In this regard at least one heat exchanger of a heat exchanger in accordance with the invention is a micro-passage heat exchanger and/or at least one heat exchanger is a tube heat exchanger.

[0051] In practice in a heat exchange system of the present invention a transport apparatus, in particular a fan is provided in a manner known per se for the transport of the transport fluid from the inlet area to the outlet area, wherein in practice the transport fluid is very often the atmosphere.

[0052] As has likewise already been mentioned, the transport parameter can be a pressure of the transport fluid, in particular a loss in pressure between the inlet area and the outlet area of the heat exchanger, and/or the transport parameter can be a flow speed of the transport fluid and/or also another characteristic flow property of the transport fluid.

[0053] Particularly advantageous for the control and/or regulation and/or for the purpose of a recording of data of an operating parameter or a condition parameter of the heat exchange system, is a control unit, in particular a control unit with a data processing unit which is signal connected to a sensor of the heat exchanger and/or with the transport apparatus and/or with the contamination sensor and/or with a heat engine for the control and/or regulation and/or for the purpose of a data collection of an operating or status parameter of the heat exchange system.

[0054] In this regard the heat exchange system can in practice be a radiator, in particular a radiator for a motor vehicle, in the special case for a land vehicle, for an aircraft or for a water vehicle, or a radiator, a condenser or a vaporiser for a mobile or a stationary heating plant, a cooling plant or an air conditioning plant, in particular a cooling apparatus for an engine, a data processing system or for a building.

[0055] The invention further relates to a method for the operation of a described heat exchange system in accordance with the present invention, wherein a transport parameter is measured and a degree of contamination of the heat exchanger is determined from the transport parameter.

[0056] In a particularly important embodiment for practice in this regard, a decline in pressure over the heat exchanger is determined from the transport parameter, wherein in particular a reduction of a heat transfer performance of the heat exchanger can be determined from the pressure loss.

[0057] In this regard a performance of the transport apparatus, in particular a speed of rotation of the fan can be controlled and/or regulated in dependence on the degree of contamination of the heat exchanger and/or a time for a service routine is automatically determined in dependence on the degree of contamination.

[0058] Advantageously in a heat exchange system in accordance with the invention in an online method, in particular via an intranet or via the internet, operating data and/or status data are monitored by a control centre and/or the heat exchange system is controlled and/or regulated in this manner.

[0059] The invention will be explained in more detail in the following, with reference to the drawings. There is shown in schematic illustration:

[0060] FIG. 1 a first embodiment of a heat exchange system in accordance with the invention with a micro-passage heat exchanger;

[0061] FIG. 2 a second embodiment in accordance with FIG. 1 with a finned tube heat exchanger;

[0062] FIG. 3 an embodiment with a differential pressure measurement for the determination of a loss of pressure;

[0063] FIG. 4 a loss of pressure at different degrees of contamination in dependence on the flow speed of the transport fluid;

[0064] FIG. 5 a loss of pressure and a performance curve in dependence on the degree of contamination.

[0065] In FIG. 1 a schematic illustration of a first embodiment of a heat exchange system with a micro-passage heat exchanger is shown, which heat exchange system is referred to in its entirety with the reference numeral 1 also in the following.

[0066] The heat exchange system 1 of FIG. 1 includes a heat exchanger 2, which is a micro-passage heat exchanger 2 in the present example, with a flow passage 201 arranged in a flow segment 21. For the exchange of heat between a transport fluid 3, which is the atmospheric air in the present case, and a heat transfer medium 4 flowing through the flow passage 210 in the operating condition, which heat transfer medium 4 for example is a refrigerant 4, such as CO₂, the transport fluid 3 is brought into flowing contact with the heat exchanger 2 via an inlet area 201 and can be led away again from the heat exchanger 2 via an outlet area 202. In accordance with the present invention a contamination sensor 5 is provided for the determination of a contamination of the heat exchanger 2, which in the present example is arranged in the flow direction of the air 3 upstream of the fin pack consisting of fins 6. The contamination sensor 6 is either a pressure sensor 6 or a speed sensor 6 or a through flow sensor 6 or another appropriate contamination sensor 6, with which a transport parameter TK, which is characteristic for the flow of the transport fluid from the inlet area 201 via the outlet area 202, can be determined.

[0067] The fin pack with the plurality of fins 6 each having a fin surface 62 serves for the increase in a heat exchange rate between the flow segment 21 and the transport fluid 3, which is atmospheric air in the present example.

[0068] In the embodiment of FIG. 1 possibly present louvers are not explicitly illustrated. Thus in a special embodiment according to FIG. 1, louvers may be provided on the fin 6 and in a different embodiment are not provided because for an appropriate difference application no louvers are required.

[0069] In practice a fan 7 for the transport of air 3, which is not illustrated in FIG. 1 for reasons of clarity, is provided for the transport of the air 3 by the pack of fins 6, so that for example a flow speed LG in accordance with FIG. 4 can be set, for example in dependence on a strength of the contamination of the heat exchanger 2, which has been detected with the aid of the contamination sensor 5. In this regard the transport fluid air 3 is blown from the fan 7 through the pack of fins 6 in the direction of the arrow 3.

