

Effect of batch size on carry-over rates

1. Focus

This datasheet aims to assess how variations in the size of collector batches impact on carry-over rates (TIL). This variation is assessed against the variation generated by the repeatability of the tests carried out at a given industrial site.

2. Principle

Five carry-over study trials, comprising 2 tracer batches at the mixer's nominal size and at least 2 collector batches of variable size, were carried out at the same industrial site according to the following plan:

- 3 tests with 2 collector batches at nominal mixer size (6t – coded TG1 to TG3) used to study test variability
- 1 test with 2 collector batches at 2/3 of the nominal size (4t – coded TM)
- 1 test with 3 collector batches at 1/3 of the nominal size (2t – coded TP)

All the batches were sampled at the entrance to the silo bin upstream of the press.

3. Equipment and apparatus

3.1. Plant

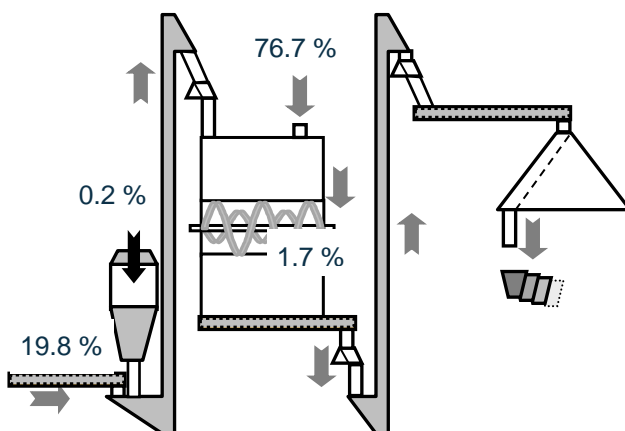


Figure 1: Plant schema (with the percentage of feed formulation incorporated at each station)

The schema for the portion diagram at the tested plant (Figure 1) also lists the percentage of ingredients incorporated in the feed formulation

selected at each station.

The 1.6% missing from the formula at the time of sampling corresponds to liquids added to the coater after pelleting, which are not factored in when calculating the recovery rate.

3.2. Tracer

The external tracer (Superfine Blue Lake microtracer) was incorporated into the end feedstuff at a dosage of 250 ppm via a premix in Rofelys injected at a rate of 2 kg/t in a bag emptier.

3.3. Feedstuff

The tests focused on 6-ton tracer batches and collector batches of 6, 4 and 2 tons. A Turkey feed was chosen according to the total quantity to be produced (110 tons). The physical characteristics of these batches demonstrate their similarities:

- Median sifting diameter: 950.7 μm (CV = 4.1%)
- Bulk density: 631.7 g/l (CV = 0.4%)
- Angle of repose (flow): 69.0 ° (CV = 2.1%)

4. Method

4.1. Batch sequencing

The tests were carried out over two successive days in the following order: TG1, TP, TG2, TM, TG3. Other feedstuff batches were manufactured between the tests.

4.2. Sampling method and location

The samples were taken at the entrance to the silo bin upstream of the press. The aim was to collect 30 samples from each batch.

Sampling periods were assessed by measuring the throughput time for similar batches prior to beginning the tests: 340 seconds for 6 tons, i.e. a flow rate of 17.6 kg/s. The periods varied according to batch size: from 3.5 to 11 seconds.

4.3. Processing the samples

The sample processing method conformed to the technical rules by grouping aliquots of each initial sample.

4.4. Analyses

In accordance with the method described in i'Tec_H17, sample analyses were duplicated on two test portions taken from the samples.

5. Results

5.1. Conformity

The tracer concentrations identified in the 10 tracer batches were below the expected concentrations. There was a systematic increase in the rate between the first and second tracer batch (average of +7.4%). Unfortunately, these recovery rates were practically all below the 70% threshold specified in the technical rules.

Tests	Batche	Recovery rates (%)	Variation
TG1	T1	62.7	+ 2.9%
	T2	64.6	
TG2	T1	60.2	+ 5.5%
	T2	63.2	
TG3	T1	59.8	+ 15.7%
	T2	69.2	
TM	T1	65.8	+ 4.0%
	T2	68.6	
TP	T1	65.8	+ 9.2%
	T2	71.7	
Mean	T1	62.9	+ 7.4%
	T2	67.5	

Table 1: Recovery rates for the 10 tracer batches

Several theories have been suggested to explain this microtracer deficit, whether real or apparent, although none have so far been considered satisfactory:

- A weighing error when preparing the premixes
- A systematic analysis error, during extraction for instance, i.e. regarding the correspondence between microtracer weight (smaller particles than usual) and the recorded optical density
- Effective loss of tracer in the facility, especially in the elevator upstream of the mixer
- A loss of colorant in the plant
- Effect of the very fine-grained microtracer batch
- A particular industrial practice

5.2. Test repeatability

The repetition of carry-over assessment tests on large feedstuff batches gave the following values:

- collector batch 1, between 7.1 and 8.1%
- collector batch 2, between 3.1 and 4.1%

The carry-over rate in the first collector batch was similar to the mean increase recorded between the two tracer batches (Table 1).

