TITLE: FILTER FOR CLEANING SYSTEM(S)

DESCRIPTION

TECHNICAL FIELD

[001] This disclosure generally pertains but not limited to the field of cleaning systems such as autonomous floor cleaning systems. More particularly, this disclosure relates to filters used in the autonomous floor cleaning systems.

BACKGROUND

[002] Cleaning systems, like floor cleaning robots, typically include a collection chamber, a conduit assembled therein, and a vacuum motor connected to the conduit. This cleaning system is designed to clean surfaces by scrubbing away debris, often facilitated by softening the debris by contacting the debris with water. The vacuum motor generates suction within the chamber and conduit. The conduit may further extend through a vacuum hose to a floor tool. Positioned near the surface, the floor tool draws in the softened debris and water, directing them into the suction port for collection in the chamber.

[003] Ideally, the water and the softened debris would remain in entirety within the collection chamber. Heavier dirt and debris tend to settle at the bottom of the collection chamber, while lighter materials like dust particles and water droplets can become entrained in the airflow and potentially escape through the vacuum hose, reaching the vacuum motor itself. This water ingress poses a significant threat to the vacuum motor, for example, corrosion, reduced efficiency, or even complete failure. In scenarios when the collection chamber may be filled at a maximum capacity, the addition of larger pieces of debris may slosh water into the suction of the vacuum motor, and the water may eventually end up therein. Conventionally, valves such as ball float valves may be provisioned within the suction port to prevent such scenarios. While the ball float valve might effectively prevent large volumes of water from entering the suction port, no protection may be provided against smaller materials and water droplets from being carried along by the airflow into the suction port.

[004] Therefore, there exists a pressing need to prevent the flow of water and lighter debris into the vacuum motor.

SUMMARY

[005] In an embodiment, a filter for a cleaning system is disclosed. The filter may include a separator element accommodated in a telescopic arrangement within a housing. The housing

may include a first hollow member configured to be connected to an inlet of the cleaning system. The inlet may be tangential to the first hollow member. Further, the filter may include a conical separator accommodated within the first hollow member and a second hollow member adjoined to the first hollow member and the conical separator. Further, the conical separator separates water from debris received from the inlet of the cleaning system in the first hollow member when the debris is centrifugally circulated relative to the conical separator. The water is drained from the first hollow member to the second hollow member.

[006] In an embodiment, a cleaning system is disclosed. The cleaning system may include a filter positioned within a collection chamber of the cleaning system. The filter may include a separator element accommodated in a telescopic arrangement within a housing. The housing may include a first hollow member configured to be connected to an inlet of the cleaning system. The inlet may be tangential to the first hollow member. Further, the filter may include a conical separator accommodated within the first hollow member and a second hollow member adjoined to the first hollow member and the conical separator. Further, the conical separator separates water from debris received from the inlet of the cleaning system in the first hollow member when the debris is centrifugally circulated relative to the conical separator. The water is drained from the first hollow member to the second hollow member.

[007] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only, and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[008] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, explain the disclosed principles.

[009] **FIG.1** illustrates a perspective view of a filter, in accordance with an embodiment of the present disclosure.

[0010] **FIG.2** illustrates a top view of the filter, in accordance with an embodiment of the present disclosure.

[0011] **FIG.3** illustrates an exploded view of the filter, in accordance with an embodiment of the present disclosure.

[0012] **FIG.4** illustrates a bottom-perspective view of the filter, in accordance with an embodiment of the present disclosure.

[0013] **FIG.5** illustrates a sectional view of the filter, in accordance with an embodiment of the present disclosure.

[0014] **FIG.6** illustrates an exploded view of the filter assembled within the cleaning system, in accordance with an embodiment of the present disclosure.

[0015] **FIG.7** illustrates the bottom view of the filter assembled within the cleaning system, in accordance with an embodiment of the present disclosure.

