SPIRAL SURFACE PROPERTY INVESTIGATION

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ABSTRACT

This paper examines the change in surface properties of the Polyurea used on spirals at different operational times: unused spiral, 28 months in operation and 58 months in operation. This is being done to investigate the alleged statement that spirals have a decrease in spiral separation efficiency after a certain period of operational time. Observing the surface characteristics under 1.5x and 36x magnification it can be concluded that the surface roughness decreases with increased operational time. This may be explained by a decrease in air inclusions and streak lines as the spiral surface wears. Decreased surface roughness should in theory have a beneficial effect on spiral separation performance. This leads to the conclusion that if a decrease in spiral separation performance is observed after a certain period of operation, it can't be attributed to the change in surface properties. Uneven wear of the spiral surface, material creep or application of force to the spiral will change the profile of the spiral and could cause an adverse effect on spiral separation performance. The metallurgical test work showed that the best results are obtained at 30 - 35% solids by mass in the spiral feed. The iron recovery was significantly higher in the new spiral in comparison to the 2012 and 2010 spirals. The mass yield to concentrate in the new spiral was approximately three times more than for the older spirals. In conclusion, the yield combined with the grade, which equals the recovery was the best for the new spiral.

KEYWORDS

Surface properties, spirals, efficiency, wear, grade, recovery, solid concentration

INTRODUCTION

An investigation was launched to research the common belief that spirals experience a decrease in efficiency, and therefore recovery, after a certain period of operation (a period of seven years has been used in the industry). The properties of the spiral that may have an effect on the efficiency are:

- A change in the surface roughness of the Polyurea
- A change in the profile or pitch angle of the trough

This investigation will look at the change in surface properties of the Polyurea at different operation times.

Two spirals of different age were received from site. The first spiral is dated March 2010 and the second spiral September 2012. Photos were taken at 36x and 1.5x magnification of the surfaces of these spirals and compared to a new spiral. The spirals (Mar 2010 & Sept 2012) as well as a new spiral were subjected to metallurgical test work to determine the drop in recovery over time. Iron ore was used for the test work at solids concentrations of 30, 35 & 40% by mass.

EXPERIMENTAL

Sample Preparation

Approximately 1000kg of the iron ore sample was made available for the test work. The material was transferred to a tarpaulin and blended. A heap was created and clean buckets were then aligned around the heap in the form of a circle. The sample was then transferred into all the buckets with a shovel, at the time simulating a rotary splitter. This procedure was repeated until all the material was transferred into the buckets. The method used was such that each bucket contained a representative sample. A sub sample of the feed was also taken and a Particle Size Distribution (PSD) determined. The specific gravity (SG) of the sample was measured using a pycnometer and was found to be 3.71 t/m^3.

Spiral Concentrators

The test work was conducted on the Multotec SC21/3 spiral fitted with a mouth organ product box as shown in Figure 1.

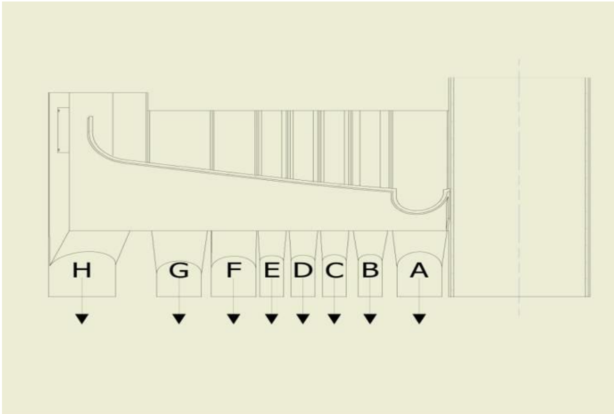


Figure 1 - Mouth organ configuration

Mouth organ fraction A represents the sample collected from the inside of the trough. It is the heaviest sample and should contain the most iron.

Slurries of different % solids by mass were fed to the spiral feed box via a distributor with an overflow to ensure constant feed conditions during the test. Figure 2 shows the setup.