Over the 3 tests, the variation (Figure 2) in carry-over in reference to TG1 for one batch systematically resulted in an inverse variation in the second batch. As such, after throughput, the two collector batches picked up very similar levels of tracer: between 108.3 and 111.2 g depending on the test.

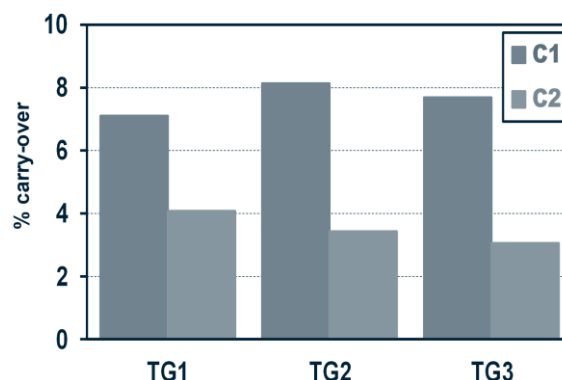


Figure 2: Bar chart giving TIL percentages for collector batches according to the various TG tests

This percentage reflects the satisfactory level of repeatability of these tests. Repeatability quality is also reflected in the coefficients of variation calculated solely on these 3 results (Table 2). Generally speaking, test repeatability at this site was considered acceptable (approx. 7%) with respect to all the elements that could generate variations. Repeatability deteriorated in the second collector batches (CV = 14.6%), probably due to larger analysis errors in relation to low tracer concentrations.

		[ppm]	% carry-over
Collect or batch 1	Mean	12.7	7.6
	Standard deviation	1.0	0.5
	CV	7.5	6.7
Collect or batch 2	Mean	5.8	3.5
	Standard deviation	0.7	0.5
	CV	12.3	14.6

Table 2: Means, standard deviations and coefficients of variation for concentrations and percentages of TIL in the two collector batches in the three, repeated TG tests

5.3. Effect of batch size

5.3.1. Carry-over profiles

Changes in carry-over rates determined by analysing aggregate samples were fairly similar (Figure 3 to Figure 5); despite the presence of a downstream peak at the start of the test, carry-over could generally be explained by the circuit upstream of the mixer. This downstream peak was larger for the second batch in the 2-ton test (TP), with the mean rate increasing between the second and third batch in this same test.

There was little perceptible change in carry-over rates between the 6-t test (TG) and the 4-t test (TM). It would appear that the concentration increased at batch end in the TM and TP tests.

