Evaluation Of The Kelsey Centrifugal Jig At Rio Kemptville Tin

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ABSTRACT

The Kelsey Centrifugal Jig is a gravity separation device which utilizes the principles of the conventional mineral jigs but with the additional feature of being able to vary the apparent gravitational field. This is accomplished by utilizing the specific induced movements of the conventional jig within a centrifuge.

Pilot plant trials have been underway since July 1988 to evaluate the potential applicability of this technology to various process streams at Rio Kemptville Tin.

The grade/recovery relationships for samples treated in the jig were consistently better than results obtained from tables. Recoveries of more than 90% were attained at concentrating factors ranging up to 20. When compared with electrostatic separators, the jig achieved equivalent metallurgical results in a two stage process, without the expensive requirement of filtration and drying. Recoveries exceeding 96% were achieved with final concentrate grades averaging higher than 60% tin.

INTRODUCTION

Mineral jigs have been used for hundreds of years. Many different types have been developed, and each one has numerous variations. In recent years, the idea of applying centrifugal forces to conventional jigs has been put to practical tests and today a number of units are in commercial production. In principle, by enhancing the apparent gravitational field, it should be possible to recover finer particles by overcoming viscosity and surface effects which tend to limit existing gravity devices. In addition, it may be possible to use gravity to separate minerals with much smaller specific gravity differences.

The Kelsey Centrifugal Jig is a gravity separation device utilizing the principles of conventional mineral jigs with the additional feature of being able to vary the apparent gravitational field. This is accomplished by utilizing the motions of a conventional jig within a centrifuge.

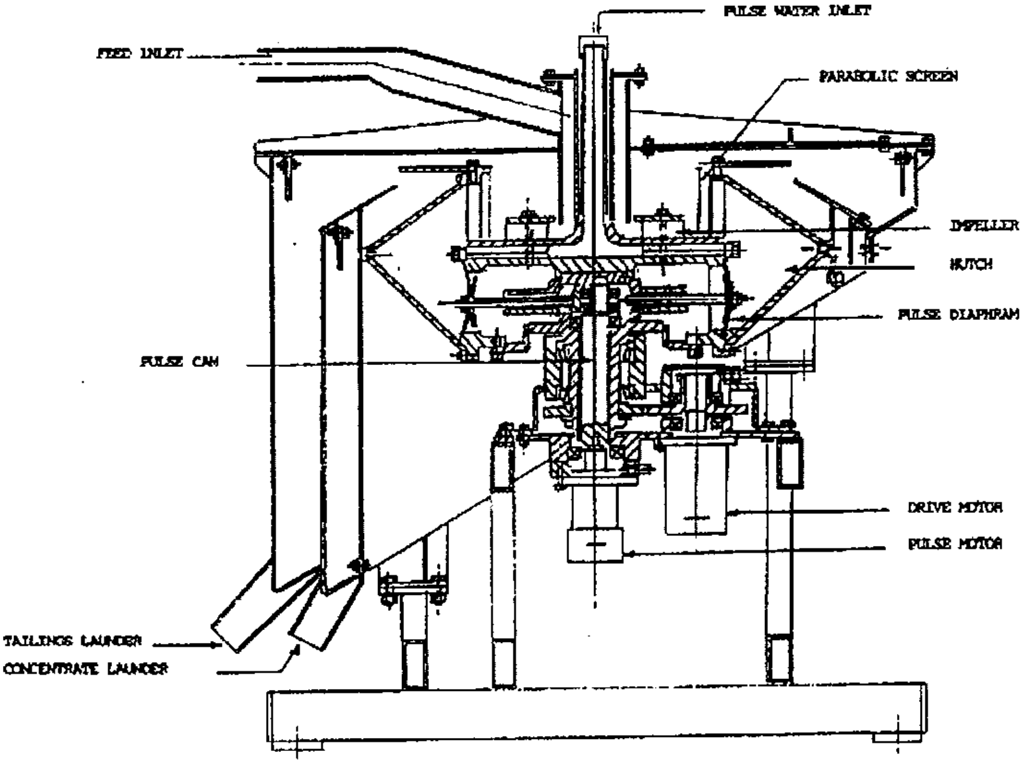
Pilot plant trials using a five ton per hour unit (nominal rated capacity) were conducted at Rio Kemptville during the period from July 1988 until February 1989 to evaluate if this technology could be successfully applied to existing gravity process streams. Tests were conducted to establish the optimum operating conditions with regards to concentrate grade and recovery. The Centrifugal Jig was also evaluated for metallurgical stability and mechanical reliability by continuous operation over means of continuous 24 hour operation.

