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Amended specification & claims
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We Claim:

1. A means (150) for determining the soiling of a workpiece (108),

   with a device (155) for capturing on a filter membrane (158) dirt particles taken up in a characteristic liquid volume that are introduced into a liquid by subjecting the workpiece (108) to the liquid; and

   with a system (169) for analyzing the dirt particle load from the liquid that has been captured by the filter membrane (158);

   characterized in that

   the system (169) for analyzing has an analyzing means (170) connected to a computer unit (202), wherein the flat filter membrane (158) takes the form of a displaceable band, which can be moved at least sectionally in relation to the analyzing means (170) by means of a transporting device (160), and wherein the computer unit (202) connected to the analyzing means (170) serves for determining a dirt-particle measured variable (M) *in the form of the type and/or number and/or size* and/or size distribution for dirt particles (166) accumulated on a section (174) of the filter membrane (158).

2. The means as claimed in claim 1, **characterized** in that the analyzing means includes a scanner, which records a profile of the surface of the filter membrane (158) with dirt particles (166) deposited on it by scanning with a laser beam.

3. The means as claimed in claim 1 or 2, **characterized** in that the analyzing means has a camera (170) for the optical recording of a section (174) of the filter membrane (158) with dirt particles (166) arranged on it and the computer unit (202) determines the dirt-particle measured variable (M) by means of image processing.

4. The means as claimed in claim 3, **characterized by** illuminating means including light sources for generating infrared light which is passed to dirt-particles (166) arranged on the filter membrane (158), the analyzing means including at least one infrared camera for detecting metallic dirt-particles (166) which are exposed to the infrared light.

5. The means as claimed in claim 4 characterized by the illuminating means being designed for providing infrared light flashes in order to generate heat pulses impinging on the dirt-particles (166) arranged on the filter membrane (158).

6. The means as claimed in one of claims 3 to 5, **characterized** in that the computer unit (202) is designed for comparing the determined dirt-particle measured variable (M) with a predeterminable threshold value (S) and is connected to a visualizing device (204) in order to display an image of the section (174) of the filter membrane (158) if the determined dirt-particle measured variable (M) for dirt particles accumulated on the section (174) of the filter membrane (158) exceeds the predeterminable threshold value (S).

7. The means as claimed in claim 6, **characterized** by the analyzing means being adapted for the optical recording of a section (174) of the filter membrane (158) with the camera using incident-light illumination and/or dark-field illumination.

8. The means as claimed in one of claims 3 to 6, **characterized** by a first illuminating means (172) for providing a transmitted-light illumination for the section (174) of the filter membrane (158) that can be recorded with the camera (170) and a second illuminating means (176) for providing an incident-light illumination and/or a dark-field illumination for the section (174) of the filter membrane (158) that can be recorded with the camera (170).

9. The means as claimed in one of claims 3 to 8, **characterized** in that, for calculating an integral brightness value (I), the computer unit (202) calculates from at least one image of a section (174) of the filter membrane (158) in band form recorded with the camera (170) under incident-light illuminationan intergral brightness value (I), in order to display this value as a degree of radiance of a dirt particle load accumulated on the section (174).

10. The means as claimed in one of claims 2 to 9, **characterized** in that the band of the filter membrane (158) is a continuous filter band and a device for removing a dirt particle load accumulated on the continuous filter band after the analysis in the system (169) is provided.

11. The means as claimed in one of claims 1 to 10, **characterized** in that the filter membrane (158) is a PET woven fabric.

12. The means as claimed in one of claims 1 to 11, **characterized** in that the system (169) for analyzing the dirt particle load that has been captured by the filter membrane (158) includes a device for orienting magnetizable dirt particles arranged on the filter membrane (158) by generating magnetic field lines.

13. The means as claimed in one of claims 1 to 12, **characterized** in that the filter membrane (158) is coated at least sectionally with a substance that changes a physical and/or chemical property when it comes into contact with liquid to which the workpiece (108) is subjected, the property being dependent on the chemical composition of the liquid, in particular dependent on the pH of the liquid.

