(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 October 2009 (22.10.2009)

PCT

(10) International Publication Number
WO 2009/127769 A1

(51) **International Patent Classification**:
B04C 5/22 (2006.01)

(21) **International Application Number**:
PCT/FI2008/000052

(22) **International Filing Date**:
16 April 2008 (16.04.2008)

(25) **Filing Language**: English

(26) **Publication Language**: English

(71) **Applicant** *(for all designated States except US)*: **LEAN-COM OY** [FI/FI]; Yrjönkatu 8-10 a 12, FI-00120 Helsinki (FI).

(72) **Inventor; and**
(75) **Inventor/Applicant** *(for US only)*: **LEPPANEN, Vesa** [FI/PT]; Rua Dr Mendonca 42, Lagos 8600-632 (PT).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

WO 2009/127769 A1

(54) **Title**: A METHOD FOR CLEANSING GASEOUS MEDIUM FLOWS WITH LIQUID OR SOLID WASHING MEDIA BY USING A CYCLONE SEPARATOR

(57) **Abstract**: The invention focuses on a method for cleansing gaseous medium flows (1) with different liquid or solid substances (12, 14) by using a cyclone separator (A). A gaseous medium flow (1) flows into the cyclone separator (A) through an inlet duct (C) and is forced into a revolving flow movement (11) inside the cyclone separator. At the end of the lower conical section (E) of the cyclone separator (A) the flow (11) changes into an outlet flow (13) that flows through the center of the inlet flow in a direction contrary to that of the inlet flow. The utilization of the durations of these different flows provides the washing media being used (12, 14) with sufficient time to act on the medium flow in order to obtain a good cleansing result. The utilization of correct feeding points (12, 14) and the structure of the cyclone separator (G, H) prevent the washing medium and the impurities that it has cleansed from the medium flow from being released along with the outlet flow (3).

A method for cleansing gaseous medium flows with liquid or solid washing media by using a cyclone separator

The invention focuses on a method for cleansing gaseous medium flows with different liquid or solid substances by the use of a cyclone separator. A gaseous medium flow flows into the cyclone separator through an inlet duct and is forced into a revolving flow movement inside the cyclone separator. At the end of the lower conical section of the cyclone separator the flow changes into an outlet flow that flows through the center of the inlet flow in a direction contrary to that of the inlet flow. The utilization of the durations of these different flows provides the washing media being used with sufficient time to act on the medium flow in order to obtain a good cleansing result. The utilization of correct feeding points and the structure of the cyclone separator prevent the washing medium and the impurities that it has cleansed from the medium flow from being released along with the outlet flow.

It is well known that cyclone separators are used for separating solid matter and liquid droplets contained within a gaseous medium flow from the gaseous medium flow. In a cyclone separator a gaseous medium flow is forced inside the cyclone separator into a centrifugal flow that revolves within the cyclone separator usually from the top downwards. When the cyclone functions vertically, the inlet duct for the gaseous medium flow is at the upper edge of the cyclone separator, as a result of which the in-flowing gaseous medium flow starts to revolve on the inside of the cylindrical cyclone separator in a downward spiral movement. When the spiral medium flow flows downwards to the conical lower part of the cyclone separator, maintaining its flow speed, the revolving medium flow accelerates at an angular speed which is dependant on the steepness of the cone. When the spiral medium flow reaches the bottom of the conical lower part of the cyclone separator, the spiral medium flow turns upwards and becomes a spiral outlet flow that maintains its direction of revolution.

Those impurities contained in the medium flow, which the cyclone, because of the separation capability typical of its structure, is not able to remove, exit along with the outlet flow. These impurities can be in gaseous, solid or liquid form. For this reason, cyclone separators are not usually considered to be good gas cleansers, especially when the impurities are gaseous and light-weight particle and droplet impurities. Large and heavy impurities can also flow out with the outlet flow, as a result of which it is difficult to define a precise separation boundary.

The separation efficiency of a cyclone separator depends on the centrifugal field that forms within the cyclone separator. It is generally known that the

greater the angular speed of a gaseous medium flow, the stronger the centrifugal field is, and the strength of a centrifugal field is directly proportional to the square of the angular speed of the medium flow. Since these movements and their durations can be calculated mathematically, it is also possible to calculate the time period during which the washing media being used act on the medium within the cyclone separator.

In order for a cyclone separator to be efficiently used for cleansing a medium, the chemical and mechanical reaction of the washing medium and the impurities within the medium as well as the time required for the reactions to occur must be known. At the same time, care must be taken to ensure that the impurities and substances that are removed from the medium do not exit with the cleansed medium.