In order to establish the optimum operating conditions the following operating variables were tested:

a) Centrifugal Force
b) Pulse Rate
c) Stroke Length
d) Ragging Type
e) Ragging Size
f) Ragging S.G.

JIG DESIGN

The Kelsey Centrifugal Jig design is based on conventional jig operating within a centrifuge. The design, shown in Fig.1, consists of a rotating bowl surrounded by a concentrate and tailings launder assembly. The bowl contains an impeller to distribute the feed, a parabolic wedge wire screen to retain the ragging, and concentrate hutches to capture and discharge the concentrate. on a conventional jig the retention screen and ragging are on a horizontal plane, where as in a centrifugal jig the screen and ragging are vertical. Pulsing is provided by means of a series of diaphrams which operate sequentially as the jig rotates.



Feed slurry enters the bowl from the top through a central feed pipe. Centrifugal forces imparted by the bowl rotation, force the slurry through the radial impeller and distribute it onto the surface of the ragging. Pulse water is fed through a separate central feed pipe into the concentrate hutches located behind the retention screen. High frequency pulsations imparted by the diaphragm create an inward water pulse which causes the ragging layer to dilate and contract at the same frequency. This in turn, results in differential acceleration of the feed and ragging particles according to their specific gravity. Particles then settle under centrifugal force causing the heavy particles to separate from the lighter particles. Particles of higher specific gravity move through the ragging and retention screen into the hutches where they are discharged through spigots into the concentrate launder. Particles with specific gravities less than the ragging are displaced from the surface of the ragging layer by incoming feed.

SUMMARY OF RESULTS

During the course of this study, nearly two hundred tests on numerous process streams were conducted. For purposes of this discussion, results for tests on the Electrostatic Separator Circuit feed stream will be reviewed.

The Electrostatic Separator Circuit feed is made up of three main minerals: Silica - specific gravity of 2.7; Topaz - specific gravity of 3.6; and Cassiterite - with a specific gravity of 7.0. The feed size distribution is fairly narrow with the bulk of the mass falling between the sizes of 75 microns and 200 microns. The majority of tin however, tends to be in the finer size fractions.

Major variables affecting the performance of the Jig are:

1. Ragging Material (specific gravity and size distribution)
2. Jig Rotational Speed (centrifugal force)
3. Pulse Action (rate and amplitude)
4. Pulse Water

RAGGING MATERIAL

Ragging material must be selected to suit the nature of the feed in terms of specific gravity and size distribution. The specific gravity must be between that of the waste and the particles being recovered. Experience has shown that ragging with a specific gravity close to that of waste particles gives optimum recoveries. In operation, the passage of heavy minerals through the ragging increases the dynamic specific gravity of the ragging and enhances its performance.

The size distribution of the ragging must be suitable for the material being processed. If the ragging is too coarse poor concentrate grades will result. If the ragging is too fine passage. of concentrate will be restricted and poor recoveries will result.

Early tests were conducted using haematite ragging with a specific gravity of 5.1. The jig was operated at 23g at 1300 pulses per minute. These conditions resulted in very high concentrate grades of about 70% Sn. Recoveries were somewhat lower than expected ranging from 85% to 90%. In an effort to improve the recovery, the haematite ragging was replaced with bauxite proppants with a specific gravity of approximately 3.6. The ragging specific gravity was nearly the same as that of the topaz and low concentrate grades were expected. Fig. 2 demonstrates that the bauxite ragging produced more favourable results than haematite ragging.