14. The means as claimed in one of claims 1 to 13, **characterized** in that the device (155) for capturing a dirt particle load taken up in a fluid volume includes a filter station (156), through which the filter membrane (158) in band form is passed for taking up dirt particles (166), wherein the filter station (156) has a main body (178) with a feeding duct (180) for supplying fluid laden with dirt particles and has an opposing body (182), which can be placed against the main body (178) and, when theopposing body (182) is placed against the main body (178), defines a filter chamber by a recess (190, 192) formed in the main body (178) and/or in the opposing body (182), which chamber is divided by the flat filter membrane (158) into a section on the main body side and a section on the opposing body side, wherein the filter chamber can be optionally opened and closed by moving the opposing body (182) and the main body (178) in relation to one another, wherein the opposing body (182) has a discharging duct (188), connected to a suction line (167), for the suction removal of fluid out of the filter chamber through the filter membrane (158), and wherein a pressure sensor (159)is provided for recording a suction pressure (P) in the suction line (167) that is dependent on the amount of dirt particle load deposited on the filter membrane (158).

15. A cleaning installation (100) with at least one cleaning station (116) and with a means (150), formed in particular as claimed in one of claims 1 to 14, for determining a soiling of a workpiece (108) that is supplied to the cleaning station (116).

16. The cleaning installation (100) as claimed in claim 15, **characterized** by a computer unit (208), which includes a computer program for automatically determining a blind value (B) of the means (150) for determining a soiling of a workpiece (108) by way of the dirt particles inherently taken up in a characteristic fluid volume of the liquid.

17. A method for setting at least one operating parameter (Δt) for at least one cleaning station (116) in a cleaning installation (100) as claimed in claim 15 or 16, in which the at least one operating parameter (Δt) is determined in dependence on a determined blind value (B) of the means (150) for determining a soiling of a workpiece (108) and in dependence on a residual soiling (R) of a cleaned workpiece (108) that is recorded by the means (150) in a computer unit (208) and is output to the at least one cleaning station (116) for the setting of the operating parameter (Δt).

18. A method for cleaning workpieces in a cleaning installation (100) formed as claimed in claim 15 or 16, in which the residual soiling (R) of the workpieces (108) is continuously recorded in the means (150) after the cleaning and the cleaning time (Δt) for the workpieces (108) supplied to the cleaning installation (100) is increased and/or a warning signal (W) is emitted if the residual soiling (R) recorded for a cleaned workpiece exceeds a threshold value (S).

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B. Naveen Kumar Varma
IN/PA-873
Agent for the Applicant

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Determining the soiling of a workpiece

Description

The invention relates to a means for determining the soiling of a workpiece, with a device for capturing on a filter membrane dirt particles taken up in a characteristic liquid volume that are introduced into a liquid by subjecting the workpiece to the liquid and with a system for analyzing the dirt particle load from the liquid that has been captured by the filter membrane.

The invention also additionally relates to a cleaning installation for the cleaning ofworkpieces, which includes a means for determining the soiling of a workpiece, and to a method for cleaning workpieces in a cleaning installation.

Dirt particles, in particular chip material, dust, casting sand, salt residues or else just liquid droplets, can impair the function of industrially produced products, such as for example injection nozzles for internal combustion engines or oil ducts in crankcases for internal combustion engines. The cleanness of workpieces in industrial production processes is therefore of great importance. Therefore, in industrial production installations, the cleanness, cleanliness or soiling of workpieces has to be systematically checked regularly. Checking the cleanness or soiling is important particularly before intermediate and final assembly operations involving workpieces that are sensitive to dirt.

WO 2012/045582 A1 discloses a means for determining the soiling of workpieces in which a workpiece can be rinsed with a fluid in order to infer a degree of soiling for the workpiece from a dirt particle load in this fluid.

The object of the invention is to provide a means for determining the soiling of workpieces that can be integrated in a cleaning installation for workpieces and provides measured variables which allow monitoring and open-loop and/or closed-loop control of the cleaning installation.

This object is achieved by a means for determining the soiling of a workpiece of the type mentioned at the beginning in which the system for analyzinghas an analyzing means connected to a computer unit, wherein the flat filter membrane takes the form of a displaceable band, which can be moved at least sectionally in relation to the analyzing means by means of a transporting device, and wherein the computer unit connected to the analyzing means serves for determining a dirt-particle measured variable (M) in the form of the type and/or number and/or size and/or size distribution for dirt particles accumulated on the section of the filter membrane.

For analyzing the dirt particles captured on the filter membrane, the analyzing means may include a scanner, which records a profile of the surface of the filter membrane with dirt particles deposited on it, preferably by scanning with a laser beam. Then a computer unit connected to the scanner can be used to infer from the scanning signal of the scanner a number and/or size and/or size distribution of dirt particles accumulated on the filter membrane.

The analyzing means preferably has a camera for the optical recording of a section of the filter membrane with dirt particles arranged on it, the computer unit determining the dirt-particle measured variable (M) by means of image processing.

