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Short Paper

X-ray Visualization of Powder Flow in a Screw Feeder for Different Shaped Screws

Uchida, K.*[1] and Okamoto, K.*[2]

*1 Research and Development Center, Ricoh Co., Ltd., Shinei-cho16-1, Tsuzuki-ku, Yokohama-shi, Kanagawa, 224-0035, Japan. E-mail: keisuke.uchida@nts.ricoh.co.jp
*2 Department of Environmental Studies School of Frontier Sciences The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan.

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1. Introduction

A screw feeder, which transports powder with rotating spiral screw, is widely utilized in various industrial fields. The design of screw shape is one of the most important issues for the efficiency of transporting and mixing performance (Tsai and Lin, 1994; Yu and Arnold, 1997). However, it is difficult to visualize powder flow inside because the powder is composed of opaque particles. For that reason, the flow structure for different shaped screws has not been studied. The authors have studied powder flow visualization by X-ray penetration and injecting metal tracers (Uchida and Okamoto, 2006). Main points of the study are to confirm that tracers can follow the flow sufficiently and path line visualization method. The flow properties, such as velocity and diffusion coefficient, are also studied quantitatively for the different shaped screws (Uchida and Okamoto, 2007). In this paper, with this method we propose a visualization technique that gives a color path line with progressing time. The previous path line visualization technique cannot include time information in the image. The screw feeder has a number of design parameters. With this visualization results, we can easily evaluate the various flow structures for different shaped screws. By way of illustration, the flows for different shaped screws are visualized with the method.

2. Experimental Setup

We employed glass bead as powder sample and tungsten particles as tracer. They have mean diameter of 0.1 mm. With X-ray penetration observation unit TF4550 manufactured by Toshiba ITC Co. Ltd., the tracer particles injected can be transparently obserbed. Figure 1 is a series of visualiztion results. The screw feeder unit from a vertical view and screw properties are shown in Fig. 2. Four screws are tested in the experiment: single blade screws with different pitch width D (Single A : D = 25 mm, Single B: D = 37.5 mm, Single C: D = 57.5 mm) and a double blade screw (Double) with pitch width D of 12.5 mm (= lead 25 mm). Their rotational speed is equally 0.4 rps.

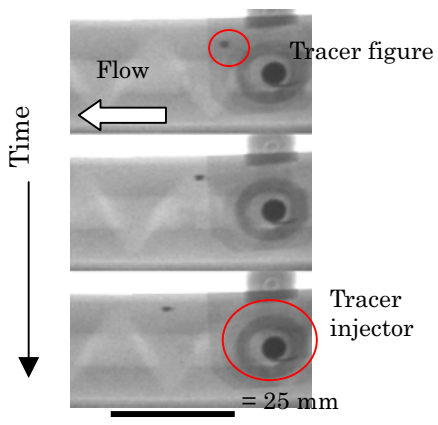

Fig. 1. Time sequential visualization images.

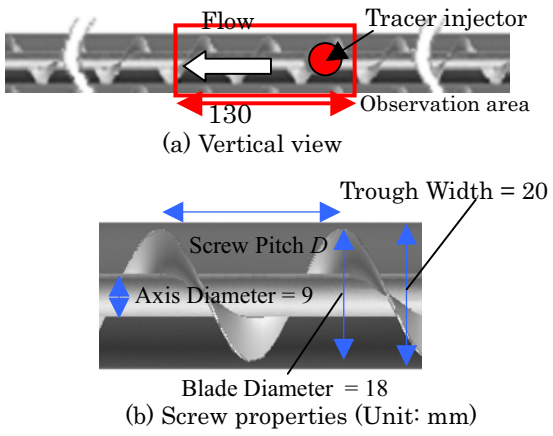

Fig. 2. Screw feeder (a) and screw properties (b).

3. Image Processing Techniques and Results

The color path line of the powder flow is obtained by the following image processing: (i) Eliminating rotating screw figure to obtain tracer figure in the visualization images, (ii) Coloring tracer figure due to the progressing time, (iii) Integrating tracer figure images with time to obtain path line, and (iv) Imposing background image under the path line image. Experimental results yielded good repeatability for each screw. Figure 3 shows the path lines for a Single A screw in extracted three independent experiments.

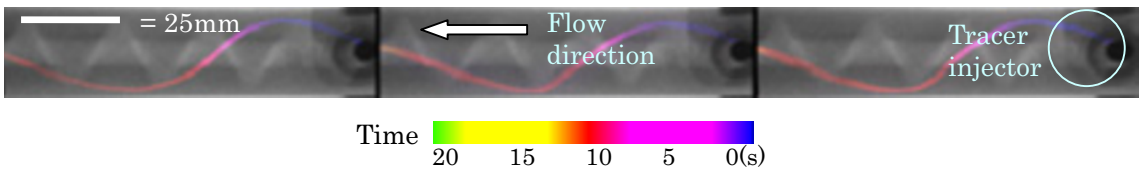

Fig. 3. The color path lines of powder flow with progressing time at Single A screw.

4. Results and Discussions

The color path lines for different shaped screws are shown in Fig. 4. The red circles in the right figure give the point where tracer is injected. The background images behind color path lines in the left figure are the screw images captured when the tracer is injected. With the images, the following flow information can be obtained qualitatively:

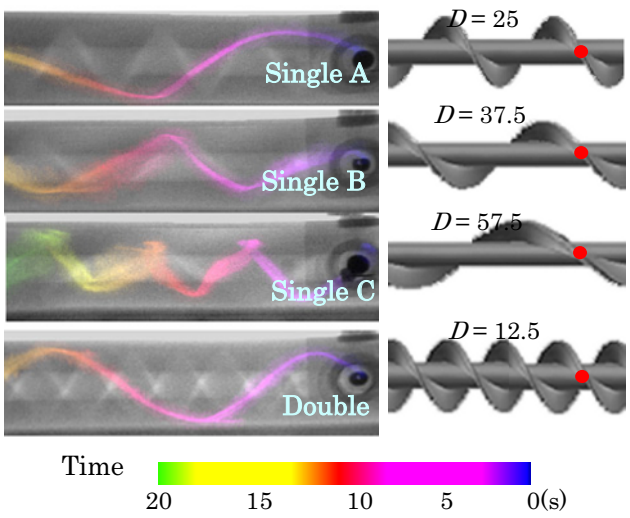

Fig. 4. The color path lines of powder flow.

i) The path line structures show the sinusoidal curve in the visualization image. Practically the path line must be a three-dimensional spiral curve.

ii) Increasing the pitch width D yields a decrease in the wavelength of the path lines at Single A, B and C screws. This probably results from the slip between powder particles and the surface of the screw. This occurs because increasing the pitch width decreases the angle between the powder transmission direction and the slope of the screw surface wall.

iii) The path line for the Single B and C screws make a sharp angle at each peak. This is in contrast with the path line for the Double screw, which has smooth peaks. This is probably caused when the screw blade passes the tracer.

iv) A Double screw gives higher transmitting velocity than a Single A screw with the same pitch width D. For the Double screw, the average distance between each powder particle and the screw blade wall parallel to the transmitted direction is half that of the Single A screw. Therefore, a more direct force is acted on each powder particle due to the screw blade.

5. Conclusion

A color visualization of powder flow path line with an x-ray image processing is proposed. We confirm that the results show good repeatability. Flow structures for different shaped screws are visualized and evaluated, showing the effectiveness of the method.

References

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