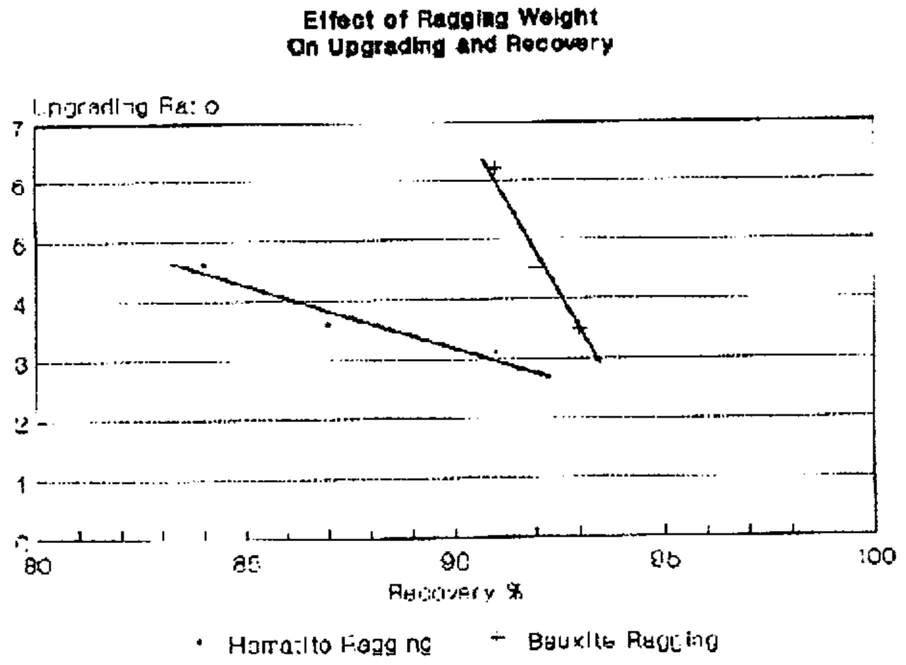


Figure - 2

At an upgrading ratio (concentrate grade divided by the feed grade) of 3.5, the bauxite ragging produced 93% recovery as compared to 89% recovery for the haematite ragging. At 91% recovery level the haematite produced an upgrading ratio of 3.1 where as the bauxite produced an upgrading ratio of 6.2.

CENTRIFUGAL FORCE

To improve the recovery of the finer particles, greater centrifugal forces are required. Jig rotational speeds ranging from 200 rpm to 800 rpm were used throughout the course of the investigations. At these speeds the apparent gravitational force ranged from 20 to 160 times the normal gravitational force.

Recovery increased initially with increasing gravitational force but dropped off at higher levels, indicating compaction of the ragging bed. At sufficiently high rotational speeds passage of concentrate through the ragging stopped. The force required to compact the ragging and stop the flow of concentrate is a function of both ragging weight and the stroke amplitude.

The effect of increased gravitational force on grade and recovery is depicted by fig.3

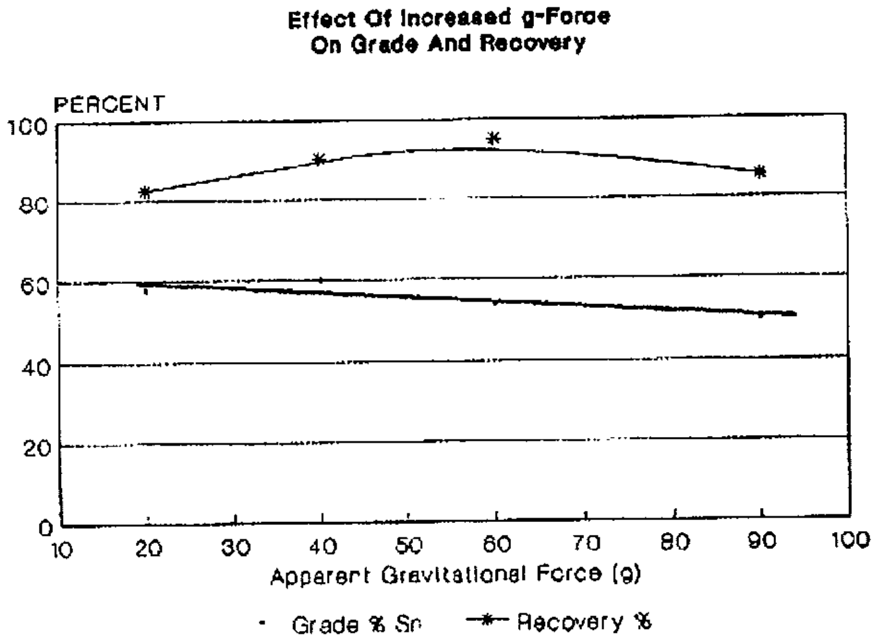


Figure - 3

The performance characteristics of the jig with respect to centrifugal force can be altered by varying the amplitude of the pulse stroke. At lower rotational speeds, a shorter stroke results in better control of the concentrate grades due to smaller dilations. As the speed is increased, a more powerful stroke is required to counter?act the centrifugal forces tending to compact the ragging. The effects of stroke length on upgrading ratio are demonstrated by fig.4.

When pulse rate and centrifugal force were held constant, increasing the stroke length decreased the recovery but produced a cleaner concentrate as indicated by the results in Table 1.