The computer unit is in this case designed for comparing the determined dirt-particle measured variable (M) with a predeterminable threshold value (S) and is connected to a visualizing device. This allows for example an image of the section of the filter membrane recorded with incident-light illumination and/or dark-field illumination to be displayed to an operator of a cleaning installation the visualizing device if the determined dirt-particle measured variable (M) for dirt particles accumulated on the section of the filter membrane exceeds the predeterminable threshold value (S).

The means includes a first illuminating means for providinga transmitted-light illumination for the section of the filter membrane that can be recorded with the camera and has a second illuminating means for providing an incident-light illumination and/or a dark-field illumination for the section of the filter membrane that can be recorded with the camera. The computer unit can then calculate for example an integral brightness value (I) from at least one image of a section of the filter membrane in band form recorded with the camera under incident-light illumination, in order to then display this value as a degree of radiance of a dirt particle load accumulated on the section.

The camera preferably has a lens, which records a section of the filter membrane with a suitable magnification. The illuminating means in the means may be equipped here with various light sources, depending on the aim of the analysis.

Another concept of the invention is that the computer unit compares the determined dirt-particle measured variable (M), such as for instance the number of dirt particles and/or the determined size of the dirt particles and/or the determined size distribution, with a reference, for example a threshold value (S) or a reference distribution. The computer unit may then for example also display an image of the corresponding section of the filter membrane recorded with incident-light illumination and/or dark-field illumination on a visualizing device if the determined number of dirt particles, the determined size of the dirt particles, the determined size of the dirt particles on the section of the filter membrane in band form, exceeds the reference, for example the threshold value, or the determined size distribution deviates from the reference distribution.

The band of the filter membrane may be a continuous filter band. Here it is of advantage if the means comprises a device for removing a dirt particle load accumulated on the continuous filter band after the analysis in the system.

In order to move the filter membrane in band form continuously, a transporting device is provided in the means.

The filter membrane may be produced for example from a woven fabric of polyethylene terephthalate (PET). The filter membrane has in this case as far as possible a filter fineness adapted to a desired analysis, and is preferably coated with further auxiliary substances, for example litmus, and/or treated with one or more auxiliary substances.

The system for analyzing the dirt particle load captured by the filter membrane may also include a device for aligning magnetizable dirt particles arranged on the filter membrane by generating a magnetic field.

The fact that the filter membrane is coated at least *sectionally with a substance that changes a physical* and/or chemical property when it comes into contact with liquid to which the workpiece is subjected, the property being dependent on the chemical composition of the liquid, in particular the pH of the liquid, means that it is possible to monitor the consistency of the liquid to which aworkpiece is subjected in the means.

The device for capturing a dirt particle load taken up in a fluid volume in a means according to the invention may include a filter station, through which the filter membrane in band form is passed for taking up dirt particles. The filter station has in this case a main body with a feeding duct for supplying fluid laden with dirt particles and has an opposing body, which can be placed against the main body and, when theopposing body is placed against the main body, defines a filter chamber by a recess formed in the main body and/or in the opposing body, which chamber is divided by the flat filter membrane into a section on the main body side and a section on the opposing body side. The filter chamber can in this case be optionally opened and closed by moving the opposing body and the main body in relation to one another. The opposing body then has a discharging duct, connected to a suction line, for the suction removal of fluid out of the filter chamber through the filter membrane. The device in this case preferably includes a pressure sensor for recording a suction pressure (P) in the suction line that is dependent on the amount of dirt particle load deposited on the filter membrane.

To achieve the effect that the fluid volume passed through the filter station can be subjected to a static pressure, it is favorable if the recess formed in the main body and/or the opposing body is sealed off and is for example surrounded by a sealing means, which seals off the filter chamber when the opposing body is lying against the main body. The sealing effect may be achieved for example by a form-fitting sealing seating or by a sealing means, for example an O-ring.

According to the invention, when the filter chamber is open, the flat filter membrane, preferably in band form, lies against the opposing body and is then separated from the main body by an air gap. This measure ensures that in the filter station no dirt particles that have accumulated on the side facing the main body are stripped off when the filter membrane in band form is displaced.

According to the invention, the means for determining the soiling of aworkpiece maybe formed both as a stationary system and as a mobile system that can be displaced in a production means, for example in order to investigate soiling of workpieces in an industrial production process by means of random samples.

The device for capturing a dirt particle load taken up in a fluid volume may be integrated in a cleaning installation with at least one cleaning station, which includes a means for determining an initial soiling of a specific number of workpieces, of a single workpiece or of a section of a workpiece that is/are supplied to the cleaning station and/or which for determining a residual soiling of a specific number of workpieces, of a single workpiece or of a section of a workpiece that has/have been cleaned in the cleaning station.

