Continuous Measurement of Waste Material Volume Flow

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Abstract

At the present time, volume flow rates in waste treatment plants are determined only discontinuously. With the aid of a contactless, sensor-based method the volume of the conveyed waste stream can be detected in real-time. In addition, information about the locations of the transported materials can be given. The data can be used to monitor and control aggregates. The procedure is applicable to all regular facilities of waste treatment plants.

Keywords

Controlling and monitoring of aggregates, laser triangulation, sensor based technology

1 Introduction

In disposal plants, waste material mass flows are usually determined by multiplying the mass flow rate during a defined period of time with the medium bulk density. Here, changes in the waste composition and short-term variations in the loading of the conveyor belt are not detected. Overload and idling of the conveyor belts are not considered in the overall result. Furthermore, no information can be given about the loading of the conveyor belts across their width.

The exact understanding of time-dependent loading conditions of the conveyor belts enables a rapid optimisation of the processes and their adjustment to current needs. As a result, the output of useful material can be raised and the quality of processed products can be increased to a higher degree.

A method for a detailed, time-dependent and low-cost measuring of volume flows on conveyor belts is being developed at the I.A.R [Department of Processing and Recycling]. With this method, volume flows are measured continuously and the current distribution of the waste material on the belt is indicated at the same time. The collected data can be evaluated statistically over periods of several months or it can be used for the direct control of aggregates. In the following, the technical background, the type of collected data and the possibilities of data usage are explained. Moreover, possible applications for volume flow measuring are introduced and an outlook on future developments is given.

2 Methods

2.1 Laser Triangulation

In a continuous volume flow measurement, height-related data is collected sensorially by a 3D camera. The examined surfaces have to reflect light diffusely. Glossy, reflective or transparent surfaces should be avoided. The underlying technology is based on the principle of laser light section triangulation. Figure 1 gives a schematic representation.

