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(54) Title: DEVICE AND METHOD FOR MONITORING AND MANAGING OF A WEB HANDLING MACHINE

(57) Abstract: A mobile device for monitoring and managing a web handling machine. Said device comprising means for sensing at least one condition of said web handling machine. The device is characterized in that the mobile device is a mobile flying device.

Device and method for monitoring and managing of a web handling machine

The invention relates to a device for monitoring and management, of a web handling machine, particularly a machine for producing or processing a fibrous web (eg paper web, pulp web or nonwoven web) or a textile web. The invention also relates to a method for monitoring and managing said machine.

In web handling machines, especially in paper machines, many monitoring and management tasks have to be carried out. These tasks include, but are not limited to inspection of mechanical parts (e.g. bearings), monitoring and controlling production processes, optimization and stabilization of quality parameters of the web and many more.

Today, many of these tasks are carried out by human inspectors.
For maintenance reasons, a human inspector makes visual inspections of crucial parts of the machinery, sometimes followed by repairs or changes at the inspected. This maintenance work is of course mostly done, when the machine is not running, because otherwise, many parts of the machine cannot be reached without a significant risk for the health and safety of the inspector.

To ensure the stable production and to prevent unplanned shut downs, the production machine is visually checked by the operators for malfunctions. While this is common practice, it is disadvantageous, because such inspections are usually not done on a regular basis due to other tasks of the personnel. It is also very inconvenient, because paper production machines can have a significant length of 100 m or more, and therefore, long walking distances are necessary.
If an inspector notices the need to change some settings of the machine, it is in many cases necessary for him or her to walk to a control room or at least inform the personnel there to do the changes at the computers there.

For some tasks, the human inspectors are supported by several sensors and measurement equipment. There may be camera systems at fixed positions around the machine, surveilling a fixed part or parts of the machine. Examples for this are ‘sheet-break-sensors’, where high-speed cameras monitor a part of the web in order to detect a sheet break early or give the possible reason for the break. While many of the sensors are fixed, some can have a certain limited maneuverability. In most cases, such sensors are traversing the web from side to side, measuring cross direction profiles of the web. But as mentioned, the movement of these sensors is limited, since they are attached to a fixed beam.

The purpose of the present invention is to propose a device for monitoring and management, of a web handling machine and also a method for monitoring and managing said machine, that overcomes the problems in the state of the art.

The problem is solved by a mobile device for monitoring and managing a web handling machine, said device comprising means for sensing at least one condition of said web handling machine, wherein the mobile device is a mobile flying device. Such a mobile device, commonly known as a drone usually has its own propulsions system like e.g. a quad copter. But the scope of the invention also includes other flying devices. One of the main ideas of the invention is to have sensing means that are not limited in position by the place, where they are installed, but can be used at any place around the web handling machine. They can also be moved in positions, where it is dangerous or inconvenient for a human inspector. Regarding the health and safety aspect, a mobile flying device used for safety relevant inspection is characterized by its high reliability and the reproducibility of its tasks. Such a device can for example be useful to rule out or at least limit 'the human factor' in such critical tasks.

Such mobile flying devices can be realized in many different sizes, depending on the tasks to be performed. A special advantage may be the possibility to build very small devices, especially devices, that are smaller, that a human body. Today, such devices can be as small as less than 25 cm, 10 cmor even less. Therefore, such a small device can be sent to places that cannot be reached by a human inspector.

A web handling machine in the context of this application is a machine to produce or treat a web-shaped material, especially a paper web, pulp web, a nonwoven web or also a textile web. Therefore, web handling machines include, but are not limited to paper machines, coating machines, calandering machine etc.

In a preferred embodiment, the mobile device comprises means for sensing at least one condition of said web handling machine comprise which are chosen from the group of camera system, -e.g. a high resolution camera system, a high speed camera system or an infrared camera system, a temperature sensor, noise sensing system, speed measurement system, motion sensing system or humidity sensor.

