Beneficiation of Tin using Kelsey Centrifugal Jigs in the new Millennium

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Abstract

The Kelsey Centrifugal Jig is an enhanced gravitational separating device which utilizes the principles of conventional mineral jigs but has the additional feature of being able to vary the apparent gravitational field. This gives added flexibility in the selectivity of particle acceleration.

The commercial introduction of the device into the mineral industry came in 1992 when the Renison Tin Mine in Tasmania, Australia began installing units to replace the existing classification and tabling circuit.

Introduction

Mineral jigs for many centuries have been used by the mining industry to extract coarse liberated particles from a wide range of minerals. Chris Kelsey has revolutionized the mineral jig industry by designing and manufacturing the only enhanced gravity jig on the world market to date.

The advancement of the Kelsey Centrifugal Jigs since its conception has been almost as swift and ingenious as the idea itself.

Mechanical availability exceeds 95% world wide with particular plants recording 98% availability. The recent commercial release of a new series of jigs will increase this excellent record to even higher levels of achievement.

The Kelsey Centrifugal Jig

The concept of the Kelsey Centrifugal Jig utilises all the parameters of a conventional jig as well as the additional feature of being able to vary the apparent gravitational field acting on very fine particles and across the ragging bed.

Whereas, in a conventional jig, the dynamics involve only specific induced movements, the Centrifugal Jig takes a conventional jig and spins it in a centrifuge. The ability to change the apparent gravitational field, up to 50 times gravity, results in a major improvement in separation efficiency, particularly of very fine minerals, by significantly reducing the effect of forces that hinder fine particle separation.

Generation of the centrifugal force is achieved by variable speed control of a spinning rotor. Inside the rotor, a screen of parabolic shape is spun coaxially together with the rotor. The screen is lined inside with ragging material which is evenly spread by the centrifugal force.

The feed pulp passes down the fixed central pipe and is distributed over the base of the ragging. The particles in the feed are accelerated towards the ragging bed, due to the apparent gravitational force, while continually rising up the bed, due to the vertical displacement caused by the incoming feed.

Those particles whose specific gravity exceeds or equals that of the ragging material will be allowed to settle in the ragging bed. Having penetrated the ragging bed, the particles then go through the processes of hindered settling and consolidated trickling. The heavier minerals pass completely through the ragging retention screen and into the concentrate hutches where they ultimately pass as slurry through concentrate spigots and into the concentrate launder. Lighter minerals that are not able to settle will be discharged over the top of the screens ragging retention ring and into the tailing launder.

The process of hindered settling within the bed is not only accentuated by the centrifugal force, but also by the pulsing of the ragging bed. The pulsing of the bed is achieved via pulse arms connected to pads to work against the jigs flexible diaphragm. Water contained within the concentrate hutches presses against the diaphragm, at a frequency and amplitude set by the operator, thus dilating the ragging bed. The level of dilation impacts on the amount of material able to pass to concentrate.

The shock wave produced by the pulses have a twofold effect. Firstly they dilate the ragging bed, as mentioned above, allowing minerals to enter the bed. Secondly they accentuate the different rates of acceleration between particles of differing specific gravities. This phenomenon can be explained in the following way:

Particles that are subject to a constant force will accelerate at a rate proportional to their mass until they reach a terminal velocity. This terminal velocity is mainly linked to the surface area of the particle. Therefore particles of the same size but differing specific gravities will separate when placed in a field of constant force but will slow their separation rate once they reach their terminal velocity. The shockwaves, produced by the pulsing action of the jig, continually stop the particles, thus limiting their time at their terminal velocity and maintaining a high rate of separation.

Metallurgical Performance in Tin Processing

The Kelsey Centrifugal Jig has been shown over the years in several mineral applications to be metallurgically and economically superior to other processing options. The ability of the jig to upgrade material substantially with minimal losses, especially in the fines region, makes this device ideal for low grade, high value streams like those found in a tin or mineral sands plant.

Many papers have been written over the years by plants operating or evaluating the Kelsey Centrifugal Jig and the metallurgical results have always been very impressive. The commercial release of the new series of Kelsey Jigs has now made the device much more amenable to processing high tonnage streams economically.