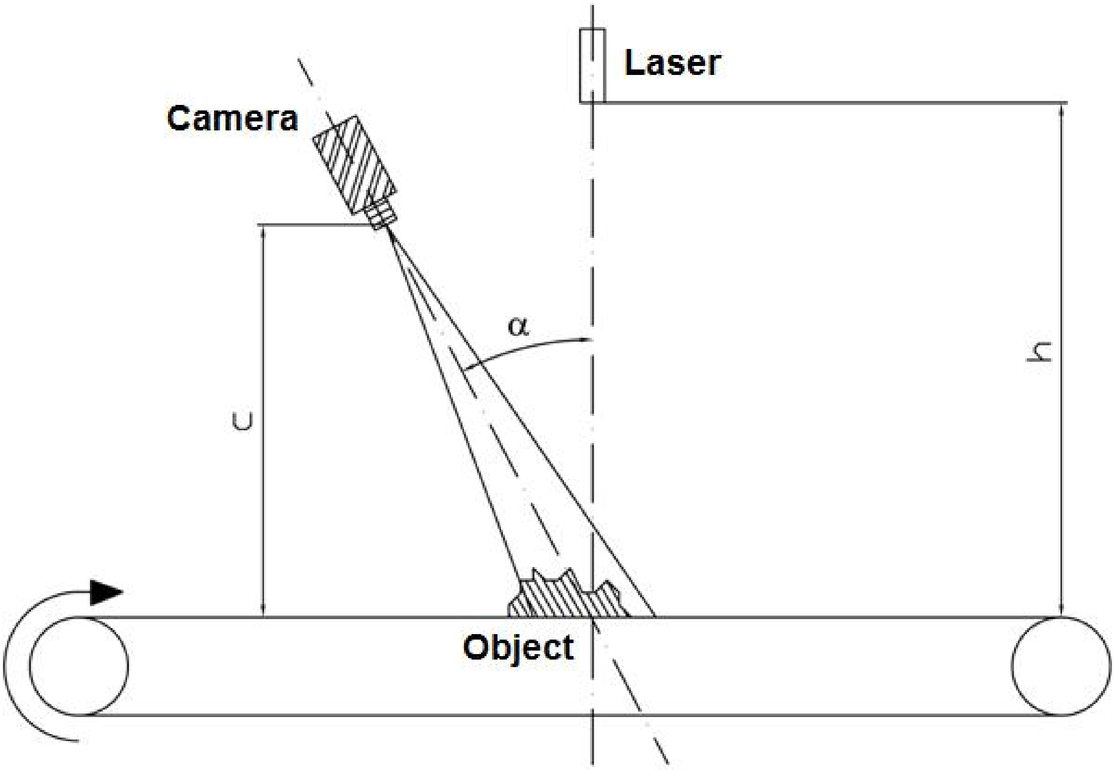

Figure 1: Measuring assembly for volume flow measurement on the basis of laser triangulation

In laser triangulation, a laser liner projects a “contour line” onto the material to be measured. The light of the line is reflected by the surfaces of the material and continuously recorded by a camera. The angle at which the light strikes the camera’s sensors serves to determine distances or heights of objects on the basis of trigonometric principles.

An evaluation software then develops a complete “contour image” from the several hundred pictures that the 3D camera takes per second. Together with trigonometric principles, this image can be used to determine the volume of the material and furthermore provides information about the waste distribution on the conveyor belt.

2.2 Measurement Setup

2.2.1 Laser

In order to generate the contour line, a laser liner is aimed vertically at the material flow. The focusable range of the laser lies between the belt surface and 40 cm above the belt surface. The costs for a laser liner with the necessary precision amount to about €100.

2.2.2 Camera

The position of the contour line varies according to the height of the loaded material. Therefore, the exact measuring of the contour line requires the measuring of the whole area above the conveyor belt. This requirement can be met by customary area cameras that are available from €250 to €1000.

The camera used at the I.A.R. has a VGA CMOS sensor and a frame rate of about 90 fps. With a conveyor belt width of one metre and a conveying speed of 0.5 metres per second, the highest possible resolution is about 8 mm^3 per voxel. The camera is connected to a PC via a gigabit ethernet interface.

2.2.3 Evaluation Software

The evaluation software was developed in the “LabVIEW” research environment by National Instruments (NI) and offers the possibility to create user- and application-oriented “measuring applications with analysis features”. At the I.A.R., a programme was written that combines the contour lines that are captured by the 3D camera into a continuous contour image. With the help of further algorithms, the volume and distribution on the belt surface are then determined.

2.2.4 Properties of the Measurement Setup

The measurement setup for the volume flow measurement is contactless and can be retrofitted to existing plant components. The basic setup is shown in figure 1. The distance of the laser from the belt surface depends on the focus and the aperture width of the laser optics and is at least twice the maximum loading height. The 3D camera is sighted so that it can capture the whole width of the conveyor belt as well as the space between the conveyor belt and the maximum loading height.

2.3 Data Acquisition

A complete data acquisition is achieved when the speed of the conveyor belt is adapted to the picture-taking rate of the camera. This rate depends on the line duration which in turn results from the exposure time, processing time and rest period.

The exposure time is set by the user depending on the brightness of the surroundings and the desired length of the conveyor belt to be covered by the picture. The longer the section of the conveyor belt to be observed, the longer the exposure time should be set.

With a frame rate of 90 pictures per second and a belt speed of 0.5 metres per second, height information of about 6 mm of the conveyor belt can be recorded with every picture. The recorded picture shows a blurred contour line composed by single surface contours that were captured during this time frame. The middle line of this blurred contour line is sufficiently accurate for the volume measurement and is used to generate the contour image.

The processing time that is necessary for the evaluation of the picture signals is constant for a set line length and takes a few milliseconds. The rest period is a variable parameter and fills the time before the next exposure.