A cleaning installation according to the invention has at least one cleaning station and includes a means for determining a soiling of a workpiece that is supplied to the cleaning station. One concept of the invention in this respect is particularly that of providing in the cleaning installation a computer unit, which includes a computer program for automatically determining a blind value (B) for the dirt particles taken up in a characteristic fluid volume of an accumulated fluid volume of the liquid.

The invention also extends to a method for setting the operating parameters (Δt) of a cleaning station in a cleaning installation. Here it is proposed to set the cleaning parameters on the one hand in dependence on a determined blind value (B) of a means for determining the soiling of a workpiece and on the other hand in dependence on a residual soiling (R) of a cleaned workpiece that is recorded by the means.

Consequently, the means according to the invention makes it possible in particular to produce a trend analysis of the cleanness values or residual soiling values of workpieces over long time periods in a cleaning installation. This allows for example statements to be made concerning the operating state of the cleaning installation and the state of filters for the cleaning liquid that are used in the cleaning installation.

The invention particularly proposes, for the cleaning of workpieces in a cleaning installation, continuously recording the residual soiling (R) of the workpieces after the cleaning and increasing the cleaning time for the workpieces supplied to the cleaning installation in one or more cleaning stations of the cleaning installation and/or emitting a warning signal if the residual soiling (R) recorded for a cleaned workpiece exceeds a threshold value (S).

The invention is explained in more detail below on the basis of the exemplary embodiment that is schematically represented in the drawing, in which:

Figure 1 shows a cleaning installation with a number of cleaning stations with a means for analyzing the soiling of workpieces and with a control computer;

Figure 2 shows a section of the means for analyzing the soiling of workpieces with a filter station;

Figure 3 shows a perspective view of the filter station; and

Figure 4 shows a partial section of the filter station.

The cleaning installation 100 shown in Figure 1 is integrated in a production line (not shown) for items, for example a production line for internal combustion engines for use in a motor vehicle. For the cleaning of workpieces 102, 104, 106, 108, 110, the installation 100 has cleaning stations or cleaning sections 112, 114, 116. In the cleaning stations or cleaning sections 112, 114, 116, the workpieces can be cleaned with a liquid cleaning fluid, such as for instance water provided with cleaning additives. In the installation 100 there is a conveying device 107, with which the workpieces 102, 104, 106, 108, 110 can be moved automatically through the cleaning stations 112, 114, 116 in the direction of the arrows 115. In the cleaning station 112, spray nozzles 118 are formed.

The spray nozzles 118 are a cleaning means for subjecting the workpiece 104 arranged in the cleaning station 112 to cleaning fluid 120. For the cleaning fluid 120 there is a collecting container 122. During the cleaning of the workpiece 104, the dirt particles rinsed off from the workpiece 104 by means of the cleaning fluid pass together with the cleaning fluid 120 into the collecting container 122. The cleaning station 114 has an immersion bath 124, in which a workpiece 106 can be moved by a manipulating means 125. In the cleaning station 116, a workpiece 108 can be cleaned with cleaning fluid in the form of cleaning liquid 132, which is passed from a collecting container 136 through a system of lines 138 to spray nozzles 140 by a circulating pump 134.

The installation 100 includes a stationary or mobile means 150 for determining the soiling of a workpiece 108 before it is cleaned in the cleaning station 116. In the means 150, both the soiling of the surface 153 of the workpiece 108 and the soiling in a section 152 inside the workpiece 108 can be determined. The section 152 of the workpiece 108 may be for example an oil duct in a crankcase for an internal combustion engine. For this purpose, the means 150 may be connected by way of a line branch 141, 142 to the section 152 of the workpiece 108 by adapter pieces 144, 146.

The workpiece 108 is in this case clamped here between the adapter pieces 144, 146 in such a way as to obtain in the line branch 141, 142 a sealed connection between the line and the workpiece 108, through which the cleaning fluid 132 is supplied and removed.

The means 150 has a buffer container 154, which communicates with the system of lines 138. The buffer container 154 is connected to a filter station 156 in a device 155 for capturing a dirt particle load taken up in a fluid volume, through which a filter membrane 158 in band form is movably passed. For this purpose, the filter membrane 158 in band form is unwound from a band roller 162 while rolling up onto a driven band roller 160 acting as a transporting device.