In many applications, the mobile flying device will probably comprise one or more camera systems, since this is crucial for inspections purposes.

These cameras may for example be used to take images from bearings even when the machine is in operation. Based on these pictures one may be able to decide, if or when they have to be replaced.

In addition or alternatively the device may also be fitted with different measurement systems like a thermometer or humidity sensor to measure for example the conditions in the drying section of a paper machine. This is – especially when the machine is running- nearly impossible for a human inspector due to the harsh conditions there (hot and humid) and also because the health and safety risk caused by fast moving parts and the running web. Very many other applications are also possible.

In a further preferred embodiment, the mobile device comprises means for data communication. These means could be suitable to send data, e.g. image data or other measured values from the sensing means to an external computer system. The data communication may also be used to receive data

from an external computer system or control system. This may be useful to control the mobile flying device. While many ways of data communications means are possible, a WiFi or Bluethooth based system may be a good choice. One could also think of using a mobile phone network, present in the production facility. The data communication may be realized using a TCP/IP protocol

In a further advantageous embodiment, the mobile device comprises an internal computer. This internal computer could be used for the navigation of the mobile flying device. Additionally or alternatively, this internal computer may also be used to analyze data e.g. data received from the sensing means and/or via data communication. Of course it is also possible, that such a data analysis is done on an external computer system. In such a case, the external computer system might send back the result of the analysis to the mobile flying device where it can then be used.

In a very advantageous embodiment, the mobile flying device may be directly integrated in a local or global network structure. The device may for example get an IP-address. If needed, the mobile flying device may have to possibility to communicate with other devices also integrated in the network. A possible application may be the mobile flying device receiving data from fixed sensors in the machine. It may even receive data via the internet from different machines in order to compare the state of the current machine to these different machines. Many more applications are possible.

One can also think of the mobile flying device communicating with other devices in order to change some settings in these devices, based on some sensed values or other information received by the mobile flying device. While this can be used to optimize the production process, it can also be used for safety reason. Here, one may think of the mobile flying device initiating an emergency shut down of the web handling machine or at least parts of it, as soon as it senses some danger. A danger may be determined, for example, using image analysis methods on the images taken from a camera included in the mobile flying device. But also here, many other applications are possible.

In a further preferred embodiment, the mobile flying device may comprise one or more tools to perform changes at the web handling machine. These tools may, for example be chosen from the group of cleaning tools, maintenance tool or repair tools. So equipping the mobile flying device with means to perform physical actions, it becomes a mobile flying robot.

The tasks to be performed by such a mobile flying robot can be manifold. It may, for example, be equipped with a fluid, than can be used to clean specific parts of the machine. It may additionally or alternatively be equipped with one or more lubricants to perform lubrication tasks. For different purposes, it may be equipped with mechanical tools, e.g. a gripping tool that allows for moving or removing items. It can even be imagined, the flying robot is equipped a multifunctional tool – a robot hand – to perform a variety of maintenance task, similar to a human inspector.

In another embodiment, the mobile device further comprises means to generate an optical and/or acoustical alert signal. By these means, the mobile device – may it be equipped with tools or not- may for example alert the personnel if it detects any relevant event, if it is performing chances at the process etc.

With respect to the method, the problem is solved by a method of monitoring or managing a web handling machine, wherein the monitoring and/or managing is at least in parts performed, using at least one mobile device according to one the claims 1 to 7.

Especially for large production plants, but also in order to perform a multitude of monitoring and or managing tasks, it may be beneficial to use more than one mobile flying device. Each of said mobile flying devices may for example be equipped with a specific set of sensing means, depending on the task and location where it is applied.

Said monitoring or managing may include at least one task chosen from the group of process inspection, health and safety inspection or maintenance inspection. Details of these tasks have already been described above in this application.