Cam Size (mm)	Jig RPM	Gn	Pulse Setting	Total Pulses	U/R	Recovery
2.0	500	63	1000	1500	3.6	96.7
3.0	500	63	1000	1500	4.0	95.5
3.5	500	63	1000	1500	4.3	91.3

TABLE 1 Effect of Stroke Length on U/R and Recovery

The decrease in recovery with a greater pulse amplitude reflects the loss of the very fine particles which are being forced out of the ragging bed by the strong pulse action.

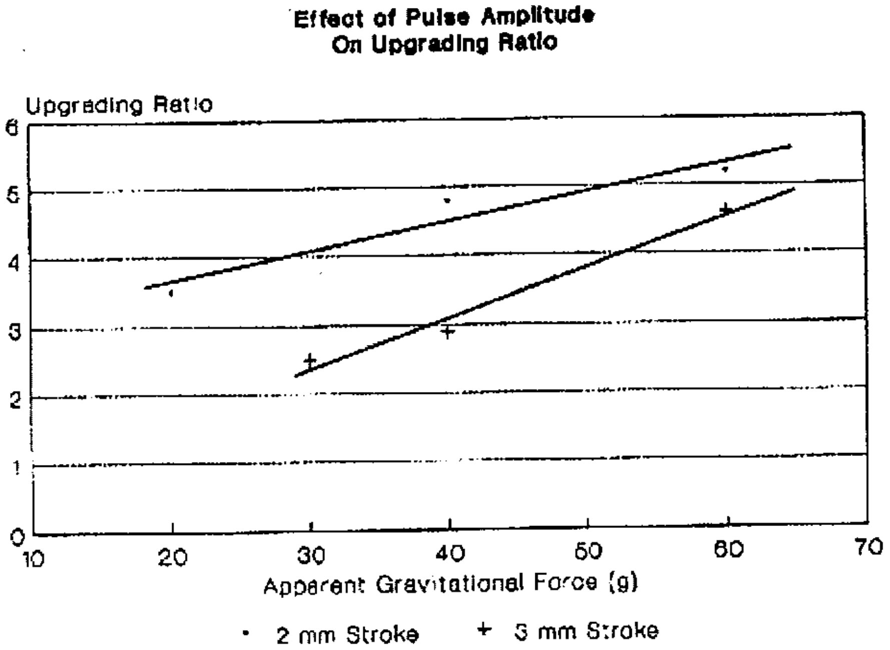


Figure - 4

PULSE ACTION

The water pulse provided by the diaphragm controls the rate and magnitude of dilation of the ragging layer. By increasing the pulse frequency, the number of dilations is increased thereby increasing the probability of trapping the heavies in the ragging bed. Fig.5 clearly demonstrates the effect of pulse action on the concentrate grade over a wide range of rotational speeds. For all speeds the concentrate grade decreased as the pulse rate was increased.

The effect of pulse rate on recovery is less pronounced and appears to be influenced by rotational speed. At low speeds, a high pulse rate was detrimental to recovery, possibly due to displacement of fines. At higher g?forces the increased pulse action produced slightly higher recoveries. The relationship between pulse rate an recovery is shown in fig.6. and 1500 pulses per minute. During the course of testing it was necessary to reduce the pulse cam from 3.5 millimetres to 3 millimetres and finally to 2 millimetres in order to prevent the gradual loss of ragging. To compensate for the shorter stroke length the pulse frequency was increased from 1500 pulses per minute to 2000 pulses per minute. This change not only resulted in improved metallurgical performance but also resulted in a much smoother operation and completely eliminated the loss of ragging. The average combined results of the rougher and scavenger tests are summarized in Table 2.