[0070] In FIG. 1, which relates to an embodiment in accordance with the invention with a micro-passage heat exchanger 2, the plurality of flow channels 210, which are micro-passages here, are clearly visible.

[0071] FIG. 2 is distinguished from the embodiment of FIG. 1 essentially only by the fact, that instead of a micro-passage heat exchanger, a classic finned tube heat exchanger is used, wherein the louver 61 is clearly to be seen in the fins

6, which in the example of FIG. 2 are not yet contaminated. A further distinction from the example of FIG. 1 is in the fact that the contamination sensor 5 is accommodated in the interior of the fin pack consisting of fins 6.

[0072] It goes without saying that in each embodiment in accordance with the invention further contamination sensors 5 are also alternatively arranged at appropriate places or a plurality of contamination sensors 5 can additionally be provided at the same time.

[0073] For very special arrangements it is even possible that in one and the same heat exchange system a micro-passage heat exchanger 2 and a classic finned tube heat exchanger are provided simultaneously.

[0074] A further embodiment which is very significant in practice with differential pressure measurement for the determination of a pressure loss ΔP over the heat exchanger 2 is schematically illustrated in FIG. 3. The fan 7 in a manner known per se conveys environmental air 3 with the characteristic transport parameter TK through the heat exchanger 2 via the inlet area 201 and guides the air 3 through a cover A from the heat exchanger system 1 via the outlet area 202 back to the environment.

[0075] For the determination of the pressure loss ΔP during the passing of the air 3 through the heat exchanger 2, a contamination sensor 5 is provided respectively on the left-hand side of the drawing in front of the inlet area 201 and on the right-hand side of the drawing behind the outlet area 202, so that the pressure loss (ΔP) over the heat exchanger 2 can be determined from a measured pressure difference.

[0076] It is to be understood that it is not really definitive for the invention, which means are used to determine the pressure loss ΔP . A different differential pressure sensor known per se can be used advantageously just as well.

[0077] In FIG. 4 finally a typical carpet plot of the characteristic transport parameter TK for a heat exchange system 1 with a micro-passage heat exchanger 2 with fins 6 and louvers 61 is schematically illustrated.

[0078] In the example of FIG. 4 the pressure loss ΔP is shown as a transport parameter TK at different degrees of contamination V, ($V_0, V_1, \dots$ up to V_{max}) in dependence on the flow speed LG of the transport fluid 3. The person averagely skilled in the art has no problems understanding that one can also plot corresponding carpet plots for other transport parameters TK, for example for the through flow amount etc. and, it goes without saying also for other types of heat exchangers, for example for a finned tube heat exchanger.

[0079] The curve V_0 belongs to a heat exchange system 1, which was freshly cleaned, in other words is not yet contaminated. The curve V_1 of the characteristic curve was recorded in the same heat exchange system 1 after a certain length of operation. The heat exchanger 2 is now already considerably more contaminated, which can be recognised in the correspondingly small pressure loss ΔP . The curve V_1 is shallower than the curve V_0 , which belongs to the uncontaminated heat exchanger 2. After further operation the heat exchanger 2 becomes more and more contaminated, until it finally displays the maximum permitted contamination via V_2, V_3 etc. in the curve V_{max} and has to be cleaned again.

[0080] Finally FIG. 5 shows in schematic illustration a characteristic diagram, that explains the connection between the degree of contamination V and the alteration in the pressure loss ΔP resulting from this and also the reduction in the heat transfer performance PW of the heat exchanger 2 which is associated with this.

[0081] The degree of contamination V of the heat exchanger **2** is illustrated on the horizontal abscissa, which increases from the left towards the right in the drawing, wherein the pressure loss ΔP through the heat exchanger **2** is shown on the left-hand axis of ordinates ΔP , whereas on the right-hand axis of ordinates PW the decline in the heat transfer performance PW resulting from the increasing degree of contamination V is simultaneously to be read out.

[0082] The solid line ΔP corresponds in this regard to the course of the pressure loss ΔP in dependence on the degree of contamination V , whereas the dotted line shows the decline in the heat transfer performance PW in dependence on the degree of contamination V . In this regard the pressure loss ΔP and the heat transfer performance PW are identically zero at a degree of contamination V , i.e. each respectively normed to 100% for the not contaminated heat exchanger **2**.

[0083] At an even slighter contamination V the fall in pressure ΔP over the heat exchanger remains almost constant initially up to a critical degree of contamination V_K , from which the pressure loss ΔP suddenly and significantly decreases with an increasing degree of contamination, until the value of the pressure loss ΔP reaches a minimum value at a degree of contamination V_m . At the same time the heat transfer performance PW falls rapidly. Prior to a contamination interval and during the contamination interval between V_K and V_m , only the louvers are initially clogged with dirt particles, which leads to the fact that turbulences of the transport fluid **3**, in other words for example the air **3** flowing through the heat exchanger **2** is reduced even more, the stronger the louvers **61** are clogged up with dirt. By this means the air **3** can pass through the heat exchanger **2** more easily and/or faster. On the one hand, this results in a reduction in the loss of pressure ΔP , and, on the other hand leads to the fact that the effective contact time or the effective contact surface between the transport medium **3** and the heat exchanger **2** is reduced, which results in the observed massive reduction in the heat transfer performance PW .