In a modified alternative embodiment of the cleaning installation, the filter membrane band 158 may also be of a continuous configuration. After the analysis of the dirt particle load taken up, the filter membrane band 158 then undergoes a cleaning step in the device 155, in the regions laden with dirt particles, and then is used once again for capturing a dirt particle load in the cleaning installation.

Consequently, the means 150 is capable of automatically determining a basic soiling (the blind value) on the basis of a dirt particle load inherent to the lines and the cleaning liquid carried therein. If the measured blind value does not correspond to the predetermined values, the rinsing process is repeated (without the workpiece) - preferably of its own accord - until the blind value is reached.

In order to analyze the soiling of the section 152 of the workpiece 108, it is rinsed for a defined time intervalΔt in a rinsing operation with a cleaning liquid, which is freed of dirt particles in a filter device 164 arranged in the line branch 141.

When it flows through the section 152 of the workpiece 108, the filtered cleaning fluid 132 thereby takes up dirt particles 166, which are carried through the buffer container 154 to the filter station 156. The dirt particles 166 are held back on a section of the filter membrane band that is passed through by the cleaning fluid 132 in the filter station 156 if their grain size is greater than the microscopic through-openings formed in the filter membrane 158 in band form. It should be noted that, according to the invention, in the cleaning installation the filter fineness or the filter efficiency is set for the filter membrane band in such a way that, as far as possible, only the dirt particle load that is deemed to be relevant to soiling is captured by it.

In order to return the cleaning fluid 132 that has passed through the filter membrane 158 in band form into the collecting container 136, in the means 150 there is a suction pump 168, which sucks up the cleaning fluid 132 from the filter membrane 158 through a suction line 167. It should be noted in this connection that, in a modified embodiment, the means 150 may also have a fluid circuit that is separate from the fluid circuit of a cleaning station in the cleaning installation 100.

The means 150 comprises a system 169 for analyzing a dirt particle load that has been taken up by the filter membrane 158 in band form in the filter station. The system 169 has a camera 170. With the camera 170 with an appropriate lens, the dirt particles deposited on the workpiece in the rinsing operation can be digitally recorded, in that the filter membrane 158 in band form with the dirt particles taken up in the filter station 156 is moved under the camera 170 in the direction of the arrow 171. The camera 170 includes an image sensor and has an imaging lens. It acts as a microscope and allows a magnifying, analyzablevisualization of the dirt particles on the filter membrane 158 in band form. The camera 170 is assigned a first illuminating means 172, with whicha transmitted-light illumination can be set for a section 174 of the filter membrane in band form on which dirt particles are located. In the system 169 there is also a second illuminating means 176, which allows the setting of an incident-light illumination for the section 174 of the filter membrane 158 in band form. It should be noted that the illuminating means 176 may alternatively or additionally also be designed for the setting of a dark-field illumination for the section 174 of the filter membrane 158 in band form. A dark-field illumination of the section 174 is understood in this case as meaning an illumination in which the illuminating light radiates onto the section 174 in such a way that the camera 170 does not record through its objective lens any illuminating light that is reflected directly by the filter membrane in band form and dirt particles arranged on it, but only receives illuminating light that is diffracted at the filter membrane in band form and dirt particles accumulated on it.

Figure 2 shows a section of the means 150 for determining the soiling of workpieces or workpiece sections with the filter station 156. The filter station 156 has a main body 178 with a feeding duct 180, which communicates with the buffer container 154. Figure 3 is a perspective view of the filter station 156. The filter station 156 has a displaceably arranged opposing body 182, which can be moved in relation to the main body 178 in a linear guiding means 187 in the direction of the double-headed arrow 184 by a driving means 186 having a hollow-shaft cylinder. The filter membrane band 158 is guided by a guiding means 185 between the main body 178 and the opposing body 182.

As can be seen in Figure 4, the main body 178 has a funnel-shaped recess 190. The opposing body 182 has a funnel-shaped recess 192. By displacing the opposing body in the direction of the double-headed arrow 184, the opposing body 182 can be placed against the main body 178, in order thereby to define a filter chamber, which is divided by the filter membrane band 158 into a section 194 on the main body side and a section 196 on the opposing body side. The fact that the opposing body 182 is moved with respect to the main body 178 in the direction of the double-headed arrow 184 means that this filter chamber can be optionally opened and closed. The opposing body 182 has a discharging duct 188 for discharging fluid 132 that has passed through a region of the filter membrane band 158 in the direction of the arrow 189.

During the analysis, the filter membrane band 158 may be clogged by cleaning liquid 132 that is heavily laden with dirt load. The suction pressure in the suction line 167 is monitored by a pressure sensor 159 connected to the computer unit 202. This allows conclusions concerning the state and the loading of the filter membrane 158 to be reached by a computer program stored in the computer unit 202.