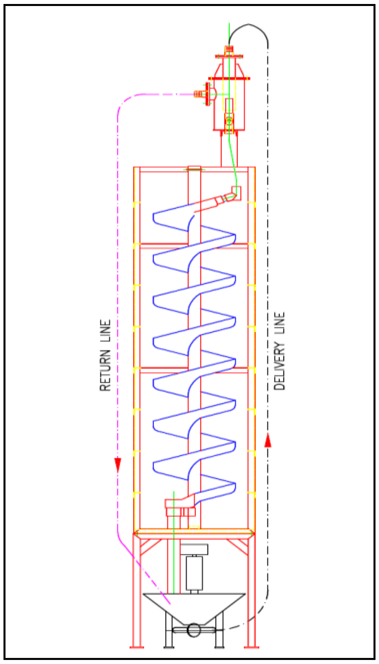
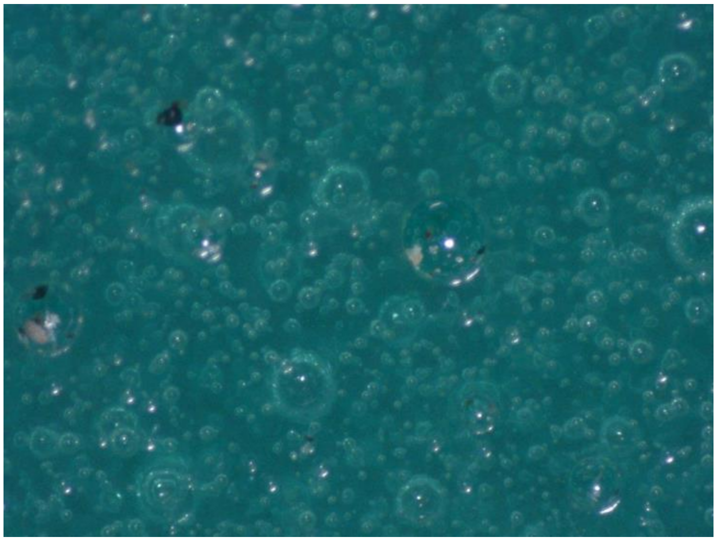


Figure 2 - Spiral test rig setup

RESULTS

Microscope Study

The photos shown Figure 3 below was taken at the bottom of the respective new spiral, September 2012 and March 2010 spirals. A 36x magnification was used.



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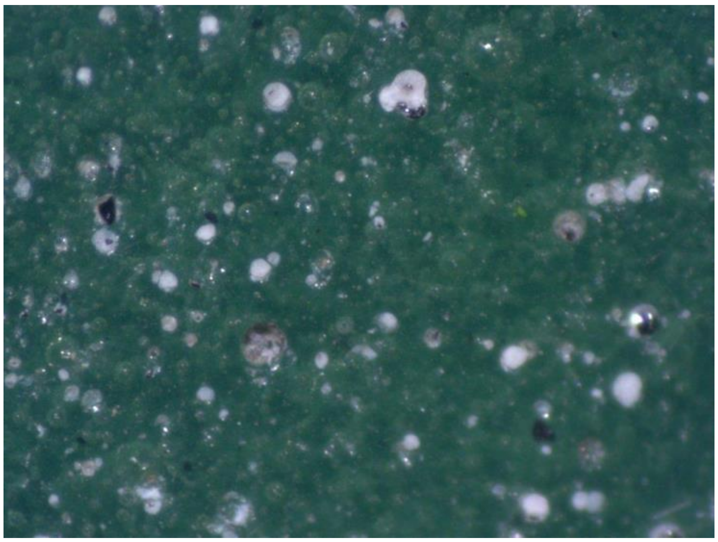

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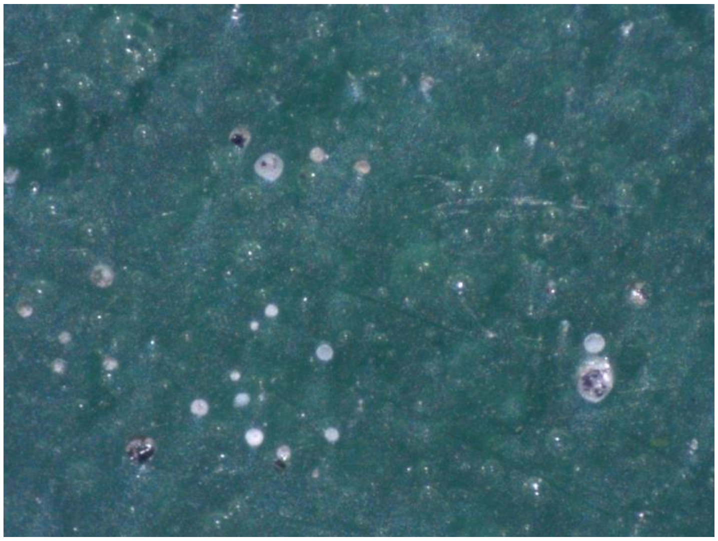

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Figure 3 - Bottom of spirals 36 x (1 - new spiral; 2 - September 2012; 3 - March 2010)

Spiral Profile Comparison

The profile was evaluated by using a 3D scanner to take scans of the three different spiral surfaces. After completing the scanning, the polygonal models were aligned by using the centre column as a reference for alignment. A cross section of the spiral surface scans was taken through the aligned images. As seen in Figure 4, the pitch angle of the 2012 spiral is significantly lower compared to the 2010 spiral or the new spiral.