[0016] **FIG.8** illustrates the sectional view of the filter assembled within the cleaning system, in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0017] Exemplary embodiments are described with reference to the accompanying drawings. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the scope of the disclosed embodiments. It is intended that the following detailed description be considered exemplary only, with the true scope being indicated by the following claims. Additional illustrative embodiments are listed.

[0018] References will now be made to exemplary embodiments of the disclosure, as illustrated in the accompanying drawings. Wherever possible, the same numerals have been used to refer to the same or like parts. The following paragraphs describe the present disclosure with reference to **FIGS. 1- 8.**

[0019] As explained earlier, water and heavy debris from the softened debris may be stored and stay in the collection chamber. However, heavy debris may settle at the bottom of the collection chamber, and the lighter particles along with water droplets may escape through the vacuum hose and may go along with the airflow towards a vacuum motor which may be undesirable. As a result, the vacuum motor may be subjected to corrosion, reduced efficiency, or even complete failure.

[0020] To this end, a filter is disclosed. Now, refer to **FIG.1,** which illustrates a perspective view 100 of a filter 102, and **FIG.2**, which illustrates the top view 200 of the of the filter 102, in accordance with an embodiment of the present disclosure. The filter 102 may be installed within a collection chamber of a cleaning system and may be configured to separate air, water, lighter debris, and the heavy debris from the softened debris material drawn through a vacuum hose of the cleaning system.

[0021] In an embodiment, the filter 102 may include an inlet 104, and a housing 110 fluidically coupled to the inlet 104. The inlet 104 may be fluidically coupled to a vacuum hose of the cleaning system (not shown in figures) through which air, softened debris, and water may be drawn. The diameter of the inlet 104 may range between 30 to 40 millimetres (mm). In an embodiment, the inlet 104 may be tangentially connected to an outer surface of the housing 110. The tangential connection of the inlet 104 may ensure that the softened debris, and water enter tangentially within the housing 110. Further, the housing 110 may include a hollow cylindrical shape with a diameter ranging between 94 mm to 118 mm. It must be noted that the primary consideration lies in the shape of the housing 110. The diameter of the housing 110 may be varied based on the extent of use and the space constraint allowed by the cleaning system.

[0022] In an embodiment, the filter 102 may further include a separator element 108 accommodated in a telescopic arrangement within a housing 110. In other words, the separator element 108 may be disposed in a reconfigurable manner and a telescopic manner within the housing 110. Particularly, the separator element 108 may be easily installed within the housing 110 and may also be removed from the housing 110 whenever required. In an embodiment, as explained earlier, air, water, and softened debris drawn from the vacuum hose may be collected within housing 110 and subjected to a separation process using the separator element 108. The separation process may result in the separation of the softened debris, air, and water, with the softened debris stored within the separator element 108, water escaping the separator element 108 to the collection chamber, and air being drawn by the vacuum motor.

[0023] In an embodiment, the diameter of the separator element 108 may be designed to be three times the diameter of the inlet 104. Accordingly, the diameter of the separator element 108 may be 90 to 95 mm, thus providing ample capacity for the collection of the softened debris. Such a design acts as a baffle against water sloshing, particularly when the collection chamber is filled with water at a maximum capacity.

[0024] In an embodiment, to ensure that the softened debris remains confined within the separator element 108, a cap 106 may be engaged to a top portion 112 of the housing 110. The cap 106 may be configured to cover and seal the top portion 112 of the housing 110 and may be configured to confine the heavy debris from the softened debris within the separator element 108, as well as maintain pressure therein. Further, to ensure seepage or escape of water from the housing 110, a portion of the separator element 108 may protrude from the bottom portion

114 of the housing 110. In an embodiment, the cap 106 may be made translucent, so that the user may be able to view an extent of occupancy of the housing 110 by the heavy debris.

