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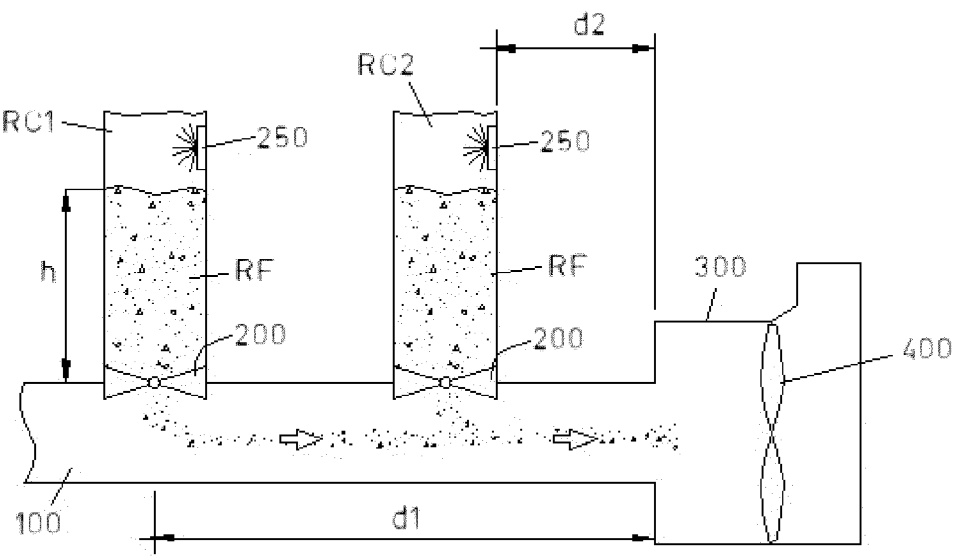
(54) **Method of pneumatic transport of refuse**

(57) It comprises performing a discharge step by which refuse (RF) is discharged from a refuse chute (RC_i) into a transport pipe (100); drawing air along the transport pipe (100) for transporting the refuse (RF) to collection station (300); controlling the transport speed of the air flow (V_A); controlling the discharge speed of the air (V_B) in the refuse chute (RC_i); varying the transport speed of the air flow (V_A), through a PID controller during transportation of refuse (RF) such that the transport speed of the refuse (T_S) is constant along the pipe (100); and varying the discharge speed of the air (V_B) for a discharge time (t_D) during discharge. A variation in the discharge speed of the air (ΔV_B) is dependent at least upon the distance (d) of each refuse chute (RC_i) to the central station (300).

FIG. 2



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Description

[0001] A method of pneumatic transport of refuse as defined in the preamble of claim 1 is disclosed herein.

BACKGROUND

[0002] Pneumatic transport systems in refuse collection systems are known. Such systems are used for transporting waste products from refuse chutes through transport pipes into a remote collection station.

[0003] The refuse chutes comprise a substantially vertical tubular receptacle extending from the site from which the refuse products are discarded to a transport pipe where the refuse products are transported upon being discharged and conveyed into the collection station. The refuse chutes on a determined area are connected to each other through the transport pipes so that the refuse is transported to the collection station where refuse is collected for treating, recycling or disposal. The transport pipes may directly lead to the collection station or to a common air transport pipe system leading to the collection station.

[0004] In known collection systems, the refuse chutes are designed to receive selective refuse of a given type therein. The refuse is stored within the refuse chute waiting for being subsequently transported into the collection station.

[0005] The refuse chutes may be provided with detecting means such as a photoelectric cell for controlling load levels for discharge. The refuse chutes are also fitted with corresponding discharge means comprising discharge valves. The discharge valves are operable according to a discharge step for emptying the waste products contained therein into the transport pipes. Such discharge step may be performed according to signals received from different devices according to conditions that are determined for discharge, such as level signals from the above mentioned detecting means.

[0006] Once the discharge valve in a refuse chute is opened, the waste products, i.e. the refuse, fall into the transport pipe where they are conveyed by the suction produced by the flow of air drawn by a fan-driven suction system into the collection station.

[0007] The discharge step can be carried out in a controlled way, that is, the discharge valves of the refuse chutes may be automatically actuated according to different parameters and conditions that are monitored by the refuse collection system.

[0008] Document EP2022731 filed by the same applicant discloses a method for controlled disposal of refuse from a network of refuse chutes. The refuse is conveyed through transport pipes into a remote collection station. Load levels within the refuse chutes are continuously measured and an energy analysis is also carried out in order to determine the effectiveness of the transport of waste. According to the method disclosed in this document, it is determined whether a number of emptying conditions are met depending on a refuse chute being considered as a reference and the refuse chutes to be analysed. Such controlled emptying method of the refuse chutes is highly efficient since the operating time of the fan assemblies is reduced and the working life of the system can be longer.

[0009] Document W00046129 discloses a refuse transport system for a specific refuse collection system in which an air inlet is disposed above the waste products when stored within a bend. According to this method for such a specific system, additional air is provided into a vertical extended storage volume with the purpose of controlling the drag force applied to the stored refuse and the concentration of refuse material in the transport air. The extended storage volume is connected to a horizontal transport pipe through a discharge valve that is also positioned in a horizontal pipe. The additional air is provided through several air inlets into a refuse chute. One of such air inlets is immediately upstream of the discharge valve.

[0010] Despite the above mentioned solutions, there is still a demand for an optimized transport of refuse especially in large collection systems where an increased amount of refuse is to be collected during a given period of time. This is particularly relevant in areas such as dense residential areas where a large number of refuse chutes is installed. In this case, the efficiency of the system must be optimized as to the transportation of the waste products along the transport pipes to the refuse collection station.