The funnel-shaped recess 192 of the opposing body 182 is surrounded by an O-ring 198, which acts as a sealing means and seals off the filter chamber laterally when the opposing body 182 is lying against the main body 178.

In a modified exemplary embodiment, the main body 178 and the opposing body 182 have on their mutually contacting surfaces a form-fitting sealing seating, for example a round planar seating, conical seating or annular seating, whereby the filter membrane band 158 is held and securely clamped and whereby the filter chamber 194, 196 is formed. In this configuration, the filter member band itself acts as a sealing means.

When the filter chamber is open, the filter membrane band lies with the side facing away from the main body 178 against the opposing body 182. In this case, the filter membrane band 158 is separated from the main body 178 in the filter station 156 by an air gap 200, so that dirt particles that have been deposited from the cleaning fluid 132 on the filter membrane band 158 in anoperation of rinsing the section 152 of the workpiece 108 are not stripped off on the main body 178 on the way to the camera 170 when the filter membrane band 158 is displaced by rotating the band rollers 160, 162.

The camera 170 is connected to a computer unit 202. The computer unit 202 is assigned a display device in the form of a monitor 204. The computer unit 202 controls the camera 170, the lens of the camera and the illuminating means 172, 176. For every operation of rinsing a workpiece 108, the computer unit 202 initiates the digital recording of the dirt particles on the filter membrane band 158,having been separated out in the filter station 156, with a transmitted-light illumination and with an incident-light and/or dark-field illumination.

The computer unit 202 includes a computer program for the image processing. With this computer program, the computer unit 202 determines from one or more images recorded with transmitted-light illumination a dirt-particle measured variable M in the form of the type and/or number and/or size and/or size distribution for dirt particles 166 accumulated on the section 174 of the filter membrane 158, having been separated out on the filter membrane band 158 in a rinsing operation in the filter station 156. Alternatively or additionally, with this computer program, the computer unit 202 may also determine from one or more recordings that have been made in incident-light and/or dark-field illumination an integral value I for the image brightness as a dirt-particle measured variable M.

The computer unit 202 then compares the determined dirt-particle measured variable M with a threshold value S entered by way of an input interface 206.

If the determined dirt-particle measured variable M exceeds the threshold value S, a display of the image of the filter membrane band 158 recorded with incident-light and/or transmitted-light illumination on the monitor 204 is initiated by the computer unit 202 and, for this purpose, the integral value I for the image brightness is additionally displayed as a dirt-particle radiance value.

It should be noted that, in a modified, alternative embodiment of the cleaning installation 100, the illuminating means 176 may also be equipped with various light sources or a combination of various light sources from the group - light sources for generating daylight-like light -, - light sources for generating ultraviolet light -, - light sources for generating infrared light, in particular for generating light flashes with wavelengths that lie in the infrared spectral range -. Daylight systems for example are particularly well-suited for transmitted-light and incident-light analyses. The sensitivity of the camera in the cleaning installation is adapted to the spectral range of the light generated by the light sources in an illuminating means. With ultraviolet light, for example, organic substances, in particular oil residues, deposited on the filter membrane can be recorded particularly well. With infrared light in connection with infrared cameras, metal particles deposited on the filter membrane can be detected particularly well. With infrared flashlight, heat pulses that bring about the rapid heating of metal particles can be generated. In the decaying phase, these particles can be detected for a long time and can be detected well with an infrared camera.

The filter membrane 158 in band form in the cleaning installation 100 may be formed as a fibrous woven fabric of polyethylene terephthalate (PET) or comprise a fibrous woven fabric that is based on the material PET or contains the material PET.

The thread density and fiber thickness in the fibrous woven fabric is in this case selected to correspond to a filtering efficiency required for the filter membrane band, i.e. to correspond to the size of the dirt particles that the filter membrane is intended to hold back.

The filter membrane band 158 is preferably coated and/or treated with chemical substances, for example with litmus. By detecting a discoloration of the filter membrane band, it is then possible to determine for example the pH of the cleaning fluid 132 in the cleaning station 116. For this purpose, the type of discoloration is recorded with the camera system and evaluated in the computer unit 202, in order to infer the state of the cleaning fluid 132.