[0025] Now, refer to **FIG. 3**, which illustrates an exploded view 300 of the filter 102 in accordance with an embodiment of the present disclosure. In an embodiment, the separator element 108 may include a first hollow member 301. The first hollow member 301 may be configured to be connected to an inlet 104 of the cleaning system. It is to be noted that the inlet 104 may be tangential to the first hollow member 301. Further, the separator element 108 may include a conical separator 302 accommodated within the first hollow member 301. The separator element 108 may further include a second hollow member 303 adjoined to the first hollow member 301 and the conical separator 302. Further, the first hollow member 301 and the second hollow member 303 may be formed as hollow cylindrical members. The second hollow member 303 may be fixated or formed with the first hollow member 301 to resemble a fixed telescopic arrangement. Further, the separator element 108, when assembled within the housing 110, the first hollow member 301 may be completely enclosed by the housing 110, and the second hollow member 303 may protrude vertically downwards from the bottom portion 114 of the housing 110. Further, the outer diameter of the first hollow member 301 may be equivalent to an inner diameter of the housing 110, which may range between 105 mm to 110 mm, such that the first hollow member 301 may be inserted within the housing 110. In an embodiment, the first hollow member 301 may be inserted within the housing 110 with a clearance of about 1-2 mm. Such clearance may be provided to facilitate the ease in the removal of the first hollow member 301 from the housing 110. It must be noted that in low clearance, i.e., in cases where the first hollow member 301 may be inserted within the housing 110 in an interference fit, the heavy debris may be stuck between the surfaces of the housing 110 and the first hollow member 301. This may lead to difficulty in removal of the first hollow member 301 from the housing 110. In an embodiment, the first hollow member 301 and the second hollow member 303 may be formed as a single structure, or the first hollow member 301 and the second hollow member 303 may be formed separately and joined together to form the separator element 108.

[0026] Further, the conical separator 302, as the name suggests, may be formed as a conical-shaped structure. The conical separator 302 may be configured to separate water from a debris received from the inlet 104 of the cleaning system 602 in the first hollow member 301. Particularly, when the debris is centrifugally circulated relative to the conical separator 302, the water separates from the debris and is drained from the first hollow member 301 to the second hollow member 303. Further, the conical separator 302 may include a bottom hollow

portion 313, and a top hollow portion 311 oppositely disposed to the bottom hollow portion 313. In an embodiment, the perpendicular height of the conical separator 302 may range between 75mm to 80 mm, the diameter of the top hollow portion 311 may range between 20 mm to 25 mm, and the diameter of the bottom hollow portion 313 may range between 55 mm to 60 mm.

[0027] In an embodiment, between the bottom hollow portion 313 and the top hollow portion 311, a tapered region may be formed. Further, the tapered region may include a plurality of slits 308. The plurality of slits may include any one of a spiral slit, a vertical slit, an elliptical slit, an array of mini slits or an array of perforated holes. For instance, the plurality of slits 308 may include, but not limited to slits extending from the top hollow portion 311 to the bottom hollow portion 313, or array of mini slits formed throughout the tapered region, or a spiral slits originating from the top hollow portion 311 to the bottom hollow portion 313. The plurality of slits 308 may be configured to allow passage of water from the softened debris and water drawn from the vacuum hose therethrough, via the bottom hollow portion 313 towards the collection chamber.

[0028] As seen in FIG. 3, it must be noted that the perpendicular height of the conical separator 302 may exceed a height of the top hollow portion 311. Having such height may prevent partial clogging of the conical separator 302, even when the first hollow member 301 and the second hollow member 303 may be clogged with the heavy debris. Hence, air and water may enter through the unclogged portion of the conical separator 302.

[0029] In an embodiment, the first hollow member 301 may include a first flange 410 adjoined to the conical separator 302. The first flange 410 may extend vertically downward by a predefined distance from a base 405 of the conical separator 302. Further, the second hollow member 303 may include a second flange (referred to as second flange 406 in FIG. 4) extending vertically downward by a predefined distance from a base 407 of the second hollow member 303. Again, referring to FIG. 3, the first flange 410 may be formed as tapered, or an angled flange. Further, the first flange 410 may be formed of an outer diameter equivalent to the inner diameter of the first hollow member 301, which may range between 105 mm to 110 mm. Further, the first flange 410 may include an inner diameter equivalent to the diameter of the second hollow member 303, which may range between 90 mm to 95 mm. In an embodiment, the outer diameter of the second flange 406 may be equivalent to the inner diameter of the second hollow member 303. Accordingly, the second flange 406 may also be inserted within the second hollow member 303 with a clearance therebetween of 1-2 mm.