The optical properties of most surfaces of the waste flow are suitable for the sensors of the volume flow measurement. Surface characteristics change the reflective properties of laser light. E.g. reflective, very dark, or transparent objects, are usually covered by surrounding dust to form a measurable surface.

3 Applications

3.1 Data Usage

The captured volume flow data can be used for plant monitoring in combination with a warning system for the personnel. The information about the volume flow helps to avoid failures and ensure the aggregates function properly. Additionally aggregates can be increased to a permanently high level of efficacy by optimizing the feeding volume.

Another possible application is the simultaneous use of a system for volume flow measurements at the input and output of aggregates. From this data, the current utilisation level of the examined aggregates as well as the current output can be determined. An overview of the possible applications is given in table 1.

Table 1 Possible applications of volume flow data

Aggregate	**Possible applications of volume flow data**
Classifier	Estimation of utilisation levels; prevention of overloads, blocking and idling periods
Sorter	Monitoring of input layer thickness; ensuring an even loading of the aggregates
Shredder	Prevention of overloads and idling periods

3.2 Classifier

The use of a continuous volume flow measurement at the inflow of classifiers can serve different goals. In drum screens, the information about the inflowing volume serves to estimate the current utilisation level and to avoid blockage, whereas in deck screens or sizers, overloads and idling periods have to be avoided.

3.3 Sorter

For sorters, an even feeding to the conveyor belt is required for an effective sorting. Here, the continuous volume flow measurement can be used for monitoring the layer thickness as well as the distribution of waste material on the width of the conveyor belt. Further examples are given in the following table 2.

Table 2 Overview of possible applications of volume flow measurement in sorters

Sorter	**Possible applications of volume flow measurement**
Magnetic separator	Monitoring of layer thickness; monitoring of material distribution
Sensor-based sorting	Securing of a monolayer; monitoring of material distribution
Air classifier	Monitoring of loading at the material inflow
Eddy current separator	Securing of a monolayer; monitoring of material distribution

3.4 Shredder

Apart from the use of volume flow measurement in classifiers and sorters, the use in shredding aggregates is also advantageous. By monitoring the supplying belts, both shredder overloads and underloads can be avoided. This ensures that the shredders are always fed with an optimum amount of shredding material (per time unit).

4 Prospective Outlook

At the moment, essentially two methods are used for estimating volume flows. The first one determines the total volume with the help of the throughput per time unit. The second option is to measure the material mass being processed e.g. with a belt scale and to determine the volume with the help of the average bulk density during a certain time period. Both methods are not suitable for real-time evaluation of volume flows and can only be used for plant controlling under certain conditions.

A continuous volume flow measurement on the other hand offers the possibility of supporting the control of the plant through a direct data transfer between the measuring equipment and the different aggregates. In the case of uneven volume flows, counter measures can be taken, e.g. by adapting the feeding of the material. Other advantages of controlling volume flow through measurement derive from the sorting of material flows for sensor-based sorting machines.

5 Conclusion

Continuous volume flow measurement is based on the principle of laser triangulation and is one of the sensor-based methods. The measuring device consists of standard components – a laser liner, an area camera with a frame rate of about 90 fps, and evaluation software that can be adjusted to the individual needs of the user. The measuring setup is contactless and can be retrofitted in existing plant components. The costs for the measuring setup amount to about €1000.

For the volume flow measurement, several hundred parts of contour data per second are recorded as “contour lines” and are combined into contour images by the evaluation software. This provides information about the volume flow and the distribution of material on the conveyor belt. Even difficult surfaces can be recorded thanks to the dusty waste surroundings. The resolution per voxel is accurate down to cubic millimetres.

Information about the volume flow can be gained at the input and the output points of all typical aggregates in waste processing plants. The possible applications of the data are diverse and include mainly plant monitoring and controlling. This encompasses the estimation of utilisation levels, the avoidance of overloads and the monitoring of layer thicknesses. Information about volume flows can be used in the future for plant controlling.

6 Sources

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