[0011] Such demand arises from an issue in known systems relating to a maximum conveying distance to which the waste products can be transported along which conditions are not varied or along which conditions vary only slightly. The problem is due to pressure leaks along the waste conveying path within the transport pipes which leads to a significant decrease in the waste transport speed.

[0012] As it is known, the larger the distance between a given refuse chute and the refuse collection station the less efficient is the refuse collection system especially in terms of energy consumption. In points located farther away from the refuse collection station, such as of the order of 2 km, the speed of the air flow and thus the negative pressure or suction produced for conveying the refuse is undesirably reduced due to the frictional and pressure leaks along the pipe. The decrease in the waste transport speed renders the transport of waste materials inefficient.

[0013] The present method allows the prior art problems relating to transport of refuse to be at least reduced while providing a number of advantages over the existing pneumatic transport systems in current waste collection installations.

SUMMARY

[0014] A method of pneumatic transport of refuse in a waste collection installation is herein disclosed according to claim 1. The method allows an efficient transport of refuse within at least one transport pipe leading to at least one central station. Advantageous embodiments are defined in the dependent claims.

[0015] The waste products, i.e. the refuse, such as example paper, containers, remnants and organic products or a mixture thereof, are initially loaded within a particular refuse chute through an upper opening for being temporarily contained therein. The refuse remains within the refuse chute until it is discharged through a discharge means. The discharge means may comprise at least one discharge valve. When the discharge means are actuated, the waste products contained within the refuse chute are discharged into the transport pipe through which it is conveyed into a central collection station. The refuse chutes may be arranged forming a network of refuse chutes all leading either directly to the collection station or to at least one common transport pipe for transporting the refuse into the central collection station.

[0016] Conveying of the waste materials into the central station is carried out through air drawn from a fan-driven suction system. Therefore, the transport of refuse will be also referred herein to as pneumatic transport of refuse.

[0017] According to the present method, when a number of conditions are met, for example, when a determined load level has been detected by sensor means associated with a particular refuse chute, the discharge valve in the refuse chute is actuated such that it is opened in order to discharge the waste products contained therein into the transport pipe. Such discharge step also takes into account the distance from the particular refuse chute to the collection station in a way that those refuse chutes located farthest from the central station or those having higher losses associated therewith are first discharged.

[0018] Once a request for discharge is detected by the system, a transport reference speed of the air flow is set by the operator. After that, a value for the transport reference speed of the air flow is automatically set according to the specific type of refuse to be discharged. An approximate value for the degree of compaction can be thus calculated. Based on such empirical data it is possible to foresee and model a different behaviour depending on the type of refuse that is transported.

[0019] The reference speed of the air is automatically set according to parameters of the waste transport process that are monitored during a transport cycle within the collection system such as the atmospheric pressure, differential pressure, relative pressure, temperature and calibration constants for the correct adjustment of the measurement electronics. The reference speed of the air may also be determined according to actual measurements during operation from measuring devices such as sensors and other metering equipment depending on the type and dimensions of the collection system.

[0020] By means of the suction produced by the air drawn through the above mentioned fan-driven suction system, the refuse is caused to advance along the transport pipe and thus conveyed into the collection station where it is collected for at least one of treating, recycling or disposal.

[0021] According to the present method, transport speed of the air in the transport pipe, and the discharge speed of the air in the refuse chute are suitably controlled by the refuse collection system through suitable control means.

[0022] As used herein, the transport speed of the air flow in the transport pipe relates to the speed of the air stream caused by the fan-driven suction system for transporting waste products and the discharge speed of the air relates to the speed of the air flow during discharge of a refuse chute.

[0023] During transport of the waste products within the transport pipes into the collection station, the speed of the air flow in the transport pipe is varied according to the present method through a proportional integral derivative closed loop feedback controller (PID controller). Such closed loop PID controller is adapted for automatically comparing the current speed of the air flow within the pipe with the transport reference speed of the air flow that is an automatic set point adjusted during the hot startup stage of the refuse collection system.

[0024] Then the transport speed of the air flow is automatically adjusted by the PID controller which makes the rotational speed of the fan motors to be increased or decreased such that the transport speed of the air flow measured is as close as possible to the transport reference speed of the air flow to be substantially constant along the transport pipe as the waste products are conveyed into the collection station.

[0025] Therefore, the air flow measured is through a centralized reference measurement system. This centralized reference measurement system can be located in o near the collection station or even in a distributed manner and be dependent on sensors.

[0026] The difference between the transport speed of the air flow and the transport reference speed of the air flow when compared increases as the distance between a given refuse chute and the central station increases. The variation of the speed of the air flow thus depends on the distance between the refuse chute being considered to the central station as well as on the characteristics of the refuse chute and the type of refuse being transported. By varying the transport speed of the air flow a decrease in the transport speed of the air flow due to friction and pressure leaks is advantageously compensated.

[0027] Such variation of the transport speed of the air is based on the above reference speed of the air and real time measurements of the current transport speed of the air, measured by central monitor, according to the specific type of refuse that is loaded within a particular refuse chute. From such data, the PID controller automatically varies the frequency on the fan motors of in the fan-driven suction system in order to adjust the transport speed of the air. In certain circumstances such as in locations near the central station the transport speed of the air could be lowered even under fan motor nominal speeds.