[0084] With even greater contamination the loss of pressure ΔP increases again. The reason for this is that now the intermediary spaces between the individual fins, into which the louvers are worked are increasingly clogged up with dirt, so that increasingly less air **3** can be transported through the heat exchanger at the same fan performance per unit of time.

[0085] In this regard it is crucial, that in the vicinity of the minimum of the loss of pressure ΔP the heat transfer performance PW has already sunk to a no longer tolerable level, in the present special example has already fallen to 50% of the maximum possible heat transfer performance PW .

[0086] It is thus a crucial recognition of the invention that a cleaning of the heat exchanger is not to be undertaken at an increase in the loss of pressure ΔP but much earlier, namely in a phase when the loss of pressure ΔP is falling significantly.

[0087] Thus, with the present invention the maintaining of cleaning intervals can be ideally guaranteed, on the one hand, and on the other hand an ideal operation of the heat exchange system in accordance with the invention can be guaranteed. Furthermore, the quasi automatic occurring electronic signals are also available for other purposes and can for example also be used to advantage for different maintenance purposes.

1. A heat exchange system including a heat exchanger (**2**) with a flow passage (**210**) arranged in a flow segment (**21**), wherein for the exchange of heat between a transport fluid (**3**) and a heat transfer medium (**4**) flowing through the flow passage (**210**) in the operating state, the transport fluid (**3**) can

be brought into flowing contact with the heat exchanger (**2**) via an inlet area (**201**) and can be led away again from the heat exchanger (**2**) via an outlet area (**202**), characterised in that, for the determination of the degree of contamination (V) of the heat exchanger (**2**), a contamination sensor (**5**) in the form of a pressure sensor (**5**) and/or of a speed sensor (**5**) is provided with which a transport parameter (TK) can be determined which is characteristic for the flow of the transport fluid (**3**) from the inlet area (**201**) via the outlet area (**202**).

2. A heat exchange system in accordance with claim 1, wherein a fin (**6**) is provided at a flow segment (**21**) to increase a heat exchange rate.

3. A heat exchange system in accordance with claim 2, wherein a through flow aperture (**61**) is provided at the fin (**6**), in particular in the form of a louver (**61**).

4. A heat exchange system in accordance with claim 1, wherein at least one heat exchanger (**2**) is a micro-passage heat exchanger (**2**).

5. A heat exchange system in accordance with claim 1, wherein at least one heat exchanger (**2**) is a tube heat exchanger (**2**).

6. A heat exchange system in accordance with claim 1, wherein a transport apparatus (**7**) is provided, in particular a fan for the transport of the transport fluid (**3**) from the inlet area (**201**) to the outlet area (**202**).

7. A heat exchange system in accordance with claim 1, wherein the transport parameter (TK) is a pressure of the transport fluid (**3**), in particular a pressure loss (ΔP) between the inlet area (**201**) and the outlet area (**202**) of the heat exchanger (**2**).

8. A heat exchange system in accordance with claim 1, wherein the transport parameter (TK) is a flow speed of the transport fluid (**3**).

9. A heat exchange system in accordance with claim 1, wherein a control unit, in particular a control unit having a data processing unit, is signal connected with a sensor of the heat exchanger (**2**) and/or with the transport apparatus (**7**) and/or with the contamination sensor (**5**) and/or with a heat engine for the control and/or regulation and/or for the purpose of a data collection of an operating or status parameter of the heat exchange system.

10. A heat exchange system in accordance with claim 1, wherein the heat exchange system is a radiator, in particular a radiator for a motor vehicle, especially for a land vehicle, for an aircraft or for a water vehicle, or a radiator, a condenser or a vaporiser for a mobile or stationary heating plant, cooling plant or air conditioning plant, in particular is a cooling device for a machine for a data processing system or for a building.

11. A method for the operation of a heat exchange system (**1**) in accordance with claim 1, wherein a transport parameter (TK) is measured and a degree of contamination (V) of a heat exchanger (**2**) is determined from the transport parameter (TK).

12. A method in accordance with claim 11, wherein a decrease in pressure (ΔP) is determined from the transport parameter (TK).

13. A method in accordance with claim 11, wherein a decline in a heat transfer performance (PW) of the heat exchanger (**2**) pressure is determined from the pressure loss (ΔP).

14. A method in accordance with claim 11, wherein a performance of the transport apparatus (**7**), in particular a speed of rotation of the fan (**7**), is controlled and/or regulated, in dependence on the degree of contamination of the heat

exchanger (2), and/or wherein a time for a service routine is automatically determined in dependence on the degree of contamination.

15. A method in accordance with claim 11, wherein in an online method, in particular via an intranet or via the interne,

operating and/or status data from the heat exchange system (1) are monitored by a control centre and/or the heat exchange system (1) is controlled and regulated.

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