It should additionally be mentioned that, in an alternative, modified embodiment of the cleaning installation 100 for the analysis of dirt particles 166 accumulated on the filter membrane band 158, a magnet may be provided,arranged under the filter membrane band 158. Magnetizable, ferritic metal particles are then oriented by the magnetic field lines generated by means of the magnet. In order to determine the number and/or size and/or size distribution of the ferritic metal particles accumulated on the filter membrane 158, the metal particles are recorded with a camera and the camera image then undergoes an image evaluation in the computer unit 202, in order in this way to detect a characteristic orientation of the metal particles and analyze it in the computer unit 202.

In a further modified embodiment of the cleaning installation 100, there may also be provided a computer unit 202, which includes a computer program for the image processing. With the computer program, the computer unit 202 determines here from one or more images recorded with transmitted-light illumination the particle size spectrum of the dirt particles separated out on the filter membrane band 158 in a rinsing operation in the filter station 156. The particle size spectrum and the average particle size then yield further characteristic variables, which are used for determining an improved threshold value S.

In a further modified embodiment of the cleaning installation 100, it is envisaged to sweep over the surface of the filter membrane band 158 with a scanner, in particular with a laser scanner. By scanning the surface with a laser beam in a line- or grid-like manner, a projected image of the filter surface geometry is then recorded and a dirt-particle measured variable M, such as the size and/or the number and/or the size distribution of dirt particles accumulated on the filter membrane, is inferred from it by means of a computer program in a computer unit 202 connected to the laser scanner. This involves for example classifying every elevation on the filter membrane that is greater than the filter surface roughness as local soiling of the filter membrane.

It should be noted that in a modified embodiment of the cleaning installation 100 there may also be provided a number of stationary and/or mobile means for determining the soiling of a section of a workpiece that are for example assigned to different cleaning stations in the cleaning installation and/or that serve for recording the soiling of different sections of a workpiece. A mobile means is for example particularly well-suited for random sample investigations.

It should additionally be noted that the means 150 for determining the soiling of a section of a workpiece 108 may also be formed for determining the number of dirt particles that are accumulated on the surface of the workpiece 108, in that the dirt particle load in a fluid volume with which the surface of the workpiecehas been rinsed off is analyzed. It is also possible to analyze the number of accumulated dirt particles in a stream of fluid from a number of workpieces, in order to obtain a value of an average dirt load of a workpiece. In particular, in an alternative embodiment, the means 150 for determining a workpiece soiling may also have a fluid circuit, which is separate from a circuit for cleaning liquid in a cleaning installation.

The device 155 described above for capturing a dirt particle load taken up in a fluid volume and the system 169 for analyzing a dirt particle load and determining the soiling of a workpiece 108 may in principle also be used outside a cleaning installation 100. They are for example also suitable for integration in a production or assembly line, in order to implement an automatic cleanness analysis there, for example an automatic cleanness analysis for what is known as a quality audit. The cleanness analysis is especially meaningful in a production or assembly line where a pre-assembly or final assembly of workpieces takes place. This allows workpieces to be checked in a random sampling manner in a production process, for example at regular intervals. This then allows an automatic batch log to be transmitted to a master computer in a production installation. With a cleanness analysis that is performed before the pre-assembly and final assembly of workpieces it can be ensured that no soiled workpiecesare fitted. Consequently, the invention is also suitable for use in an assembly line for the pre-assembly or final assembly of complex systems that are made up of a number of components.

For controlling the cleaning processes for the workpieces 102, 104, 106, 108 in the cleaning sections or cleaning stations 112, 114, 116, the cleaning installation 100 includes a control computer 208. The control computer also controls the conveying means for the workpieces in the cleaning installation 100 and allows the cleaning station 116 to be coupled to the means 150 for determining the soiling of a workpiece, and thereby to determine the soiling of a workpiece. The cleaning processes for workpieces in the cleaning stations or cleaning sections 112, 114, 116 are controlled in that various cleaning parameters in the form of pump pressure P and/or cleaning duration Δt and/or valve positions for controlling the flow of cleaning fluid are set there.

The control computer 208 includes a computer program, which allows automatic setting of the operating parameters for the cleaning station or cleaning sections 112, 114, 116 and ensures that the workpieces

102, 104, 106, 108, 110 cleaned in the cleaning installation 100 satisfy a predetermined cleanness criterion.

This computer program has a routine for determining the blind value B of the means 150 for recording the soiling of a workpiece 108. In order to determine the blind value B of the means, the cleaning liquid is circulated in successive rinsing processes in the cleaning station 116 without a workpiece arranged therein.

The cleaning fluid is thereby passed through a piece of pipe arranged between the adapter pieces 144, 146. As far as possible, this piece of pipe preferably has little or no soiling. It consequently forms a reference for an unsoiled workpiece. The dirt particles in the cleaning liquid circulated through the cleaning station or the cleaning section 116 of the means 150 are then separated at the filter membrane 158 for each and every rinsing process.