[0028] Adjusting the transport speed of the air through the above mentioned PID controller is carried out by adjusting frequency converters that are associated with the respective motor means in the fan-driven suction system of the refuse collection system. This enables the speed of the refuse to be automatically adapted according to the requirements in order to keep the transport speed of the waste products at least substantially constant. Such adjustment in the transport speed of the air flow is performed by constant monitoring of the current speed of the air flow measured_by the PID controller causing the transport speed of the air to be always at least substantially constant substantially along the entire length of the transport pipes. Varying the suction force to keep the transport speed of the air flow constant may be carried out according to a specific type refuse to be conveyed.

[0029] By maintaining the transport speed of the waste products constant erosion and impacts on the inside of the pipe, especially in elbows, are efficiently reduced. Discharge speed of the air values are reduced when refuse is close to the central station. Pipe wear off is thus also reduced. Vacuum pressure can be therefore applied to efficiently and smoothly convey refuse.

[0030] When carrying out the present method, the transport speed of the air is preferably measured by a reference monitor with several devices preferably located in the central station and/or in the transport pipe. Since variations in the transport speed of the air mainly depend on the distance between a particular refuse chute and the central collecting station, measuring the current transport speed of the air at the central station is advantageous over prior art methods in which measuring are carried out through devices fitted in the transport pipes, distant from the collection station.

[0031] According to the present method, in combination with the above variation of the transport speed of the air flow by the PID controller, such that the speed of the refuse is substantially constant along the transport pipe, an increase in the discharge speed of the air is also performed by the collection system for a discharge time.

[0032] The discharge time is the time during which the discharge operation is performed. The variation in the discharge speed of the air depends at least upon the distance from each refuse chute being considered to the central station.

[0033] The increase in the discharge speed of the air is also performed by the PID controller. This increase in the discharge speed of the air is performed during the discharge step. Once a discharge operation of refuse chute has been completed, i.e. once the discharge valve has been closed again, the refuse collection system continues working with the rated working pressure for a period of time determined by the refuse collection system for transporting the refuse discharged from the refuse chute as stated above.

[0034] The period of time during which the refuse chute is conveyed by the fan-driven suction system in the refuse collection system takes into account the discharge time of a next refuse chute. This ensures that the waste being transported is beyond the refuse chute that has been discharged. The discharge time depends on the height from which the refuse is discharged and the speed of the refuse being discharged.

[0035] The increase in the discharge speed of the air for each refuse chute is provided from the moment the discharge valve of the refuse chute being considered is opening to perform a refuse discharge until the discharge valve of a next the refuse chute is opening. More specifically, when the discharge time has been elapsed, the air valve in the next refuse chute to be discharged is opened by the system and the air valve of the refuse chute already discharged is closed. In this state, the system adjusts the transport speed of the air flow with respect to the reference speed of the air flow again by using the PID control as stated above. As successive discharges of refuse chutes are performed within the same cycle and the distance to the central station is increasingly short or long, the increase value of the transport speed of the air to be added to the reference speed of the air flow is smaller allowing speed peaks to be smooth and reducing turbulent flow inside the pipe.

[0036] A transport speed of refuse may be determined as a value that is proportional to the transport speed of the air along the transport pipe. Therefore, the goal is to keep the transport speed of the air and hence the transport speed of refuse at least substantially constant along the entire length of the transport pipes in the network of refuse chutes in the collection system.

[0037] According to the present method, the increase of the discharge speed of the air is carried out during the discharge step. In some embodiments, such an increase of the discharge speed of the air is carried out exclusively during the discharge step. This increase of the speed may be preferably carried out when refuse chutes containing the same type of refuse are discharged so that the refuse is transported sequentially and dynamically from those farthest to those nearest to the central station in a full cycle from the starting of the fans. The refuse can be alternatively transported sequentially and dynamically from those nearest to those farthest the central station. This depends on the type of waste product.

[0038] By controlling and adjusting the discharge speed of the air any decrease in such velocity when the refuse comes into the airflow within the transport pipe is compensated. This also helps to prevent jamming and clogging of the refuse at low speeds during waste discharge step.

[0039] When a refuse chute is emptied and its corresponding discharge valve is subsequently closed, the transport air speed is again adjusted by the refuse collection system no extra transport air from the fan-driven suction system. The transport speed of the air will be varied again if necessary during the corresponding next refuse chute discharge step.

[0040] By controlling and adjusting the discharge speed of the air during discharge clogging can be efficiently reduced especially in cases of massive discharge. In addition, noise due to air stream can be also advantageously reduced. The refuse chute emptying speed can be also reduced in remote locations while ensuring that clogging does not take place.

[0041] Both the step of varying the transport speed of the air in order to make the transport speed of the refuse at least substantially constant along the transport pipe and the step of varying the discharge speed of the air during the discharge of the refuse may be combined such that they may be carried out in parallel according to the present method. Such steps may be performed automatically.

[0042] At least one of the step of varying the transport speed of the air and the step varying the discharge speed of the air is carried out by increasing the speed of the air.

[0043] Several inlet air valves may be provided at different points of the installation. Such inlet air valves are used to decrease the pressure. This could also be advantageous for reducing noise when in use.

[0044] The present method is capable of varying the transport speed at any point along the transport pipes at any distance from the collection station. The transport speed can be thus accurately measured in the collection station such that the transport speed of the air flow and the discharge speed of the air can be increased efficiently as necessary in order to compensate for losses.

[0045] The present method allows controlling the transport speed of refuse in pneumatic refuse collection systems such that a minimum transport speed for each specific type of refuse and a stable control thereof is performed. The energy balance of the system is highly improved.

