

TITLE OF INVENTION: ROTARY SURFACE TREATMENT TOOL

FIELD

[0001] The present invention relates to a rotary surface treatment tool. While the present invention will be described with reference to its use in cleaning machines including autonomous floor cleaning robots, it is to be appreciated that the invention is not restricted to this application, and that other applications are also envisaged.

BACKGROUND

[0002] The following discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

[0003] Rotary surface treatment tools including cleaning rollers and pads are typically comprising of a rigid core/support base and an external surface treatment layer including fabric like a microfibre cloth, or a brush. These rotary surface treatment tools transmit the rotary action with a certain amount of force to the surface being cleaned. Cleaning machines such as autonomous floor cleaning robots use rotary surface treatment tools such as rollers and brushes to clean different surfaces including floor surfaces. The amount of force transmitted to a floor surface, is typically managed by a linear actuator provided within the cleaning machine that lowers the surface tool into contact with the ground. Compression springs may thereafter be used to provide a contact force between the rotary surface treatment tool and the floor surface. There is however a need to manage this contact force between the rotary surface treatment tool and the floor surface because a contact force that is too light may reduce cleaning efficacy as there is not enough friction to remove debris. However, a contact force that is too heavy might result in excessive wear and tear of the cleaning machine including the rotary surface treatment tools and/or reduced traction experienced by a cleaning machine, or excessive wear and tear of the ground surface causing visible damage or poor performance of the surface being cleaned.

[0004] In some cleaning machines, there may be a lack of space onboard the cleaning machine, or the cleaning machine may not have any ability to control the complex machinery required to create and control the compression force applied to the surface tools. This can result in less-than-ideal cleaning performance if a degree of compressibility is not provided for. There is a direct effect between the cleaning contact by an exterior material of the rotary surface treatment tool and its 'pick-up' performance, 'pick-up' being a technical term referring to the performance of a cleaning material. However, introducing mechanical actuators to control compression also creates complexity that would also raise the overall capital costs of the cleaning machine.

[0005] The ability of the rotary surface treatment tool to retain moisture is also a function of the cleaning material adhered on the exterior of the surface tool. In rotary surface treatment tools having a stiff core, the moisture retention can be very low, such that stain removal efficacy is severely limited. Stain removal requires moisture as a solvent to hydrate and act on the chemical composition of a stain, and the moisture becomes the substrate to entrain and transport the stain creating particles away from the floor surface. A stiff core also reduces the ability of a rotary surface treatment tool to interact successfully with hard debris, such that on contact will be directed under the tool towards a vacuum nozzle, or around it toward a vacuum nozzle. A stiff core creates the effect of pushing away hard debris such as Lego® blocks or stones away from the vacuum nozzles of the cleaning machine instead of towards it.

[0006] A rotary surface treatment tool having a stiff core can also impact the overall machine's acoustic performance. The noise emitted from the tool during a surface treatment operation can generally be higher when the stiffness of the core is relatively high.

[0007] An object of the invention is to ameliorate one or more of the above-mentioned difficulties.

SUMMARY

[0008] According to an aspect of the present disclosure, there is provided a rotary surface treatment tool for a cleaning machine comprising:

a rotatable relatively rigid support base adapted to be rotatably driven by the cleaning machine;

a surface treatment layer supported on the support base and rotatable together with the support base; and

a relatively compliant layer provided intermediate the support base and the surface treatment layer, and supporting thereon the surface treatment layer.

[0009] In some embodiments, the compliant layer is formed of compressible foam material.

[0010] In some embodiments, the foam material has a stiffness range of $\leq 0.5\text{N/cm}$.

[0011] In some embodiments, the foam material is of an open cell foam type.

[0012] In some embodiments, the open cell type foam material includes polyurethane of different pores per inch (PPI).

[0013] In some embodiments, the foam material is of a closed cell type.

[0014] In some embodiments, the closed cell type material includes EPDM, neoprene or SBR.

[0015] In some embodiments, the support base is an inner core, and the compliant layer and surface treatment layer is supported around the inner core.

[0016] In some embodiments, the support base is a generally planar disc, and the compliant layer and surface treatment layer are respectively supported on the planar disc.

[0017] According to another aspect of the present disclosure, there is provide a cleaning machine including at least one surface treatment tool as described above.

[0018] According to a further aspect of the present disclosure, there is provided a method of configuring a pressure applied by a rotary surface treatment tool of a cleaning machine on a surface being treated, the rotary surface treatment tool having a relatively rigid support base adapted to be rotatably driven by the cleaning machine; and a surface treatment layer supported on the support base and rotatable together with the support base; the method comprising providing a relatively compliant layer intermediate the support base and the surface treatment layer, the surface treatment layer being supported on the compliant layer.

[0019] In some embodiments, the method comprises selecting compressible foam material of a predetermined stiffness and/or density to configure the pressure.