The goal of the invention is to incorporate the possibility for cleansing a gaseous medium into a cyclone separator and to ensure that the cleansed gaseous medium is removed from the cyclone separator without impurities or washing medium residuals.

The method applied in this invention is known for the fact that the correct positioning of the washing medium injection is used as an addition to the structure of a cyclone separator in order to improve the separation capability of the cyclone separator.

The solution applied in this invention makes it possible to prevent impurities contained in the outlet flow from making their way to the outlet duct and from there to the outlet flow. In addition, the mechanical structure of the outlet duct brings about an improvement in the separation capability in comparison to that obtained with a conventional outlet duct.

The invention is based on the fact that the washing medium used in cleansing a medium is injected into the medium flow either immediately after the inlet duct through one or several nozzles during the first revolution if the washing medium requires a long action time or in the outlet flow in which case the outlet flow has to re-enter the circulation and join the uncleansed gaseous medium that is entering separator. These injections can also be used simultaneously. In the outlet duct any particles that do not belong in the gaseous medium are still in the centrifugal field, and the structure of the outlet duct, which is part of this invention, brings about a small reduction on the edges of the centrifugal field, as a result of which the remaining particles stay in the structure of the outlet duct, and the medium flowing out of the separator is as clean as possible.

A detailed explanation of this invention is provided in the solution principle presented in the attached diagram; however, this invention is intended to extend beyond the presented solution principle. The diagram shows a schematic cross-section of an economical set-up of the cyclone separator used in the method specified in this invention.

The cyclone separator shown in the diagram is labeled generally with the letter A. Cyclone separator A consists of a main frame, which is a cylinder labeled B, an inlet duct C through which the medium flow to be purified 1 enters as well as an outlet tube D through which the purified medium exits as flow 3. A cone E that narrows downwards is attached to cylinder B of the Cyclone separator A. At the bottom of cone there is a removal hole F through which the impurities separated from the medium are removed as outlet flow 2. This type of solution is conventional, applying already known technology, and does not, in itself, show any part of the invention.

Medium flow 1 that flows into cyclone separator A starts to revolve inside cylinder B as flow 11 and as it revolves around exit pipe D it moves in a downwardly direction. According to the invention, washing medium 12 can be injected into this flow at a pressure generated by a separate pump when the washing medium requires as long a duration as possible to act on the impurities contained in medium flow 11 and in order to enable these impurities to be removed. This is the situation, in particular, when the impurities are in gaseous form. The washing medium solution is more often than not water, although it can also be any other injectable liquid or solid substance or chemical compound.

When medium flow 11 reaches the lower cone E of cyclone separator A, flow 11 starts to revolve at an ever decreasing radius of revolution while, however, still maintaining the speed at which it entered cyclone separator A. As a result, the angular speed of flow 11 increases as the flow proceeds down cone E. Hence, the centrifugal field increases as a square of the angular speed, which causes the solid matter and liquid droplets in the centrifugal field to fly out onto the walls of lower cone E from where they fall down into exit hole F through which they can be removed as outlet flow 2. In the lower part of lower cone E flow 11 turns upwards becoming outlet flow 13 that is located in the centre of flow 11 and that has the same direction of revolution as flow 11 but moves in a direction contrary to that of flow 11 towards outlet duct D. Since the speed of the outlet flow is virtually the same as that of flow 11 but its diameter considerably smaller due to lower cone E, the angular speed of outlet flow 13 is considerably greater than that of flow 11.

In accordance with the invention, this outlet flow 13 can be dispersed by injecting washing medium 14 at the flow in a direction directly against its direction of flow at a pressure generated by a separate pump when the purpose of injecting the washing medium is to improve the structural separation capability of the cyclone separator and the cleansing result. The solid particles and liquid droplets contained in the outlet flow are dispersed into flow 11 and, thereby, back into the separation. After acting on flow 11 that revolves in the cyclone separator, washing medium 14 is sent into the outlet flow.

In order to obtain the best cleansing result and separation capability, washing medium 14 must be injected at a point at which the force generated by the injection is equivalent to that required to disperse outlet flow 13. This differs depending on the structure of the cyclone and, among other things, the steepness of the conical part. The invention enables the solid particles and liquid droplets contained in the outlet flow to return back into the main circulation as efficiently as possible.