[0046] A global control of the waste transport is performed. According to the present method, a refuse chute is only discharged when there is a convenient value of transport speed before starting the discharge step. This is an integral method for controlling the transport speed in a way that erosion in the transport pipes due to excessive speeds and impacts are reduced. An adaptive control of the transport speed is performed depending of the location and the conditions of the refuse chutes. The difference between the measured in situ transport speed and the speed measured from the collection station is controlled and automatically compensated according to the installation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047] Particular embodiments of the present invention will be described in the following by way of non-limiting examples, with reference to the appended drawings, in which:

Figure 1 is a general view showing a urban pneumatic refuse collection system;

Figure 2 is a diagrammatic view of a refuse collection system in which two refuse chutes have been depicted; and

Figure 3 is a diagrammatical plan view of a network of branches of refuse chutes in the refuse collection system shown in figure 2.

DETAILED DESCRIPTION OF EMBODIMENTS

[0048] The refuse system that is diagrammatically comprises a network 600 of n refuse chutes RC1, RC_2... RC_i... RC_n, as shown in figure 3. Only two refuse chutes RC1, RC2 are shown in figure 2.

[0049] Referring to figure 2, each refuse chute RC_i in the network 600 comprises a substantially vertical tubular receptacle that is arranged fixed on a private community 500 as shown in figure 1, where refuse RF are to be collected in large amounts.

[0050] The receptacle of the refuse chutes RC1, RC2 shown extends from the site from which the refuse products are discarded to a transport pipe 100.

[0051] The present refuse collection system operates according to the method described below. It is to be noted that in the present embodiment all the refuse chutes RC_i involved in the method described herein are intended to contain the same type of refuse RF.

[0052] The refuse products RF are transported along the above mentioned transport pipe 100 upon being discharged from the refuse chute RC_i through a corresponding discharge valve means 200 fitted in the refuse chute RC_i.

[0053] Refuse products RF are conveyed along the transport pipe 100 a collection station 300 as depicted in figure 1 and digrammatically shown in figure 2. In the embodiment shown, each refuse chute RC_i is provided with detecting means 250 such as a photoelectric cell for controlling load levels h for discharge. The detecting means 250 are shown in figure 2. Other suitable detecting means 250 can be additionally or alternatively used.

[0054] The discharge valve means 200 are provided at a bottom portion of the refuse chutes RC_i. The discharge valve means 200 comprise suitable discharge valves. When a discharge valve 200 is driven to be opened, the refuse RF inside the refuse chute RC_i is discharged into the transport pipe 100 as shown in figure 2 of the drawings.

[0055] The common transport pipe 100 connects each refuse chute RC_i of the network 600 of refuse chutes RC1, RC_2... RC_i... RC_n. Several common transport pipes 100 may be provided in a transport pipe system forming part of the network 600 of n refuse chutes RC_1, RC_2... RC_i... RC_n as shown in figure 3. The transport pipes 100 may comprise branches as shown.

[0056] The common transport pipes 100 lead to the central collection station 300. The refuse RF is treated, compacted, etc. in the central collection station 300 for further transporting for recycling or disposal.

[0057] Waste products, i.e. the refuse RF, are driven through the transport pipe 100, as shown in figure 2, into the collection station 300 by means of the suction produced by the flow of air drawn by a fan-driven suction system 400 comprising a fan capable of generating an air depression for conveniently drawing the refuse RF into the collection station 300.

[0058] Remote control means (not shown) are provided which are operated through a suitable software application. Such remote control means are adapted for receiving incoming signals from a load level signal from the photoelectric cells 250 in each refuse chute RC_i and outputting signals to the corresponding discharge valves 200 therein when a volume of refuse RF, that is a load level or height h of refuse RF within the refuse chute RC_i, is being considered to be sufficient has been detected for discharge to the transport pipe 100.

[0059] Therefore, when a number of conditions are met such as for example when a determined load level h has been detected as stated above, the discharge valve 200 is actuated by the system such that it is opened in order to discharge the waste products, i.e. the refuse RF, contained within the refuse chutes RC_i into the transport pipe 100.

[0060] The above conditions may also include other conditions such as the distance d_1, d_2, ... d_i, .. d_n from the particular refuse chute RC_1, RC_2... RC_i... RC_n to the collection station 300 (see figure 2). In this respect, the refuse chute RC_1 that is located farthest in the embodiment shown in figure 2 (or nearest in other possible embodiments) from the central station 300 or having higher losses associated therewith is discharged first.

[0061] Once a request for discharge is detected by the refuse collection system, a reference speed of the air flow R_S is set according to a specific type of refuse RF. The reference speed of the air flow R_S is predetermined before starting up of the refuse collection system. Different values for the reference speed of the air flow R_S are automatically calculated by the collection system according to each type of refuse RF to be transported. Such calculation takes into account parameters of the process that are monitored during a transport cycle within the collection system such as the atmospheric pressure, differential pressure, relative pressure, temperature and calibration constants for the correct adjustment of the measurement electronics.

[0062] The reference speed of the air flow R_S is also automatically calculated according to actual measurements when in use. This is carried out through measuring devices such as sensors and other metering equipment are used for determining the speed of the air flow A_S and the refuse transport speed T_S depending on the type and dimensions of the collection system.

[0063] The speed of the air flow A_S is measured at the central station 300. Variations in the speed of the air flow A_S mainly depend on the distance d_1, d_2.. d_i..d_n between a particular refuse chute RC_1, RC_2... RC_i... RC_n and the central collecting station 300. This is advantageous over measuring devices fitted in the pipes, distant from the central collection station 300.