[0020] According to yet another embodiment of the present disclosure, there is provided a method of configuring moisture retention and/or acoustic performance within a rotary surface treatment tool, the rotary surface treatment tool having a relatively rigid support base adapted to be rotatably driven by the cleaning machine; and a surface treatment layer supported on the support base and rotatable together with the support base; the method comprising providing a relatively compliant layer intermediate the support base and the surface treatment layer, the surface treatment layer being supported on the compliant layer.

[0021] In some embodiments, the method comprises selecting compressible foam material of a predetermined stiffness and/or density to configure the acoustic performance.

[0022] In some embodiments, the method comprises selecting compressible foam material of a predetermined stiffness and/or density to configure the moisture retention.

[0023] Other aspects and features will become apparent to those of ordinary skill in the art upon review of the following description of specific embodiments in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] In the figures, which illustrate, by way of example only, embodiments of the present invention,

[0025] [Figure 1] is a perspective view of a rotary surface treatment tool according to one embodiment of the present disclosure;

[0026] [Figure 2] is an exploded perspective view of the rotary surface treatment tool according to [fig. 1];

[0027] [Figures 3a to 3c] respectively show an end, side and cross-sectional view of the rotary surface treatment tool according to [fig. 1]; and

[0028] [Figures 4a to 4d] respectively show a side, top, cross-sectional and perspective view of a second embodiment of a rotary surface treatment tool according to the present disclosure.

[0029] Other arrangements of the invention are possible and, consequently, the accompanying drawings are not to be understood as superseding the generality of the preceding description of the invention.

DETAILED DESCRIPTION

[0030] Throughout this document, unless otherwise indicated to the contrary, the terms “comprising”, “consisting of”, “having” and the like, are to be construed as non-exhaustive, or in other words, as meaning “including, but not limited to”.

[0031] Furthermore, throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including” will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0032] Example embodiments of the present invention will now be described with reference to the accompanying drawings. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present invention. Other definitions for selected terms used herein may be found within the detailed description of the invention and apply throughout the

description. Additionally, unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which this invention belongs. Where possible, the same reference numerals are used throughout the figures for clarity and consistency.

[0033] [Figs. 1 to 3c] shows a first embodiment of a rotary surface treatment tool 1 according to the present disclosure. The rotary surface treatment tool 1 includes a relatively rigid support base in the form of an inner core 3. The inner core 3 can be rotatably driven by the cleaning machine (not shown) and supports thereon a surface treatment layer 5, and a relatively compliant layer 7 provided intermediate the inner core 3 and the surface treatment layer 5. The compliant layer 7 may be formed from a compressible foam material. The foam material that could be used include open and closed cell types to leverage on the moisture absorption capabilities and/or possible stiffness ranges of different compliant material. Examples of open cell foam includes polyurethane of various PPI (pores per inch) and closed cell foam including, but not limited to EPDM, neoprene and SBR.

[0034] The compliant layer 7 provides a configurable pressure between the rotary surface treatment tool 1 and a surface being treated including cleaned by the surface treatment tool by varying the stiffness and/or density of the foam material selected for the compliant layer 7. The moisture retention of the surface treatment tool 1 can also be controlled by varying the stiffness and/or density of the selected foam material. The foam material may for example have a stiffness range of $\leq 0.5\text{N/cm}$. The increased moisture retention of the rotary surface treatment tool 1 helps to loosen debris on the surface by dissolving and then transporting away the debris off the surface.

[0035] The stiffness of the compliant layer 7 may also be selected to thereby vary the acoustic performance of the rotary surface treatment tool 1. Generally, the selection of the stiffness of the compliant layer 7 allows a designer to determine the cleaning performance of the rotary surface treatment tool 1. However, the selection of the compliance layer stiffness is a compromise between scrubbing performance, which requires higher stiffness, and pick-up performance, which requires greater softness. However, the stiffness of the compliant layer 7 may also or alternatively be selected to prioritise the acoustic performance of the rotary surface treatment tool 1.

The noise emitted during a surface treatment operation of the rotary surface treatment tool 1 may be reduced by using a softer compliant layer 7, while more noise may be emitted when a stiffer compliant layer 7 is selected. By modifying the stiffness of the compliant layer 7, the resonance frequencies and vibration characteristics of the rotary surface treatment tool 1 can be controlled, leading to enhanced acoustic properties. The rotary surface treatment tool 1 according to the present disclosure allows for versatile customization and optimization of the roller's acoustic performance in various applications.

[0036] The surface treatment layer 5 may for example include cleaning material such as microfibre fabric or brushes for providing surface treatment including brushing, wiping, mopping, or burnishing of a surface.

[0037] [Figs. 4a to 4d] show another embodiment of a rotary surface treatment tool 10 according to the present disclosure including a support base in the form of a generally planar disc 30, and a relatively compliant layer 70 and surface treatment layer 50 respectively supported on the planar disc 30. The compliant layer 70 may also be formed of a compressible foam material similar to the earlier described embodiment shown in [figs. 1 to 3c]. The surface treatment layer 50 is shown in the form of a brush. It is however envisaged that other surface treatment material such as microfibre fabric could alternatively be used for the surface treatment layer 50.