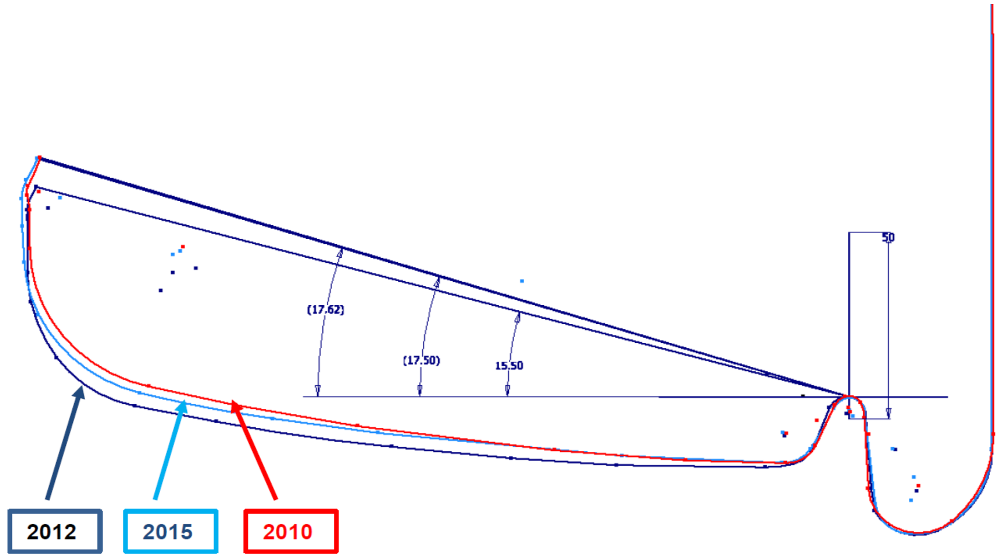

Figure 4 - Cross section

Surface Roughness Measurements

Surface roughness measurements were done on the three spirals. Surface roughness is a component of surface texture. Surface roughness is a measure of the finely spaced surface irregularities. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. The most common method used to measure surface finish is to use a diamond stylus profilometer. The stylus is run perpendicular to the lay of the surface. The probe usually traces along a straight line on a flat surface. Figure 5 shows the surface roughness profile of the new spiral. The profile roughness parameter (Ra) value was 2.4340µm. The Ra value was 3.5401µm for the September 2012 spiral and 2.2483µm for the March 2010 spiral.

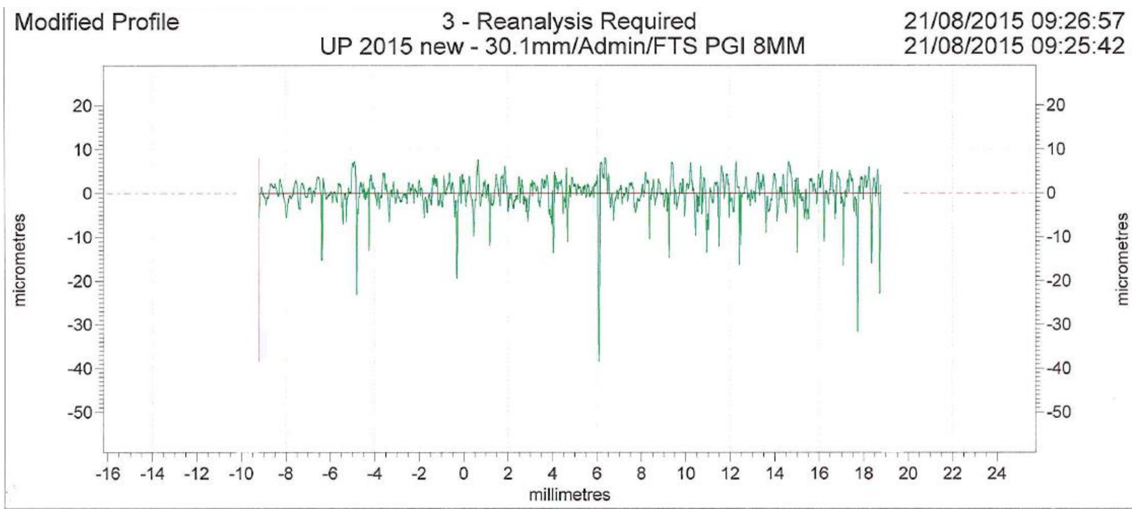

Figure 5 – Surface roughness of the new spiral

Spiral Test Work Results

The results are summarised as two relationship lines:

