Tracing Granular Products Using RFID

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Introduction

Traceability is important for quality control and process improvements, but it is often difficult to track or trace products in continuous process production, since products and product lots are difficult to separate. In the past, engineers have had to rely on coarse calculations for tracing products, but new possibilities emerge as new technology and models are being used. Radio frequency identification (RFID) have been suggested to be used for tracing granular material flows [2-4], where a fraction of the granules are marked with RFID transponders. In this paper, we present experiences from applying RFID tracers to achieve traceability the iron ore pellets distribution chain.

The case, LKAB's Kiruna — Narvik distribution chain of pellets

LKAB's distribution chain of iron ore pellets include two longer transports by boat and train, three large intermediate storages, and many conveyor transports in-between. The process contains a mixture of continuous and batch flows, and is thus semi-continuous. At the plant, the inflow of pellets to the first silos is continuous, but after that, flows are batch-wise. However, the batch sizes vary depending on arrival or departures of trains and boats. Traceability is further complicated by the design of some process steps, where the flow includes mixing and steps with intermittent flow which induce residence time variation.

RFID Equipment: Transponders

To model the behaviour of a granular product, a transponder needs to be shaped and have properties closely matching the product it is intended to trace, in this case a pellets, to avoid risking segregation. The sizes and densities, shapes and other properties of the granular media thus limit the RFID transponder types that are useful for the specific application. However, earlier experiments had shown that only few of the transponders small enough to fit within casings the size of a pellet (Ø 15 mm) was detected by the readers, whereas larger transponders were detected more easily. Unfortunately, size is a determinant for particle segregation. Also particle density may influence segregation, and an experiment was set up to test if density could be used to compensate the more easily detected transponders' larger sizes.

The tested transponders are seen in Figure 1. The control treatment Type A has similar size, shape, density, and surface structure as a regular pellet, and it is used to emulate the pellet's flow behaviour. The pellets are normally spherical, and the density of a pellet is approximately 4.3 g/cm3. Type A contains a 12 mm passive transponder with a 14 mm casing and a density of 4.3 g/cm3. The other two types, B and C, both contain a 22 mm long transponder and their casings are larger than a pellet, with a spherical 24 mm casing. Earlier experiments had showed that lighter, larger pellet transponders also had a larger residence time. In this case, the densities for larger transponders are therefore equal (Type B) or higher (Type C, 6.1 g/cm^3) than the regular pellets

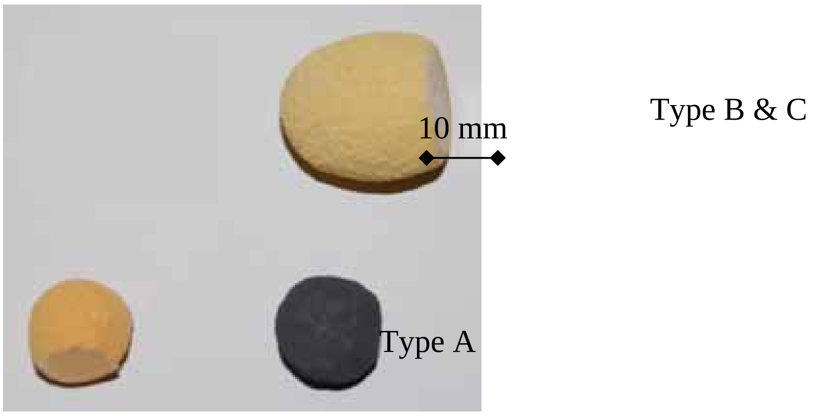

Figure 1. *The two transponder casing types and a pellet.*

RFID Equipment: Antennas

As the readability for a given system is improved if the reading ranges are small, the readers should be mounted closely to where the transponders will enter the reading field. The antennas have been placed at conveyors, which means that the sizes of the antennas are governed by conveyor belt dimensions and that reading distances are large. The angle between the reader and transponder antennas also influences the reading range, but note that the transponders may lie in any direction and that this angle cannot be controlled. Two different orientations of the reader antennas are therefore used to increase the probability of detection of the transponder pellets, see Figure 2.

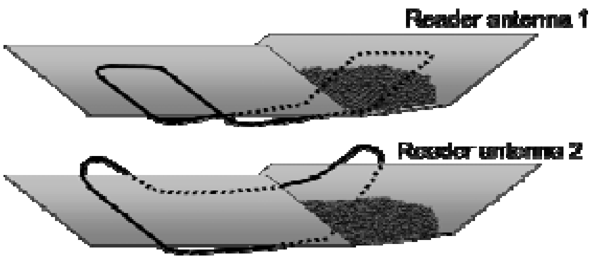

Figure 2. *The two reader-antenna shapes. The antenna of reader 1 is mounted under the conveyor and the antenna of reader 2 is mounted around it.*

Experimental Results

The two transponder types B and C behaved similarly within the experiment and are only discussed as the large transponder types. Comparing the residence times for the transponder sizes in Figure 3, we see that they are grouped into five distinctive groups, or blocks, related to five occasions when transponders were inserted. The mean difference between the blocks is due to differences in silo levels and train loading schemes. More important is that we cannot spot any regularly appearing differences between the behaviour of small and large transponders and an ANOVA test did not suggest a statistical difference between the means when the block effect was subtracted.

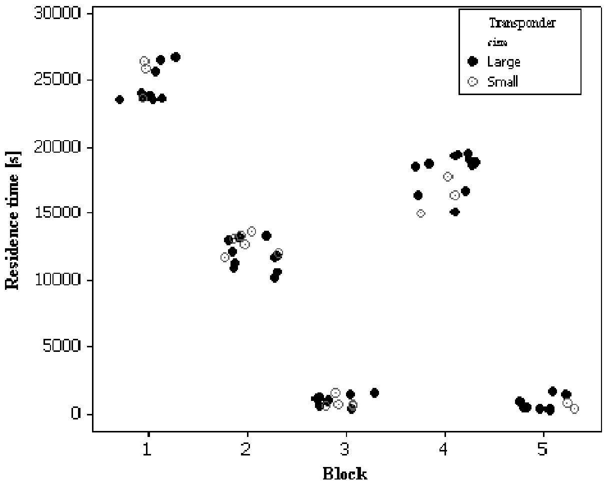

Figure 3. *Transponder residence times for the experiment. The difference in mean residence time depends on intermittent loading of trains.*

Discussion and Conclusions

We did not find evidence that the larger transponders encapsulated in a casing with similar or higher density had different residence times, and thus segregated during these experiments. These larger transponders were therefore better suited for use as product batch delimiters since their read rate was significantly higher than that of the small transponders. However, the RFID results in this paper are based on a relatively few transponder trials, and the whole transportation process was not included in the experiment. These results are to be validated by additional experiments that cover a longer part of the distribution chain.

It is more difficult to create traceability in continuous processes, and traceability changes to a statistical property rather than a deterministic one. Here we have shown how RFID may be used to improve the ability to track and trace products in continuous and semi-continuous granular product flows, which ultimately will improve quality control, product quality and reduce waste.

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