[0038] The rotary surface treatment tool 1,10 according to the present disclosure provides advantages to the user, developer and manufacturer of such surface treatment tools. A user is provided with a lower cost cleaning arrangement for their cleaning machine that can provide a degree of contact force, without additional actuation mechanisms. A developer is provided with another cleaning arrangement that decouples the apparent stiffness of the rotary surface treatment tool away from the surface treatment material so that: the company can purchase or customize any number of surfacing tool materials, without a constraint of requiring a specific stiffness. This also facilitates customisation of cleaning solutions to comply with the cleaning specifications of other companies as required. It also allows manufacturers of rotary surface treatment tools to focus on producing high quality cleaning materials without a need to focus on variations in stiffness requirements

[0039] It should be appreciated by the person skilled in the art that the above invention is not limited to the embodiment described. It is to be appreciated that modifications and improvements may be made without departing from the scope of the present invention.

[0040] It should be further appreciated by the person skilled in the art that one or more of the above modifications or improvements, not being mutually exclusive, may be further combined to form yet further embodiments of the present invention.

CLAIMS

[Claim 1] A rotary surface treatment tool for a cleaning machine comprising:

a relatively rigid support base adapted to be rotatably driven by the cleaning machine;

a surface treatment layer supported on the support base and rotatable together with the support base; and

a relatively compliant layer provided intermediate the support base and the surface treatment layer, and supporting thereon the surface treatment layer.

[Claim 2] A rotary surface treatment tool according to claim 1, wherein the compliant layer is formed of compressible foam material.

[Claim 3] A rotary surface treatment tool according to claim 2, wherein the foam material has a stiffness range of $\leq 0.5\text{N/cm}$.

[Claim 4] A rotary surface treatment tool according to claim 2, wherein the foam material is of an open cell foam type.

[Claim 5] A rotary surface treatment tool according to claim 4, wherein the open cell type foam material includes polyurethane of different pores per inch (PPI).

[Claim 6] A rotary surface treatment tool according to claim 2, wherein the foam material is of a closed cell foam type.

[Claim 7] A rotary surface treatment tool according to claim 6, wherein the closed cell type material includes EPDM, neoprene or SBR.

[Claim 8] A rotary surface treatment tool according to any one of the preceding claims, wherein the support base is an inner core, and the compliant layer and surface treatment layer is supported around the inner core.

[Claim 9] A rotary surface treatment tool according to any one of claims 1 to 7, wherein the support base is a generally planar disc, and the compliant layer and surface treatment layer are respectively supported on the planar disc.

[Claim 10] A cleaning machine including at least one rotary surface treatment tool as claimed in any one of the preceding claims.

[Claim 11] A method of configuring a pressure applied by a rotary surface treatment tool of a cleaning machine on a surface being treated, the rotary surface treatment tool having a relatively rigid support base adapted to be rotatably driven by the cleaning machine; and a surface treatment layer supported on the support base and rotatable together with the support base; the method comprising providing a relatively compliant layer intermediate the support base and the surface treatment layer, the surface treatment layer being supported on the compliant layer.

[Claim 12] A method according to claim 11, comprising selecting compressible foam material of a predetermined stiffness and/or density to configure the pressure.

[Claim 13] A method according to claim 12, wherein the foam material has a stiffness range of $\leq 0.5\text{N/cm}$.

[Claim 14] A method according to claim 12, wherein the foam material is of an open cell foam type.

[Claim 15] A method according to claim 14, wherein the open cell type foam material includes polyurethane of different pores per inch (PPI).

[Claim 16] A method according to claim 12, wherein the foam material is of a closed cell foam type.

[Claim 17] A method according to claim 16, wherein the closed cell type material includes EPDM, neoprene or SBR.

[Claim 18] A method of configuring moisture retention and/or acoustic performance within a rotary surface treatment tool, the rotary surface treatment tool having a relatively rigid support base adapted to be rotatably driven by the cleaning machine; and a surface treatment layer supported on the support base and rotatable together with the support base; the method comprising providing a relatively compliant layer intermediate the support base and the surface treatment layer, the surface treatment layer being supported on the compliant layer.

[Claim 19] A method according to claim 18, comprising selecting compressible foam material of a predetermined stiffness and/or density to configure the acoustic performance.

[Claim 20] A method according to claim 18 or 19, comprising selecting compressible foam material of a predetermined stiffness and/or density to configure the moisture retention.

[Claim 21] A method according to claim 19 or 20, wherein the foam material has a stiffness range of $\leq 0.5\text{N/cm}$.

[Claim 22] A method according to claim 19 or 20, wherein the foam material is of an open cell foam type.

[Claim 23] A method according to claim 22, wherein the open cell type foam material includes polyurethane of different pores per inch (PPI).

[Claim 24] A method according to claim 19 or 20, wherein the foam material is of a closed cell foam type.

[Claim 25] A method according to claim 24, wherein the closed cell type material includes EPDM, neoprene or SBR.