Typical Shaking Table and Kelsey Jig Comparison

Stream	Kelsey Centrifugal Jig			Shaking Table		
	Wt%	Sn%	Dist'n%	Wt%	Sn%	Dist'n%
Feed	100	13.5	100	100	13.6	100
Conc	21.5	61.1	97.5	25.8	49.2	93.5
Scav. Tail	78.5	0.4	2.5	74.2	1.2	6.5

"When compared to shaking tables and electrostatic separators, the jig was less sensitive to changes in feed grade and had a much higher capacity per square foot of floor space".[1]

Typical Size Distribution from a Kelsey Jig in Operation

Size	*Feed*		*Concentrate*		*Tail*		*Rec.*
µm	Wt%	Sn%	Wt%	Sn%	Wt%	Sn%	%Sn
300	3.14	3.96	0.17	48.90	6.25	2.37	42.29
212	9.04	9.34	2.75	46.90	10.94	4.19	60.55
150	8.19	17.3	5.96	56.30	9.01	4.09	82.34
106	15.52	18.8	12.61	59.70	16.41	3.48	86.53
75	21.49	18	17.13	55.40	23.32	3.38	86.58
53	15.98	22.7	19.02	56.80	17.13	4.74	86.32
38	13.53	32.3	21.46	57.80	9.06	9.53	84.41
-38	13.11	44.1	20.90	61.50	7.88	18.90	82.49
Total	**100**	**21.96**	**100**	**56.43**	**100**	**5.49**	**83.10**

Comparison with other Enhanced Gravity Separating Devices

CVRD research facility in Brazil conducted a survey for a tin operation to investigate the option of using enhanced gravity separators in its new operation. The independent and thorough survey revealed the Kelsey Centrifugal Jig far exceeded the metallurgical performance of the other separators.

Comparison of Devices on Spiral Feed

Equipment	Mass Rec. (%)	Sn Rec. (%)
Kelsey Jig	3.79	84.15
Falcon	49.03	76

It is quite clear from the independant comparison that the Kelsey Centrifugal Jig with its jigging action is able to reject a vast amount of material to tailings and yet maintain a high recovery, especially the fine valuable minerals.

Typical Kelsey Jig Results from around a Tin Circuit - Conducted at CVRD

Sample	Objective	Mass Recovery (%)	Tin Recovery (%)	Enrich-ment Ratio
Tables 1 and 2 combined tailings	Max recovery	1.02	56.90	55.81
	Max grade	0.44	26.13	60.00
Table 3 tailings	Max recovery	13.91	83.16	5.98
	Max grade	8.40	77.86	9.27
Scavenger of table 3 tailings	Max recovery	2.21	56.60	25.66
	Max grade	2.21	56.60	25.66
Tables feed	Max recovery	5.64	89.99	15.95
	Max grade	4.13	80.39	19.47
Spirals feed	Max recovery	3.79	84.15	22.21
	Max grade	3.33	82.94	24.93
Fine fraction of spirals tailings	Max recovery	14.58	89.32	6.13
	Max grade	14.58	89.32	6.13

The main conclusions from this particular test work are outlined below (Silva, 1999)[3]: The success of the application of the centrifugal jigs for this particular ore is mostly due to its ability to concentrate fine cassiterite particles (less than 50 µm). In the previous flow sheet, these particles could not be concentrated by tables in an efficient way and had to be recovered by flotation, which was expensive and still not very efficient. With the usage of centrifugal force combined to bed classification of the Kelsey Jig it was possible to concentrate all size ranges with high recoveries.

Recently a Kelsey Centrifugal Jig was purchased by Minsur SA in Peru to be installed in the San Rafael Tin Plant. This plant produces about 50% of the worlds tin due to the high tonnage and rich grade of the ore.

Minsur SA invited all enhanced gravity devices to test their equipment on-site so that the engineering staff could determine the best equipment for their operation. After extensive testing of well over 30 streams around the plant it became very clear that again the Kelsey Centrifugal Jig is the most viable addition to the existing circuit.

It was the ability of the Kelsey Centrifugal Jig to achieve very high enrichment ratios in combination with recovery which ensured its success.

Mechanical Operation of the Kelsey Centrifugal Jig

Since the completion of Mechanical R&D from 1988-92 the purchasers of Kelsey Jigs have been enjoying excellent mechanical results at their installations. The Jigs are being installed with control equipment and automatic screen cleaners which makes them an operator free piece of equipment.

The Model J1800 is a much larger device than the other Kelsey Centrifugal Jigs, the central bowl has a diameter of 1800mm with over twice the capacity of the smaller units. The internal screen area has over twice the surface area of the next smallest model the J1300.

Cast iron launders and inclined operation result in the unit requiring the smallest footprint possible for compact installations.

Operator involvement is now only about 0.25hrs per day, which includes general housekeeping of the circuit. This figure is dramatically reduced on multiple installations.

Conclusion

The tin industry to date has chosen to use one type of high tonnage enhanced gravity separator only "The Kelsey Centrifugal Jig". With the new series on Kelsey Jigs now commercially available the likelihood of this dominance continuing is very high.

References

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