[0064] The fan-driven suction system 400 are actuated and the suction produced causes the refuse RF to advance along the transport pipe 100. This causes the refuse RF to be conveyed into the collection station 300 where it is collected for treating, recycling or disposal as stated above.

[0065] The speed of the air flow A_S in the transport pipe 100 and the speed of the refuse T_S being transported in the transport pipe 100 are both controlled by the refuse collection system through suitable control means.

[0066] During transport of the waste products RF within the transport pipes 100 into the collection station 300, the speed of the air flow A_S in the transport pipe 100 is varied according to the present method through a proportional integral derivative closed loop feedback controller (PID controller). The PID controller automatically compares the current speed of the air flow A_S within the transport pipe 100 with the above mentioned reference speed of the air flow R_S. Then the speed of the air flow A_S is automatically adjusted by the PID controller which causes the rotational speed of the fan motors to be increased or decreased such that the speed of the air flow A_S measured is as close as possible to the reference speed of the air flow R_S and such that the speed of the refuse RF, i.e. the transport speed T_S is substantially constant along the transport pipe 100 as the waste products RF are conveyed into the collection station 300. This allows compensating for any decrease of speed of the air flow A_S due to friction and pressure leaks are compensated.

[0067] Differences between the compared values of the speed flow R_S, T_S vary as the distance d_i between a given refuse chute RC_i and the central station 300 increases. The variation of the transport speed of the air ΔV_A thus depends on the distance d_1, d_2.. d_i..d_n between a particular refuse chute RC_1, RC_2... RC_i... RC_n and the central collecting station 300, the characteristics of the refuse chute RC_i and the type of refuse RF being transported through the transport pipe 100.

[0068] The variation of the transport speed of the air ΔV_A is usually an increase or decrease over the speed of the air flow A_S. This increase in the transport air speed ΔV_A is based on the reference speed of the air flow R_S together with real time measurements of the speed of the air flow A_S according to the type of refuse RF within a particular refuse chute RC_i. From such data, the PID controller automatically varies the frequency on the fan motors in the fan-driven suction system 400 thus adjusting the speed of the air flow A_S. In certain circumstances such as in locations near the central station 300 the speed of the air flow A_S could be lowered below the fan motor nominal speed. Therefore, the speed of the refuse T_S is automatically adapted according to the requirements in order to keep such transport speed T_S at least substantially constant.

[0069] The increase in the transport air speed ΔV_A can be calculated as follows:

$$\Delta V_A = G_S \cdot R_S/(1 + G_S \cdot A_S)$$

Wherein

ΔV_A is the increase in the transport air speed that is automatically calculated by the system

R_S is the reference speed of the air flow according to the type of refuse RF.

A_S is the current speed of the air to be compared with the reference speed of the air.

G_S is a constant value ranging from 0.002 to 0.007.

[0070] The suction force of the fan-driven suction system 400 is automatically varied through constant monitoring of the control PID in order to keep the transport speed T_S constant as explained, according to a specific type of refuse RF to be conveyed. This allows reducing erosion and impacts on the inside of the transport pipes 100.

[0071] In combination with the increase in the transport air speed ΔV_A for keeping the speed of the refuse T_S (transport speed) at least substantially constant along the transport pipe 100, an additional air discharge is provided. This involves an increase in the discharge air speed ΔV_B that is automatically performed for a discharge time t_D which will be explained further below. This increase in the discharge air speed ΔV_B is carried out when refuse chutes RC_i containing the same type of refuse RF are discharged. The refuse RF is thus transported sequentially and dynamically from those refuse chutes RC_1 located farthest, as shown in figure 2, to those refuse chutes RC_2 located nearest to the central station 300 in a full cycle from the starting of the fans. It is to be noted that in other embodiments, the refuse RF is transported sequentially and dynamically from refuse chutes RC_2 located nearest to those refuse chutes RC_1 located farthest to the central station 300 in a full cycle from the starting of the fans.

[0072] The variation in the speed of the air flow A_S depends at least upon the distance d_1, d_2.. d_i..d_n from a particular refuse chute being considered RC_1, RC_2... RC_i... RC_n to the central collecting station 300.

[0073] Such increase in the discharge air speed ΔV_B may be determined through the formula:

$$\Delta V_B = (d - l) \cdot p,$$

wherein:

d (that is, d_1, d_2.. d_i..d_n) is the distance from a particular refuse chute RC_1, RC_2... RC_i... RC_n to the central collecting station 300, and

l, p represent pressure leaks in the refuse collection system which are determined through experimental measurements when starting up the refuse collection system through pressure and speed tests. Specifically, l is a parameter relating to pressure leaks in refuse chutes RC_2 located nearer the central station 300; and p is a parameter relating to pressure leaks in the remaining refuse chutes. In a typical refuse collection system, p ranges from 0.0020 to 0.0070, for example, and l may be of the order of 500. These values may vary depending on the particular refuse collection system.

[0074] Therefore, from the value of the distance d_1, d_2.. d_i..d_n from a particular refuse chute being considered RC_1, RC_2... RC_i... RC_n to the central collecting station 300 and taking into account the pressure leaks l, p in the installation a variable increase in the discharge air speed ΔV_B during discharge according to the refuse chute RF to be emptied is calculated automatically.

[0075] Such increase in the discharge air speed ΔV_B is performed by the PID controller during the discharge step. Once a discharge operation of a refuse chute RC_i has been completed, i.e. once the discharge valve 200 has been closed again, the refuse collection system continues working with the rated working pressure for a period of time determined by the refuse collection system for transporting the refuse RF discharged from the refuse chute RC_i as stated above.