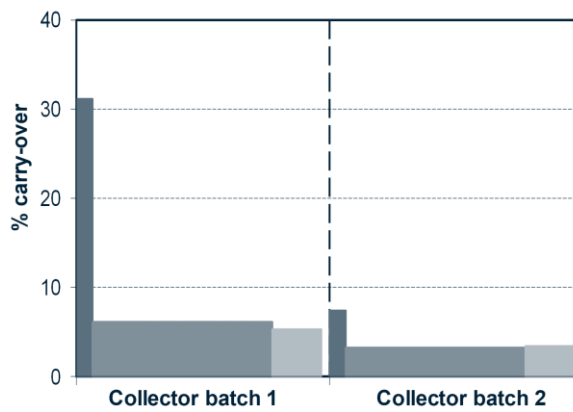


Figure 3: Change in mean carry-over in the 2 collector batches for the TG tests

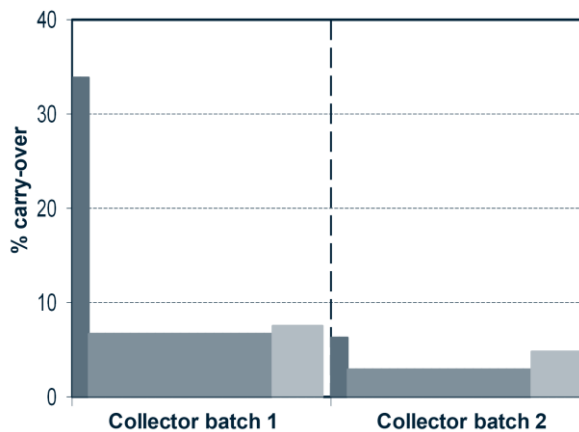


Figure 4: Change in carry-over in the 2 collector batches for the TM test

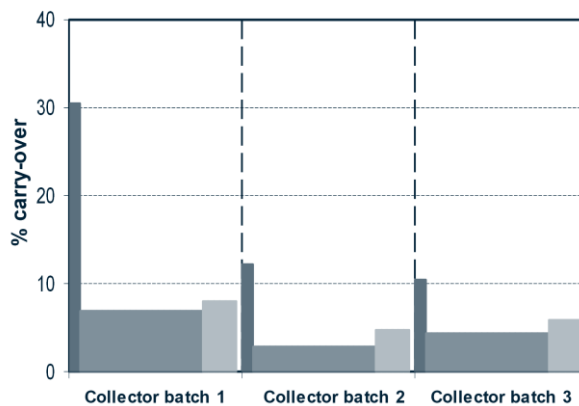


Figure 5: Change in carry-over in the 3 collector batches for the TP test

5.3.2. Overall carry-over rate

The locations used to incorporate raw materials (Figure 1) throughput approx. 20% of the formula used to flush additives arriving from the bag emptying station at the base of the elevator.

Reducing the batch size from 6 to 2 tons therefore reduces the amount of flushing at the base of the elevator from 1.2 tons to 0.4 tons.

If these 400 kg are not sufficient to effectively flush the elevator upstream of the mixer, carry-over would be expected to continue until a sufficient quantity of raw materials had passed into the elevator to allow any residual additives to be flushed out. This should

result in a decrease in the concentration of the collector batches.

Conversely, if batch size decreases and the same quantity of tracer is recovered, the concentration should increase. The issue here is finding out which of the two phenomena are likely to prevail.

Ultimately, reducing batch size by a 1/3, and then 2/3 resulted in a very slight increase (12.7, 15.0 and 15.7 ppm from TG to TP) in the mean concentration of the first collector batches. To that extent, neither of the two phenomena took precedence over the other.

The largest increase was recorded during the switch from 6 to 4 tons (Figure 6) with an increase of 1%. The switch from 4 to 2 tons had no effect on carry-over rates in the first collector batch (8.6% in both cases).

Concerning the change in carry-over in the second collector batches, switching from 6 to 4 tons did not generate any significant variation in % carry-over. The only change observed was when switching from 4 to 2 tons, which resulted in a slight non-significant increase (3.5% to 3.8%). The end result of this slight, but steady, increase of carry-over in the second collector batches, alongside decreasing batch size, was reflected in higher carry-over rates in the third collector batch for the 2-ton test.

It is as if the decrease in the size of the collector batches resulted in an increase in continuous carry-over in a greater number of batches rather than a significant increase in the carry-over rate in the collector batches. This behaviour will have to be verified with other batch sizes.

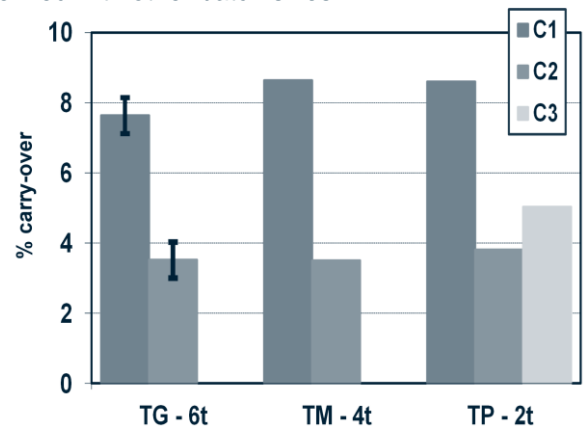


Figure 6: Bar chart showing the measured concentration percentages in the collector batches in relation to the various tests carried out according to the size of the collector batches (the vertical bars on the TG test blocks show the variation of the standard deviation around the mean)

Throughput of the various collector batches generated a certain recovery capacity calculated as a tracer weight based on a batch's size and mean concentration. The total quantity of tracer recovered increased steadily as the weight of tracer passing through the circuit increased (Figure 7). The throughput of a large batch therefore always gives a higher yield than a throughput of the same quantity split into a number of batches. This could suggest that the collection capability increases with

increasing batch size, and that this phenomenon is stronger than dilution.