**Effect of Pulse Rate
On Concentrate Grade**

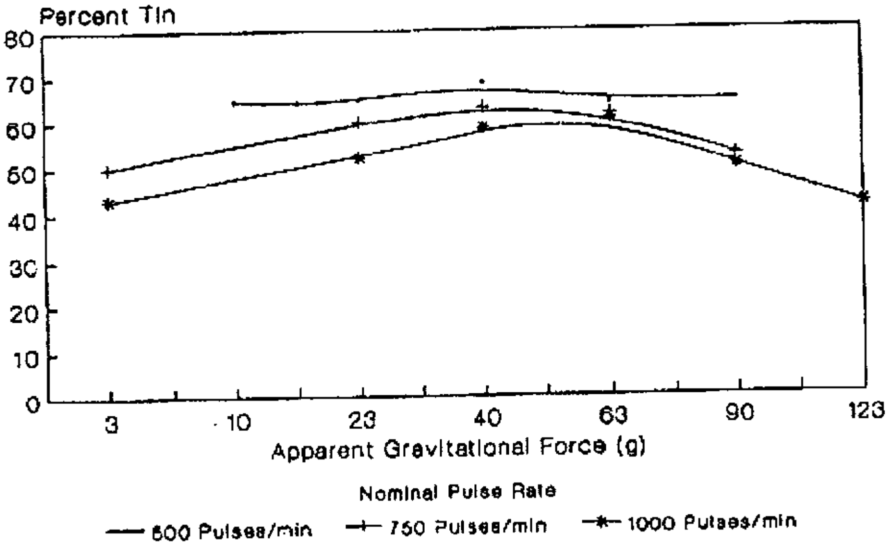


Figure - 5

**Effect of Pulse Rate
On Recovery**

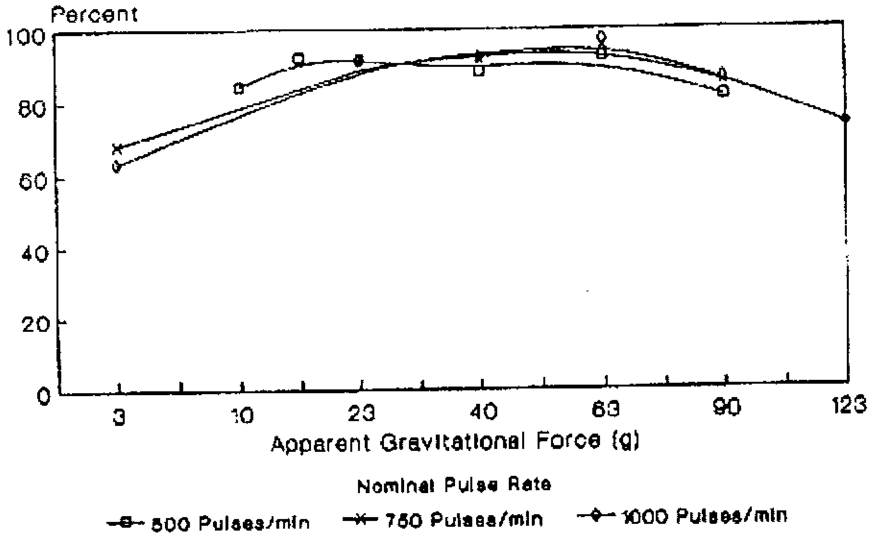


Figure - 6

	Wt %	%Sn	
		Assay	Distribution
Jig Feed	100.0	13.5	100.0
Rougher Concentrate	19.6	63.2	91.8
Rougher Tail (Scav.Fd)	80.4	1.3	8.3
Scavenger Concentrate	1.9	40.5	5.8
Tailings	78.5	0.4	2.5
Combined Concentrate	21.5	61.2	97.5

TABLE 2 Combined Results from Rougher Scavenger Tests

The Jig performance was compared to historical operating data from the electrostatic separation circuit and also to data obtained from treating the same feed on shaking tables.

In each case the circuit configuration included a roughing and scavenging stage. The comparative results are summarized below.

CENTRIFUGAL JIG

	Wt %	Sn %	Dist'n %
Jig Feed	100.0	13.5	100.0
Combined Rougher/Scav Conc	21.5	61.1	97.5
Scavenger Tails	78.5	0.4	2.5

ELECTROSTATIC SEPARATORS

	Wt %	Sn %	Dist'n %
Electrostatic Feed	100.0	14.4	100.0
Electrostatic Conc	23.5	59.3	96.5
Electrostatic Tails	76.5	0.6	3.5

TABLE SEPARATION

	Wt.%	Sn %	Dist'n %
Table Feed	100.0	13.6	100.0
Table Concentrate	25.8	49.2	93.5
Scav Table Tails	74.2	1.2	6.5

CONCLUSION

The centrifugal jig tested at Rio Kemptville, demonstrated excellent potential for extending gravity separation techniques to fine particles. The ability to vary the apparent gravitational force provides flexibility to allow for optimization of the conditions for feed stream. Response to changes in control settings was fast and very stable.

When compared to shaking tables and electrostatic separators, the jig was less sensitive to changes in feed grade and had much higher capacity per square foot of floor space.