

# **THE KELSEY CENTRIFUGAL JIG**

## **Extending the Size Range Amenable to Heavy Media Separation**

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### **ABSTRACT**

Heavy Media separation is utilised to separate materials on the basis of differences in specific gravity. The separating medium is an aqueous suspension of relatively fine particulates of combined specific gravity intermediate between the materials being separated.

Drum separators are utilised to process ore streams in the size range –80mm +6mm. The top size is governed by the ore liberation characteristics; the bottom size is a parameter of the equipment utilised. Gravitational force is insufficient to separate finer particles in baths of reasonable size.

Cyclone separators are utilised to process ore streams in the size range –6mm +500 micron. These separators efficiently separate since the replacement of gravitational force by 4 or 5 G of centrifugal force has extended the treatable size range. The minimum size treatable is restricted by the centrifugal force achievable and the densification of the heavy media suspension which results in uncontrollable and unacceptable performance.

The Kelsey Centrifugal Jig extends the treatable size range down to less than 10 microns by utilising up to 100 G of centrifugal force. The limitations of heavy media suspension are resolved by using a solid heavy medium in the separation zone.

This paper details the operation of the Kelsey Centrifugal Jig and presents performance results from a range of mineral species assessed. The potential for extension of the size range applicable to heavy media separation is discussed.

### **INTRODUCTION**

The objective of mineral processing is to separate mineral species. The efficiency of that process is a function of the efficiency of the particular unit operation and the amenability of the mineral species suite presented to the separation mechanism employed.

IN gravity separation, the efficiency of the process is a function of:

1. Inherent efficiency of the unit operation (with its particle size dependency)
2. Mineral distribution in the ore and its specific gravity variation with size
3. Operational parameters that effect the inherent efficiency of the unit operation

Heavy media separation is utilised on ores with specific gravity differences between the valuable mineral particle and the non-valuable. This fixed feed condition reduces the parameters affecting performance to the inherent efficiency of the unit operation and the efficiency response to the non-optimal operational parameters.

The performance of any heavy media separator can be represented on a Tromp or Partition curve (Tromp 1937, Loveday 1970). Certain characteristics of this curve are used as definitions of separator performance.

The Separating Density is the density of separation at which an equal amount of one component is misplaced in each of the two separator products. At this density a particle has an equal chance of going to either the sinks or the floats of the separator, and is the density at which the distribution curve has a value of 50%. IT is defined as the mean density of the infinitely small density range in which an equal percentage of one component appears in the floats and the sinks of the separator. Figure 1 shows the general shape of the distribution curve.

- a) The vertical straight line CMB represents the theoretical separating density. All lighter material should float and all heavier material sink.
- b) However, the actual separation is represented by the curve FMO. The area FMB represents the true floats that have reported to the sinks, while the area CMO represents the true sinks that have reported to the floats. These two areas are not necessarily equal. The approach of the curve to vertical indicates approach to ideal separation, while the hatched areas represent the deviation from ideality (Symington and Others 1957, Abbott and Others 1969, Armstrong and Cammack 1969).

The Ecart Probable Moyen or Probable Error ( $E_p$ ) is a guide to the efficiency of separation in a separating device. It is determined from the Tromp Curve and is defined as half of the differential in density between 25% and 75% partition coefficient on the distribution curve, ie:

$$E_p = 0.5 \cdot (x_{25} - x_{75})$$

The lower the  $E_p$  value, then the smaller the difference in density between the 25% and 75% partition coefficient, and hence the more efficient the separation. Conversely a higher  $E_p$  value indicates a wider spread of density and a less efficient separation.

The value of the distribution curve is that it is typical of the size of the material treated and the type of separator, but it is independent of the sink and float analyses of the material treated (ie its composition). Thus similar curves, although of different Tromp Cut Point, are obtained when the same sizes of widely different materials are treated in the same separator. It is because of this that it is possible to predict the performance of the separator (Burt 1984).

The performance of a separator is close to ideal at the coarsest end of the size distribution treated (ie  $E_p$  approaches 0). Particles of size 80-50 mm in drum separators and 6-3 mm in cyclone separators are easily separated (provided excess near gravity material is not present). However, as the feed size decreases the performance deteriorates. This is indicated by an increase in the Ecart Probable Moyen,  $E_p$ . This inverse relationship between size and  $E_p$  is primarily due to the decreasing separation force, which results in the inability of particles of a certain size being able to overcome the rheological properties of the separating medium.  $E_p$  values greater than 1 result in excessive sinks in floats and vice versa.