[0076] The period of time during which a refuse chute RC_1 is conveyed by the fan-driven suction system 400 in the refuse collection system takes into account the discharge time t_D of a next refuse chute RC_2. This ensures that the waste RF being transported is beyond the refuse chute RC_1 that has been discharged. The discharge time t_D depends on the height h from which the refuse is discharged and the speed of the refuse T_S being discharged.

[0077] The increase in the discharge air speed ΔV_B for each refuse chute RC_1 is provided from the moment the discharge valve 200 of said refuse chute is opening to perform a refuse discharge until the discharge valve 200 of a next the refuse chute RC_2 is opening. When the discharge time t_D has elapsed, the air valve 200 in the next refuse chute RC_2 to be discharged is opened by the system and the air valve 200 of the refuse chute already discharged RC_1 is closed. In this state, the system adjusts the speed of the air flow A_S with respect to the reference speed of the air flow R_S again through the PID control. As successive discharges of refuse chutes RC_1, RC_2, ... are performed within the same cycle and the distance d to the central station 300 is increasingly short or long, the increase in the discharge air speed ΔV_B to be added is smaller allowing speed peaks to be smooth and reducing turbulent flow inside the transport pipe 100.

[0078] The discharge time t_D is the time during which the discharge operation is performed, that is, the time taken to at least partially discharge the refuse RF from a given refuse chute RC_i. The discharge time t_D may be determined through the following formula:

$$t_D = T_{RFn} + [(d_n - d_{(n+1)})/(T_S)] + s,$$

wherein:

T_{RFn} is the time taken by the refuse to be discharged from a first refuse chute RC_1;
d_n is the distance from a first refuse chute RC_1 to the central station 300;
$d_{(n+1)}$ is the distance from a second refuse chute RC_2, next to the first refuse chute RC_1, to the central station 300;
T_S is the speed of the refuse RF through the transport pipe 100 between the first and second refuse chutes RC_1, RC_2; and
s is a safety time.

[0079] The speed of the refuse T_S through the transport pipe 100 between the first and second refuse chutes RC_1, RC_2 may be determined as a value that is proportional to the speed of the air flow A_S along the transport pipe 100.

[0080] When a particular refuse chute RC_i is emptied and the corresponding discharge valve 200 is closed, the speed of the air flow A_S is again adjusted by the refuse collection system without adding the above increase in the transport air speed ΔV_A. Such increase in the transport air speed ΔV_A will be added again during the corresponding next refuse chute discharge step.

[0081] Both the step of varying the speed of the air flow A_S through an increase in the transport air speed ΔV_A such that the speed of the refuse T_S being transported is substantially constant along the transport pipe 100 and the step of increasing the speed of the air through an increase in the discharge air speed ΔV_B during the discharge of the refuse RF are carried out in parallel.

[0082] The increase of transport air speed ΔV_A can be made through different inlet points (not shown) in the conveying airflow within the collection system. The inlet points may be different according to different waste discharge points. Each refuse chute RC_i has at least one air valve and a unique air path to the transport pipe 100.

[0083] Different suction points may also be provided. The suction points may be automatically varied within this air path so suction may be varied as the other refuse chutes are being emptied and waste is advanced into the central station 300. The suction points are automatically varied according to variables of the process such as pressure and speed of the air.

[0084] Several air valves may also be provided in order to decrease the power of the fans 400. This could also be advantageous for reducing noise caused by depression.

[0085] With the present method, refuse chutes RC_i can be emptied with minimum values of the air speed A_S, such as of the order of 20 m/s.

Claims

1. A method of pneumatic transport of refuse (RF) in a waste collection installation, the waste collection installation including at least one refuse chute (RC_1, RC_2... RC_i... RC_n) for temporary containing refuse (RF) therein, a transport pipe (100) for transporting the refuse (RF) discharged from the refuse chute (RC_i) into a collection station (300), and means (400) for drawing air for transporting the refuse, the method comprising the steps of:

   - performing a discharge step by which refuse (RF) is discharged from a refuse chute (RC_i) into the transport pipe (100);
   - drawing air along the transport pipe (100) for transporting the refuse (RF) to the collection station (300);
   - controlling the transport speed of the air flow (V_A) in the transport pipe (100); and
   - controlling the discharge speed of the air (V_B) in the refuse chute (RC_i);

   wherein it further comprises the step of

   - varying the transport speed of the air flow (V_A), through a proportional integral derivative controller (PID controller) which compares the current speed of the air flow (A_S) with a reference speed of the air flow (R_S), during transportation of the refuse (RF) such that the transport speed of the refuse (T_S) is substantially constant along the transport pipe (100); and
   - varying the discharge speed of the air (V_B) for a discharge time (t_D) during which the discharge operation is performed, a variation in the discharge speed of the air (ΔV_B) being dependent at least upon the distance (d) of each refuse chute (RC_i) to the central station (300).

2. The method of claim 1, wherein the step of varying the transport speed of the air flow (V_A) and the step of varying the discharge speed of the air (V_B) are performed automatically.

3. The method of claim 1 or claim 2, wherein the step of varying the transport speed of the air flow (V_A) and the step of varying discharge speed of the air (V_B) are performed in parallel.

4. The method as claimed in any of the preceding claims, wherein the transport speed of the air flow (V_A) is measured at the central station (300).

5. The method as claimed in any of the preceding claims, wherein the step of varying the discharge speed of the air (V_B) is carried out exclusively during the discharge step.

6. The method as claimed in any of the preceding claims, wherein the variation in the discharge speed of the air (ΔV_B) is determined through the formula (ΔV_B)= (d - l) · p, wherein (d) is the distance from the refuse chute (RC_i) to the central station (300); and (l, p) are constant values relating to pressure leaks.