[0030] In an embodiment, the conical separator 302 may include a protrusion 309 extending from the top hollow portion 311. The protrusion 309 may be configured to engage a slot 314 formed on the cap 106, such that the protrusion 309 may be interlocked within the slot 314. As a result, such engagement also results in interlocking of the conical separator 302 with the cap 106, such that any inadvertent motion of the conical separator 302 may be prevented. In an embodiment, the protrusion 309 may include a grip portion 315. The grip portion 315 may be held by the user and pulled, to remove the first hollow member 301 and the second hollow member 303 from the housing 110 without contacting the softened debris accumulated therein.

[0031] In an embodiment, the housing 110 may include an inlet conduit 304. The inlet conduit 304 may be formed of a diameter equivalent to the diameter of the inlet 104. Further, the inlet 104 may be sealed and adjoined to the inlet conduit 304 using a seal 316 and one or more fasteners 312a, 312b, 312c, and 312d. Further, the inlet conduit 304 may be formed tangentially to the outer surface of the housing 110, and as a result, the softened debris and water may enter tangentially within the housing 110. Accordingly, the softened debris and water may encounter low resistance while entering the housing 110.

[0032] In an embodiment, now referring to **FIG. 4,** which illustrates a bottom perspective view 400 of the filter 102**,** in accordance with an embodiment of the present disclosure. As explained earlier, the separator element 108 may include the first flange 410 extending vertically downward from the base 405 of the conical separator 302 and the second flange 406 extending vertically downward from the base 407 of the second hollow member 303. In an embodiment, the base 405 of the conical separator 302 410may include a first set of grooves 402a formed on a circumference of the base 405 and adjoined to the first flange 410. The first set of grooves 402a may be configured to drain water separated by the conical separator 302 to the second hollow member 303.

[0033] In an embodiment, the base 407 of the second hollow member 303 may include a second set of grooves 402b formed on a circumference of the base 407 and adjoined to the second flange 406. The second set of grooves 402b may be configured to drain water received from the first set of grooves towards a collection chamber of the cleaning system (602).410 In an embodiment, each groove of the first set of grooves 402a and the second set of grooves 402b may be formed as a semi-circular arc, with the diameter of each arc ranging between 5 mm to 10mm. It must be noted that the aforementioned dimensions are variable and can assume any value deemed suitable to fulfil the intended function of separating water, air, and the softened

debris. The dimensions may be varied based on the requirements for optimum functioning of the cleaning system.

[0034] In an embodiment, the air and water entering the plurality of slits 308 may be drained to the collection chamber through the first set of grooves 402a, or the second set of grooves 402b, or both. It must be noted that the first set of grooves 402a and the second set of grooves 402b may individually drain the air and water into the collection chamber, even in the scenario in which the first set of grooves 402a may be clogged with heavy debris, the second set of grooves 402b may continue to drain air and water to the collection chamber, and vice versa.

[0035] In an embodiment, the filter 102 may further include a passage 408 formed between the first flange 404 and the second flange 406. The filter 102 may further include a bore 409 formed on the second flange 406 and in line with the passage 408. The passage 408 and the bore 409 may be cooperatively configured to drain water towards the collection chamber of the cleaning system.