The rheological properties affecting the performance of the separator are:

1. The effective viscosity of the suspension, which is the viscosity experienced by the ore particles. This, ideally, should be as low as possible.
2. The yield stress of the suspension which ideally, should be as low as possible.
3. The stability of the suspension which should be as high as possible.

IN drum separators, gravitational force is insufficient to allow separation of particles of less than 6mm in a reasonable bath area. IN cyclone separators, normally developed centrifugal forces (3-5 G) are insufficient to allow separation of particles sized less than 1mm to 500 micron in the residence time available. Attempts to increase centrifugal force (by boosting cyclone inlet pressure) can result in heavy medium densification in the suspension. The resultant performance is uncontrollable and unacceptable.

The Kelsey Centrifugal Jig can impose a separating centrifugal force of up to 100 G, as compared to 3-5 G in a cyclone. The rheological effects are not a concern since the transporting fluid is not a suspension but water itself. The density separation is assisted using a solid, relatively coarse medium, intermediate in specific gravity, with the jiggling action providing particle differentiation. Values of  $E_p$  of 0.2 – 0.3 at sizes between 2mm – 20 micron are achievable providing reasonable specific gravity difference exists.

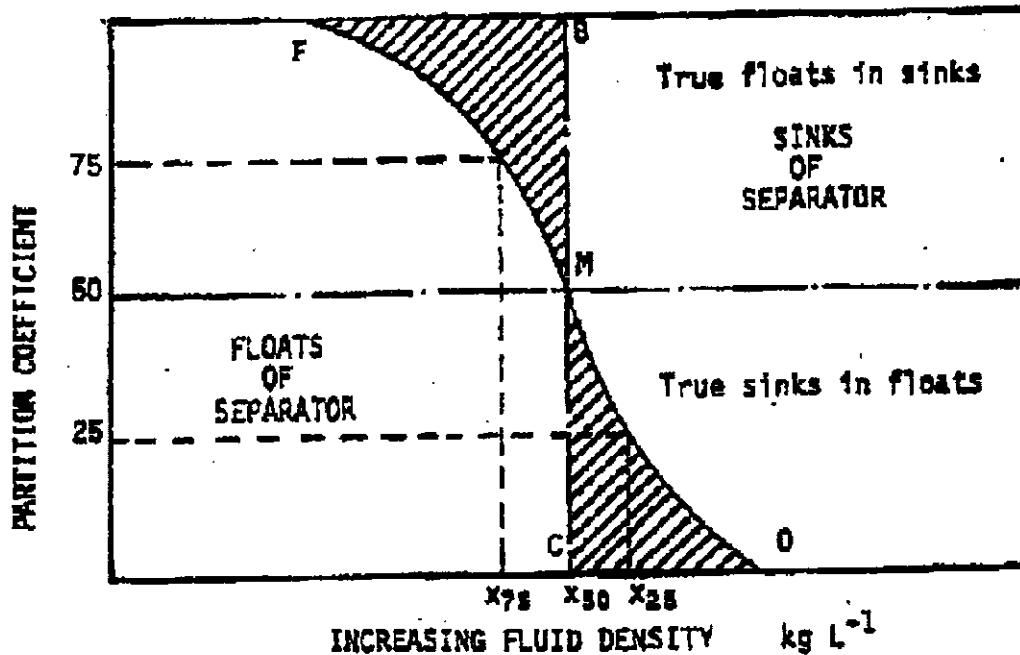


Fig. 1. The Tromp or Partition Curve

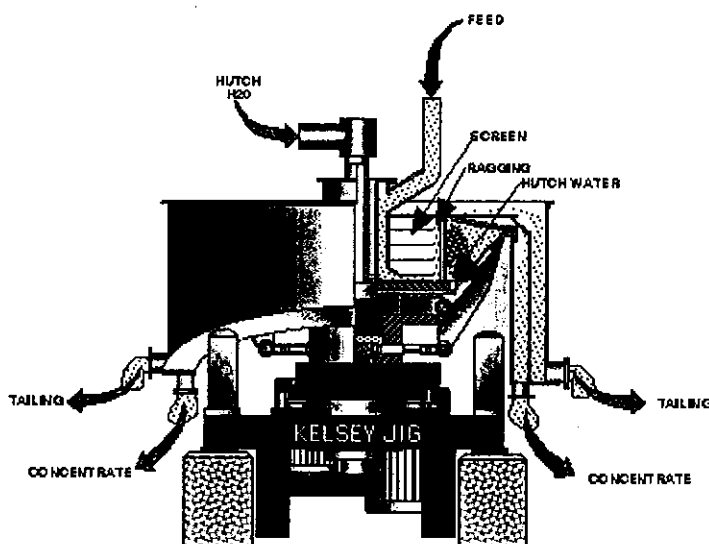
### THE KELSEY CENTRIFUGAL JIG

The Kelsey Centrifugal Jig engineering concept (Figure 2) is a radical departure from the conventional jig configurations presently being used. 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. This gives added flexibility in the selectivity of particle acceleration. Where, as 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 is a major departure in the recovery of fine minerals. This is achieved by variable speed control of the spinning rotor. Inside the rotor a screen of parabolic shape is spun coaxially together with the rotor. The screen is lined inside with the ragging spread, again coaxially, by centrifugal force, evenly over the inside surface of the screen.

The feed pulp passes down the fixed centre annular pipe and is distributed over the ragging. The feed flows upward over the ragging causing the tailings to overflow the retention plate and then to the discharge orifices. The concentrate passes through the ragging and screen and is discharged through the rotating spigots. Hutch makeup water (the additional clean water required for the pulsing flow) is fed through the spinning centre pipe.

The pulsator is driven to create a water pulse inwardly through the screen and ragging sequentially, while differentially accelerating the feed and ragging particles according to their specific gravity. The particles then settle under centrifugal force (or induced apparent gravitational force) causing the heavy mineral separation from the lighter fraction.