Lastly, at this plant, the increase in the total quantity of recovered tracer generally followed a fairly good straight line relationship, with approx. 37 g of tracer recovered with batch throughputs of at least 2 tons, plus the increase in the quantity of the collector batch which is 7.6 g per ton of collector batch produced. Dividing the batches up therefore plays a smaller role than the total weight of the collector feedstuff that was produced.

It is important to note though, that the quantity of tracer recovered per ton tends to decrease slightly as batch size increases (Figure 8). This result could possibly be explained by a lower tracer concentration in hyperstructures affected by larger batches and, also, by the greater dilution capability of the recovered tracer.

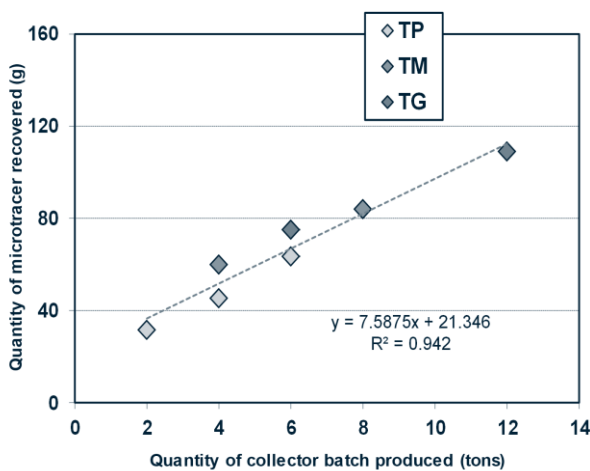


Figure 7: Total quantities of tracer recovered by the various cumulated masses formed from successive collector batches

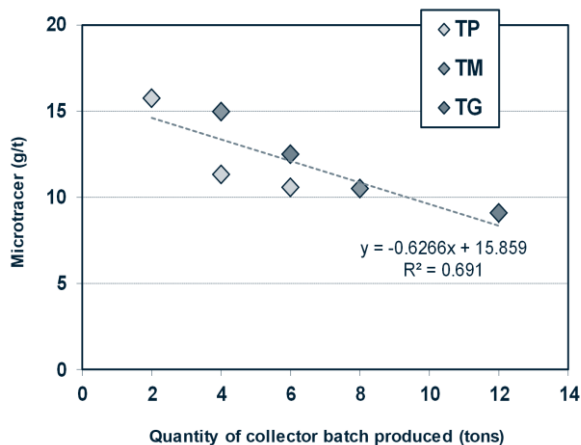


Figure 8: Quantities of tracer recovered per ton of collector batch

6. Conclusion

Despite the low recovery rates recorded during this test series, there were still some conclusive findings.

Firstly, repeatability in terms of measurements or profiles was acceptable, thus demonstrating the reliability and validity of this measurement.

Secondly, size variations in collector batches tend to decrease collection performance, slightly increase tracer concentration, and generate an apparent continuation of carry-over over a greater number of batches.

The quantities recovered in the circuit upstream of the mixer can be estimated by calculating the quantities of premix that correspond to the core samples of each collector batch. If the weighing hopper had provided effective recovery (the opposite case will be demonstrated below), irrespective of batch size, it would have been reasonable to expect residual deposits to be recovered from the elevator in similar quantities during each test, and that the smaller batches should have the highest carry-over rates. This calculation gave the quantity of premix recovered by the three small collector batches (based solely on samples b from these batches) as 4.1 kg, while the quantities recovered by the 2 large batches were 7.0 and 7.7 kg respectively. Lastly, the 2 intermediate size batches recovered 5.3 kg.

These results reveal that the variation in batch size appears to generate differences in recovery capability, even in the circuit used to incorporate additives.

In terms of production management, while throughputting a small batch may help to remove a certain amount of active product carry-over (flushing principle), thereby partially reducing the concentration in the next, normal-sized batch, it is not, however, as effective as throughputting a normal sized batch. It is impossible to calculate an accurate mass balance due to this issue with recovery rates; it would be useful to speculate on the eventual carry-over rate in a nominal-size batch that passes through the system after a minimum-size batch (33%). Based on the assumption, in all likelihood incorrect, that a nominal-size batch (6 tons) would recover all the tracer collected by the last two collector batches for test TP (2 tons), the latter should then contain 5.3 ppm, i.e. 2.9% of the concentration of the last tracer batch (Test TP). The continued carry-over observed during this test suggests that the results could even be higher than this.