By analyzing and quantifying in the means 150 the amount of dirt particles that are entrained in a volume of cleaning liquid used in a rinsing process, the computer program in the control computer 208 then determines a value for the dirt particle load with respect to an individual rinsing process. If this value remains the same for successive rinsing processes without a workpiece arranged in the cleaning station, this value corresponds to the soiling inherent to each and every volume of cleaning liquid in the cleaning station or in the cleaning section 116 of the installation that the soiling cannot go below (blind value).

In order to determine in the cleaning installation 100 the cleaning parameters that are favorable for the cleaning of a workpiece, a workpiece to be cleaned from a series of similarly soiled workpieces that are to be cleaned is moved through the cleaning installation 100. The workpiece is thereby cleaned in the cleaning stations or cleaning sections 112, 114, 116 of the cleaning installation 100 with predetermined cleaning parameters for a specific time period Δt_1. Once each and every cleaning operation in a cleaning station 112, 114, 116 has been completed, the cleaning result a residual soiling R of the corresponding workpiece is then analyzed in the cleaning station 116 by means of the means 150 for determining the soiling of a workpiece 108. If this residual soiling R is greater than a threshold value S referring to a specific cleaning station, the cleaning operation is repeated in the cleaning station concerned for a defined further time period Δt_2 and the cleaning result is checked once again in the cleaning station or the cleaning section 116 in the way described above. The computer program in the control computer 208 determines in this way a value for afavorable cleaning time$\Delta t_g = \Sigma_i \Delta t_i$ in the cleaning stations of the cleaning installation 100, and consequently cleaning parameters that ensure that a certain residual soiling R is not exceeded during the cleaning of workpieces.

When successive workpieces from a series of workpieces are cleaned in the cleaning installation 100, after the completion of the cleaning operation, a measurement of the residual soiling R of the workpieceis carried out in the cleaning station or the cleaning section 116 by means of the means 150 (trend analysis). If the computer program in the control computer 208 establishes that the residual soiling thereby recorded exceeds a threshold value S, the cleaning time Δt for the cleaning of the workpieces in the cleaning stations 112, 114, 116 is correspondingly increased in the cleaning installation 100. As an alternative to this, it is also possible that the computer program then emits by way of the control computer a warning signal to an operator of the cleaning installation 100.

To sum up, the following preferred features of the invention should be noted in particular: The invention relates to a means 150 for determining the soiling of a workpiece 108. The means includes a device 155for capturing on a filter membrane 158 dirt particles taken up in a characteristic liquid volume that are introduced into a liquid by subjecting the workpiece 108 to the liquid. In the means 150 there is a system 169 for analyzing the dirt particle load from the liquid that has been captured by the filter membrane 158. The system 169 for analyzing has an analyzing means 170 connected to a computer unit 202, wherein the flat filter membrane 158 takes the form of a band and can be moved at least sectionally in relation to the analyzing means 170 by means of a transporting device 160. The computer unit 202 connected to the analyzing means 170 serves for determining a dirt-particle measured variable (M) in the form of the type and/or number and/or size and/or size distribution for dirt particles 166 accumulated on the section 174 of the filter membrane 158.

List of designations:

100	Cleaning installation
102, 104, 106, 108, 110	Workpiece
112, 114, 116	Cleaning station
115	Arrow
118	Spray nozzle
120	Cleaning fluid
122	Collecting container
124	Immersion bath
125	Manipulating means
132	Cleaning liquid, cleaning fluid
134	Circulating pump
136	Collecting container
138	System of lines
140	Spray nozzle
141, 142	Line branch
144, 146	Adapter pieces
150	Means
152	Section
154	Buffer container
155	Device
156	Filter station
158	Filter membrane
160, 162	Band roller, transporting device
164	Filter means
166	Dirtparticles
167	Suction line
168	Suctionpump
169	System
170	Camera
171	Arrow
172	First illuminating means (transmitted light)

176	Second illuminating means (incident light)
174	Section of the filter membrane band
178	Main body
180	Feeding duct
182	Opposing body
184	Double-headed arrow
185	Guiding means
186	Driving means
187	Linear guiding means
188	Discharging duct
189	Arrow
190	Recess in main body
192	Recess in opposing body
194	Section of main body
196	Section of opposing body
198	O-ring, sealing means
200	Air gap
202	Computer unit
204	Monitor
206	Input interface
208	Control computer