The main operating variables which are adjusted to control processing of different types of material are, centrifugal force, ragging material and size distribution. The obvious advantages of the Kelsey Centrifugal Jig are higher production capacities using less plant area, extended recovery ranges to include ultra fines and the viability of processing slimes, industrial sludge and tailings to recover high value minerals not recovered by other separation methods.



**Figure 2:  
The Kelsey  
Centrifugal Jig**

## RESULTS

Production units are in operation on a range of minerals.

### 1. Gravity concentrate upgrading of tin

	Feed	Concentrate
D-80	600 micron	150 micron
Grade	10-15% Sn	55-65% Sn
Recovery		70-80%

The recovery is lower than optimum due to excessive feed tonnage. During test work tin recoveries at approximately 10 micron are typically 70%

2. Cleaning of tantalum pentoxide plant product

	Feed	Concentrate
D-80	600 micron	-
Grade	4-6% Ta <sub>2</sub> O <sub>5</sub>	24-26% Ta <sub>2</sub> O <sub>5</sub>
Recovery		91-94%

3. Fines recovery of iron ore from a taconite operation

	Feed	Concentrate
D-80	-	150 micron
Grade	10-20% Fe	60-69% Fe
Recovery		40-50%

The silica content of the concentrate is 1.1 – 3.0% SiO<sub>2</sub>.

Testwork on coarse grained zircon / kyanite streams (180 micron) has given excellent performance indications.

-250+180 mic	Feed	Concentrate
Grade - ZrO <sub>2</sub>	36.4	62.3
- Al <sub>2</sub> O <sub>3</sub>	11.6	1.37
Recovery		94.6

-180+125 mic	Feed	Concentrate
Grade - ZrO <sub>2</sub>	47.8	62.5
- Al <sub>2</sub> O <sub>3</sub>	1.94	1.00
Recovery		99.2

The Kelsey Centrifugal Jig can effectively be used on material too fine for heavy media cyclone separation. No operational problems will occur down to 5 microns (depending on mineralogy and size dependence).

Anticipated results for a typical iron ore heavy media plant tailing (-100 microns) would look like the following:

	Mass %	Fe %	SiO <sub>2</sub> %
Product	50	65	2
New Tails	50	25	26
Old Tails	100	45	15

A similar mass balance can be predicted for manganese dioxide tailings.

-1mm +100 mic	Mass %	Mn %	SiO <sub>2</sub> %	Al <sub>2</sub> O <sub>3</sub> %
Product	51	50	6	2
Tailing	49	9.2	55	4
Old Tails	100	30	30	3

-100 micron	Mass %	Mn %	SiO <sub>2</sub> %	Al <sub>2</sub> O <sub>3</sub> %
Product	36.2	47	10	2.5
Tailing	63.8	4.70	57	14.30
Old Tails	100	20	40	10

## CONCLUSION

The Kelsey Centrifugal Jig can dramatically improve the economics of heavy media operations by extending the size range amenable to upgrading. The operation is performed in a single stage without the concerns of suspension rheology that are ever present in conventional heavy media operations.

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