7. The method of claim 6, wherein the constant values relating to pressure leaks (l, p) range from 300 to 1000.

8. The method as claimed in any of the preceding claims, wherein the variation in the transport speed of the air (V_B) is determined through the formula (ΔV_A) = (G_S)· (R_S)/(1 + (G_S) · (A_S)) wherein (ΔV_A) is the variation in the transport speed of the refuse (T_S) that is automatically calculated by the system, (R_S) is the reference speed of the air flow according to the type of refuse (RF), (A_S) is the current speed of the air flow to be compared with the reference speed of the air flow (R_S) and (G_S) is a constant value.

9. The method of claim 8, wherein the constant value (G_S) ranges from 0.002 to 0.007.

10. The method as claimed in any of the preceding claims, wherein the discharge time (t_D) is determined through the formula (t_D) = (T_{RFn}) + [(d_n-$d_{(n+1)}$)/(T_S)] + s, wherein (T_{RFn}) is the time taken by the refuse (RF) to be discharged from a first refuse chute (RC_1); (d_n) is the distance from the first refuse chute (RC_1) to the central station (300); ($d_{(n+1)}$) is the distance from a second refuse (RC_2) to the central station (300); (T_S) is the speed of the refuse (RF) through the transport pipe (100) between the first and second refuse chutes (RC_1, RC_2); and (s) is a safety time.

11. The method as claimed in any of the preceding claims, wherein at least one of the step of varying the transport speed of the air flow (V_A) and the step of varying the discharge speed of the air (ΔV_B) are carried out when refuse chutes containing the same type of refuse are discharged

12. The method as claimed in any of the preceding claims, wherein the discharge step is performed sequentially from those refuse chutes (RC_i) located farthest from the central station (300) to those refuse chutes (RC_i) located nearer the central station (300) or vice versa.

13. The method as claimed in any of the preceding claims, wherein at least one of the step of varying transport speed of the air flow (V_A) and the step of varying the discharge speed of the air (V_B) is carried out by increasing the values speed of the air flow or speed of the air, respectively.

FIG. 1

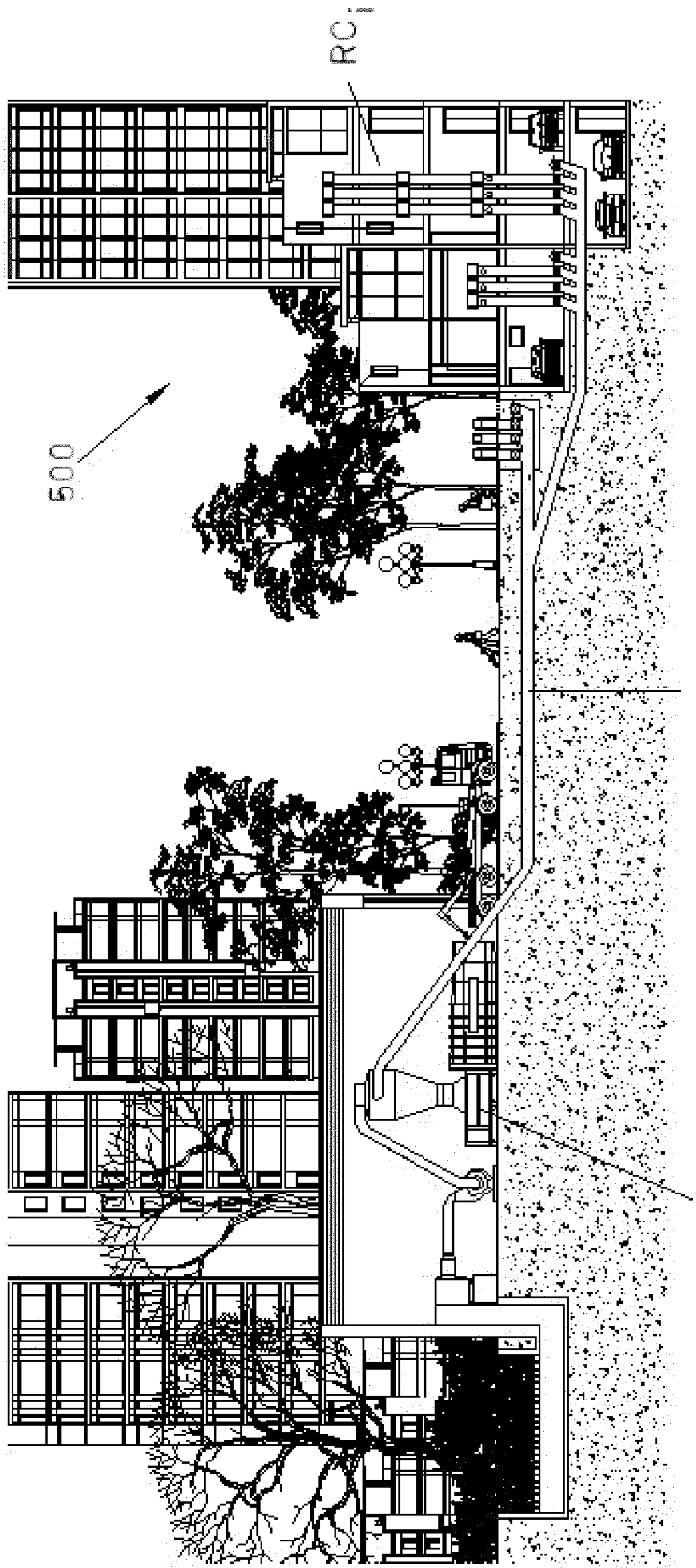
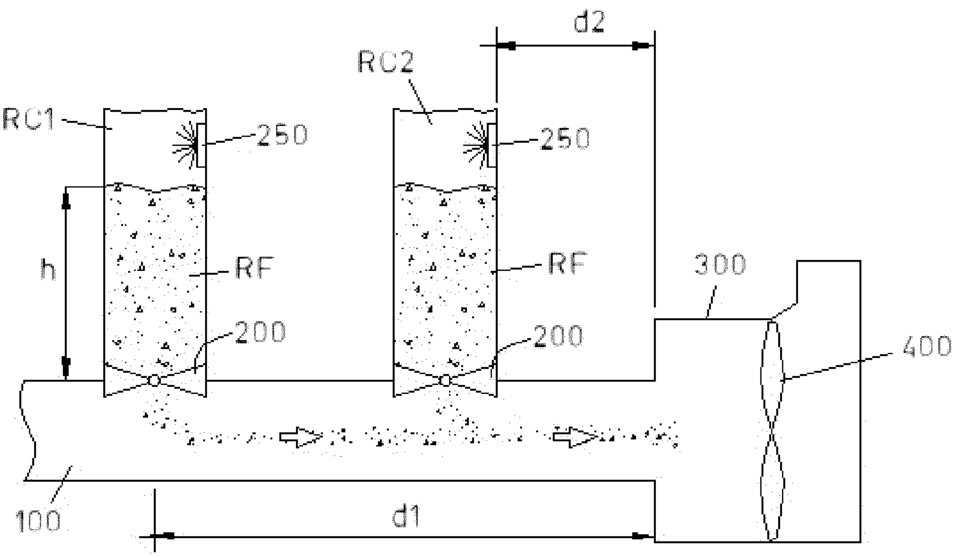