- Grade vs. Yield: This relationship gives the concentrate grade when a certain percentage of the feed mass on a spiral stage reports to the concentrate. For this application an ideal relationship is a high mass yield percentage containing a low percentage of slag.
- Recovery vs. Yield: The relationship illustrates the cumulative recoveries of the materials for each stage at the respective cumulative mass yield. This relationship gives an indication of the amount of material that is recovered at a certain mass yield to concentrate. A relationship above the 1:1 Ratio Curve indicates that a recovery of that material has occurred and a relationship below the curve indicate rejection of that particular material. The further the relationships are away from this curve the more efficiently the material can be separated on the spiral.

Table 1- Results at 35% solids by mass

Variable	New	2012	2010
Feed grade (%Fe)	40.5	40.4	40.5
$\%SiO_2$ in feed	31.7	31.7	31.7
Concentrate (A+B+C)	56.3	55.5	57.4
%Fe recovery (A+B+C)	15.6	2.7	6.3
$\%SiO_2$ in concentrate	14.1	11.8	12.0
Mass yield (%)	11.2	2.0	4.4
Middlings (D-E) grade	51.0	51.2	48.5
%Fe recovery (D-E)	29.3	23.5	21.4
$\%SiO_2$ in middlings	19.7	17.4	22.2
Tailings (F+G+H) grade	24.8	35.0	34.5
%Si recovery (F+G+H)	41.0	55.1	46.8
$\%SiO_2$ in tailings	49.4	38.9	38.8

Figure 6 below illustrates the cumulative grade/yield relationship for all the spirals at 35% solids concentration.

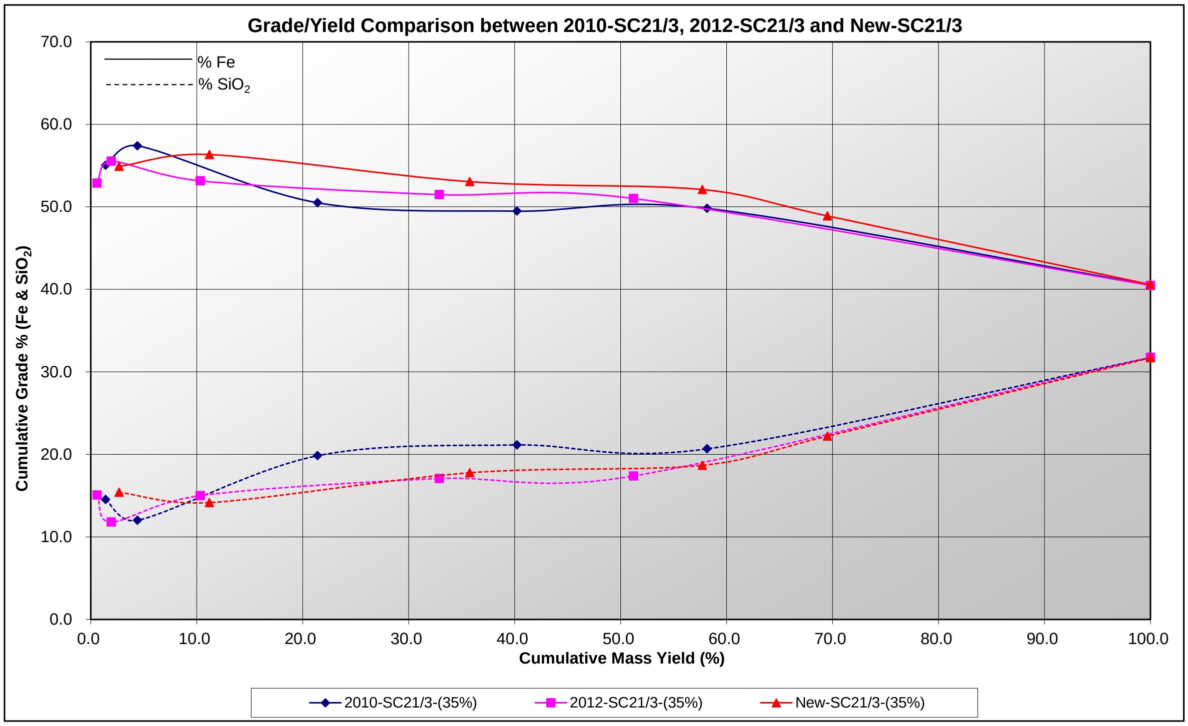

Figure 6 - Grade/yield relationship for all the spirals at 35% solids

Figure 7 indicates the recovery/yield relationship for all the spirals at 35% solids.