In a preferred realization of the method, said at least one mobile flying device least one mobile device may repeatedly move along a predetermined inspection path. Due to the fact, that the device has the capability to fly, there is an enormous freedom to trace such inspection paths. They may, for example be traced over or underneath the running web, enter small corners or may lead high up the machine.

As an alternative or even additionally, one of said mobile devices may have the capability to trace its paths in an autonomous way. That is, the path is determined or at least modified based on data received by the device. One obvious choice might be the use of image data, taken from a camera attached to the mobile device, said data being analyzed by image analysis. But also other options are possible.

Finally, it may also be possible, that the device is controlled by a human controller. These human controller may be in close vicinity of the mobile device (e.g. in the control room, using a remote control). But if the mobile device is for example connected to the internet, the human controller could also be in a totally different location.

In a further variant of the method, at least one mobile device sends and/or receives data from an external computer while moving. As mentioned above, a connection to a network (e.g. local network or the internet) may be favorable.

This data may or may not be used to change the operation of the web handling machine.

If more than one mobile device is used, it may be favorable, if said mobile devices have the capability to communicate with each other (e.g. exchange data directly) and/or with other physical systems.

It should be noted, that it may be beneficial to have at least one backup device, because the mobile flying devices need to be serviced themselves – most frequently the batteries have to be recharged for example. In order to keep an uninterrupted inspection process, it may be beneficial to have a replacement device for these events.

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What is claimed:

1. Mobile device for monitoring and managing a web handling machine, said device comprising means for sensing at least one condition of said web handling machine, **wherein** the mobile device is a mobile flying device.

2. Mobile device according to claim 1, **wherein** said mean for sensing at least one condition of said web handling machine comprise one or more means chosen from the group of camera system, temperature sensor, noise sensing system, speed measurement system, motion sensing system or humidity sensor.

3. Mobile device according to claim 1, wherein said mobile device further comprises means for data communication suitable to send and/or receive data.

4. Mobile device according to claim 1, wherein said mobile device further comprises an internal computer.

5. Mobile device according to claim 1, wherein said mobile device further comprises one or more tools to perform changes at the web handling machine.

6. Mobile device according to claim 5, wherein said one or more tools are chosen from the group of cleaning tools, maintenance tool or repair tools.

7. Mobile device according to claim 1, wherein said device further comprises means to generate an optical and/or acoustical alert signal.

8. Method of monitoring or managing a web handling machine, wherein the monitoring and/or managing is at least in parts performed, using at least one mobile device according to one the claims 1 to 7.

9. Method according to claim 8, wherein said at least one mobile device one of repeatedly moves along a predetermined inspection path, moves in an autonomous way or is controlled by a human controller.

10. Method according to claim 7, wherein said at least one mobile device sends and/or receives data from an external computer while moving.

11. Method according to claim 10, wherein data sent by said at least one mobile device is used to change the operation of the web handling machine.

12. Method according to claim 8, wherein said monitoring or managing includes at least one task chosen from the group of process inspection, health and safety inspection or maintenance inspection.

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A. CLASSIFICATION OF SUBJECT MATTER
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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B25J B64C G01B G05D G05B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/168420 A1 (NADERHIRN MICHAEL [AT] ET AL) 19 June 2014 (2014-06-19) paragraph [0015] - paragraph [0018] paragraph [0026] - paragraph [0028] figure 1 figure 4 ----- -/--	1-12

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

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

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

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

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Name and mailing address of the ISA/	Authorized officer
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	A. KEEMINK ET AL: "Mechanical design of a manipulation system for unmanned aerial vehicles", 2013 IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION (ICRA); 6-10 MAY 2013; KARLSRUHE, GERMANY, 6 May 2013 (2013-05-06), pages 3147-3152, XP055330248, US ISSN: 1050-4729, DOI: 10.1109/ICRA.2012.6224749 ISBN: 978-1-4673-5641-1 page 3147, column 2 page 3148, column 1 - column 2 figure 1 figure 5	1-12
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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		EP 2702382 A2	05-03-2014
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