[0036] In an embodiment, now referring to **FIG. 5,** which illustrates a sectional view 500 of the filter 102 in accordance with an embodiment of the present disclosure. As explained earlier, the filter 102 may include the inlet 104 fluidically coupled to the inlet conduit 304. Air, water, and softened debris may be drawn through the inlet 104, and through the inlet conduit 304, towards the conical separator 302 using a suction created by the operation of the vacuum motor. Further, the vacuum motor, when operated, may be configured to create suction within the filter 102. As a result of the suction created, the air, water, and softened debris may be subjected to a centrifugal force around the conical separator 302 (indicated by the indicia in the figure). The centrifugal force may result in the accumulation of the larger debris within a collection portion 502 formed between the conical separator 302 and the walls of the separator element 108. The centrifugal force may also prevent the plurality of slits 308 of the conical separator 302 from being clogged by heavy debris, i.e., the heavy debris may be thrown radially outward and away from the slits 308 within the collection portion 502. Accordingly, the plurality of slits 308 may be clog-free. Hence, the easy passage of water and light debris to the collection chamber may be feasible. Further, the centrifugal force may be configured to pressurize water and air present in the separator element 108 through the plurality of slits 308, the first set of grooves 402a, the second set of grooves 402b to the collection chamber through the passage 408 (as indicated by indicia). As air, lighter debris, and water may be transmitted to the collection chamber, the heavy debris may be settled within the collection portion 502 of the separator element 108.

[0037] In an embodiment, the filter 102 may be reconfigurable within the cleaning system(s), i.e., the filter 102 may be easily installed/removed from the cleaning system. For example, if the collection portion 502 reaches a maximum occupancy by the heavier debris, the filter 102 may be removed from the cleaning system for cleaning, or other maintenance procedures and may be reinstalled within the cleaning system. The installation of the filter 102 with the cleaning system is explained in detail in conjunction with FIGs. 6-8.

[0038] Now referring to **FIG. 6**, which illustrates an exploded view 600 of the filter 102 assembled with the cleaning system 602, in accordance with an embodiment of the present disclosure, **FIG.7**, which illustrates the bottom sectional view 700 of the filter 102 assembled with the cleaning system 602, in accordance with an embodiment of the present disclosure, and **FIG.8**, which illustrates the sectional view 800 of the filter 102 assembled with the cleaning system 602, in accordance with an embodiment of the present disclosure.

[0039] In an embodiment, the filter 102 may be positioned within the collection chamber 604 of the cleaning system 602. In an embodiment, the housing 110 may include a plurality of tabs 606a, 606b, which may be placed on top wedges of the collection chamber 604 when the filter 102 may be installed within the cleaning system 602. Such tabs may be configured to support the filter 102, when placed thereon. Further, the inlet 104 of the filter may be externally connected to an inlet, or a suction port (not shown in figure) of the cleaning system 602, and the inlet conduit 304 may be internally connected to the suction port of the cleaning system 602. Therefore, when suction is created by the vacuum pump, the air, water, and softened debris may be drawn through the inlet 104, the suction port, and the inlet conduit 304.

[0040] In an embodiment, the housing 110 of the filter 102 may include a vacuum outlet 702 fluidically coupled to the inlet 104 of the cleaning system 602. Further, the vacuum motor may be positioned at the top of the cleaning system 602 and may be connected to a vacuum outlet 702. In an embodiment, the vacuum outlet 702 may be positioned distantly from the collection chamber 604, or at a position where the distance between the vacuum outlet 702 and the collection chamber may be sufficient such that the water and the light debris may be prevented from entering the vacuum motor.

[0041] In an alternative embodiment, the vacuum outlet 702 may be positioned in close proximity to the collection chamber 604, only when an additional filter element may be installed therein. In other words, the vacuum outlet 702 may include a filter element (not shown), which may also prevent water and the light debris from entering the vacuum motor.

[0042] In an embodiment, the vacuum motor when operated, may be configured to draw air from the collection chamber 604, and as a result, vacuum may be created therein. Accordingly, due to creation of vacuum, a suction is created which may eventually lead to drawing of air, water, and soften debris into the separator element 108, from which air may be separated. This separated air may be further drawn by the vacuum motor to reintroduce vacuum within the collection chamber 604, and hence, the process may be re-iterated.

[0043] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0044] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to inventions containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, typically means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In

those instances where a convention analogous to “at least one of A, B, or C, etc.” is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., “a system having at least one of A, B, or C” would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase “A or B” will be understood to include the possibilities of “A” or “B” or “A and B.”