FIG. 2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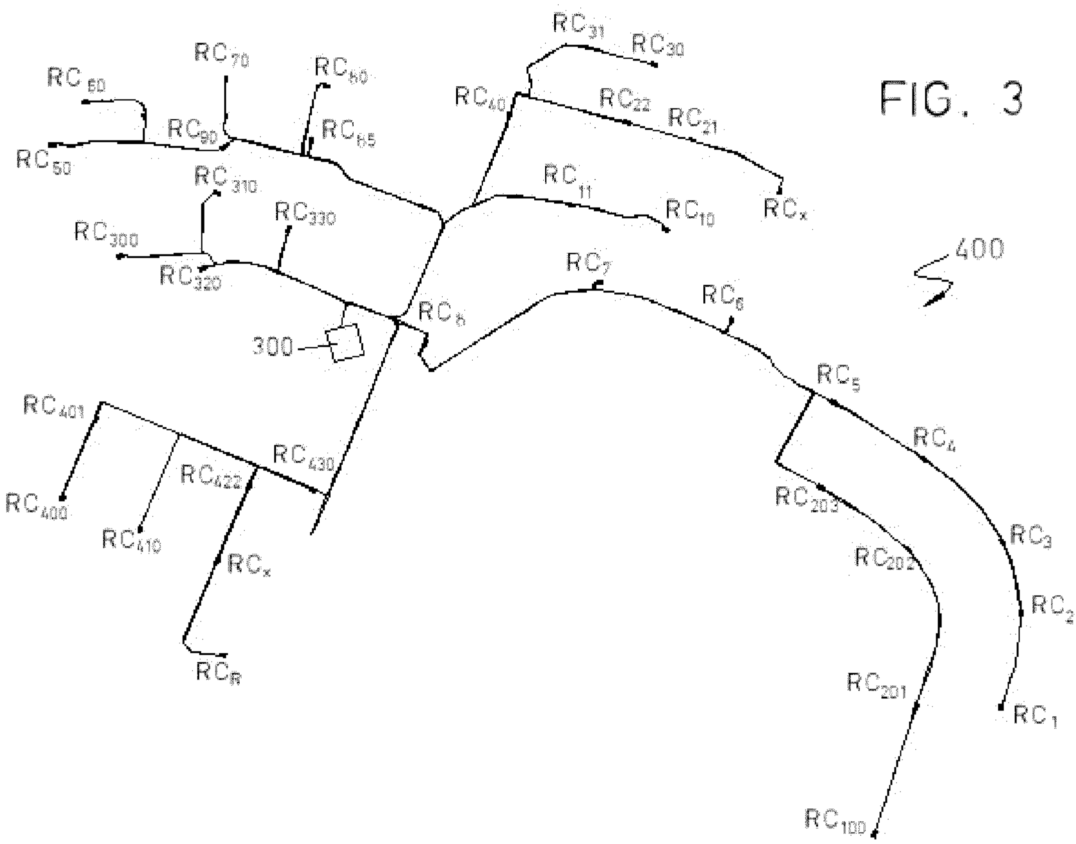
RC1
250
250
h
RF
RF
300
200
200
400
100
d1


RC_{31}
RC_{30}
RC_{70}
RC_{60}
RC_{80}
RC_{40}
RC_{22}
RC_{21}
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RC_x
RC_{300}
400
RC_7
RC_{320}
RC_6
RC_8
300
RC_5
RC_{401}
RC_4
RC_{430}
RC_{422}
RC_{400}
RC_{203}
RC_3
RC_{410}
RC_x
RC_{202}
RC_2
RC_R
RC_{201}
RC_1
RC_{100}

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 12 38 2324

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	31 January 2013	Martínez Navarro, A

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3

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