Despite the injection of washing medium 14, most of the volume of outlet flow 13 continues moving upwards in a spiral motion. Any solid particles and liquid droplets are deposited on the edges of outlet duct D as a result of the centrifugal field. These particles are removed by altering the centrifugal field in such a way that at the outer edge of the outlet flow the angular speed falls as a result of an extension G that contains within itself another extension H the lower end of which is narrower than outlet duct D but that expands upwards. In this way, most of the outlet flow continues through extension H, while the angular speed at the outer edge of flow 13 that contains most of the impurities falls so low that the solid matter and liquid droplets that it contains fall down and run back into the cyclone along the outer edge of outlet duct D.

The method developed in this invention makes it possible to achieve a controlled and very good cleansing result and high separation efficiency in comparison to those obtained using a conventional cyclone. The effect of the solution developed in this invention on the structure and appearance of a cyclone separator is very small.

The above is only a general solution based on the invention, and many modifications can be made to it within the framework of the invention concept presented in the following patent claims.

Patent Claims

1) A method for cleansing gaseous medium flows (1) with different liquid or solid washing media (12, 14) utilizing a cyclone separator (A), in which the gaseous medium flow to be cleansed (1) flows into the cyclone separator through an inlet duct (C) and is forced into a revolving flow movement (11) inside the cyclone separator, and in which, depending on the amount of time required by the used washing medium to act, the washing medium is injected into the flow either immediately after the flow enters the cyclone (12) or against the outlet flow (14) in which case the injection also disperses the outlet flow (13) thus preventing solid matter or liquid droplets from entering, along with the cleansed medium flow, the outlet duct (D) the structure of which includes a structure (G, H) for removing solid matter and liquid droplets through a drop in pressure, k n o w n for the fact that the injection of a washing medium (12, 14) utilizing a separate pump is used to take advantage of the basic chemical properties of the washing medium (12) as well as to return the particles still mechanically in the outlet flow back into the cleansing cycle (14).

2) The method described in patent claim 1, k n o w n for the fact that the structure of the outlet duct (D) contains an extension (H), the purpose of which is to remove solid matter or free liquid droplets by creating a pressure drop on the surface of the outlet flow and which is located in an extension of the outlet duct (G).

3) A method described in patent claims 1 – 2, k n o w n for the fact that the distance and power of an injection point (14) installed against the outlet flow (13) can be adjusted to such a location and power in order to achieve the best cleansing result.

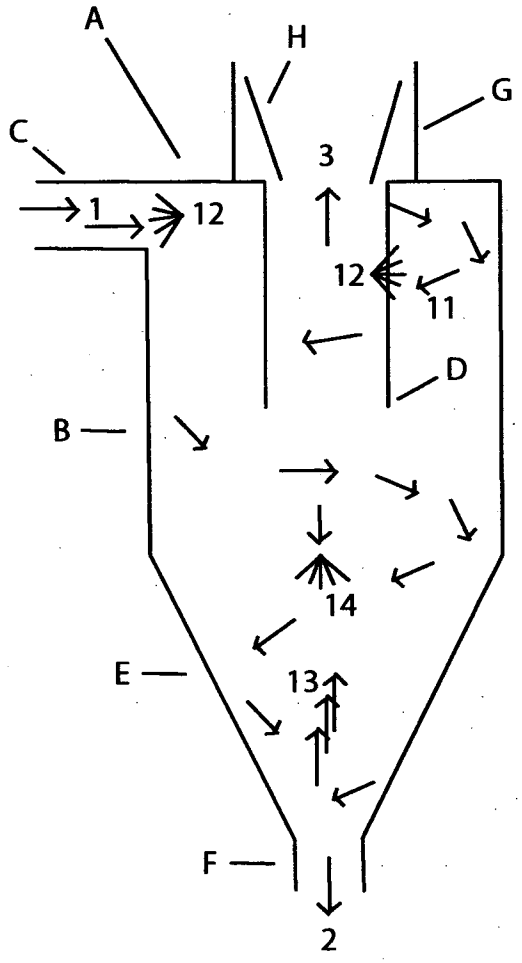

Fig.
A method for cleansing gaseous medium flows with liquid or solid washing media by using cyclone separator.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2008/000052

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC8: B04C, B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 1356866 A (SCHWARZ HOLYWELL LTD) 19 June 1974 (19.06.1974), Figure	1-3
A	SU 915908 A1 (LETYUK ALEKSANDR et al.) 30 March 1982 (30.03.1982), Figure 1	1-3

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 December 2008 (30.12.2008)	09 January 2009 (09.01.2009)

Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland
Facsimile No. +358 9 6939 5328

Authorized officer
Timo Maunola
Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2008/000052

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
GB 1356866 A	19/06/1974	None	
SU 915908 A1	30/03/1982	None	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2008/000052

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.
B04C 5/22 (2006.01)