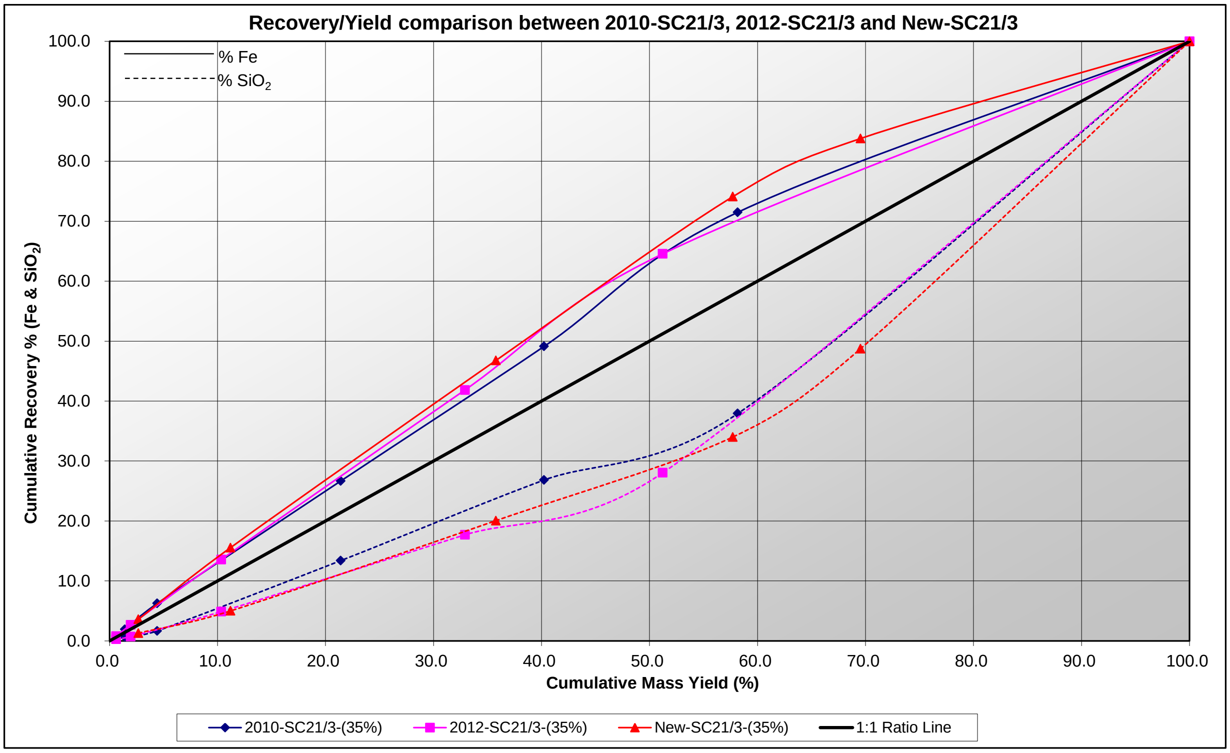

Figure 7 - Recovery/yield relationship for all the spirals at 35% solids

CONCLUSION

Looking at the surface characteristics under 1.5x and 36x magnification it can be concluded that the surface roughness decreases with increased operational time. This may be explained by a decrease in air inclusions and streak lines as the spiral surface wears.

Decreased surface roughness should in theory have a beneficial effect on spiral separation performance. This leads to the conclusion that if a decrease in spiral separation performance is observed after a certain period of operation, it can't be attributed to the change in surface properties. Uneven wear of the spiral surface, material creep or application of force to the spiral will change the profile of the spiral and could cause a negative effect on spiral separation performance.

It should however be noted that these conclusions are solely based on the observations obtained by interpretation of the spiral surface at different stages of operational time.

The metallurgical test work showed that the best results are obtained at 30-35% solids by mass in the spiral feed. The iron recovery was significantly higher in the new spiral in comparison to the 2012 and 2010 spirals. The mass yield to concentrate in the new spiral was approximately three times more than for the older spirals. In conclusion, the yield combined with the grade, which equals the recovery was the best for the new spiral.

There is not a clear understanding or obvious reason why the performance of the 2012 spiral was so poor. The 2010 spiral performed better than the 2012 unit.

It is suggested to repeat the study with chromite material. The study should include a spiral which had been in operation for up to 7 years.

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