



**GRAVITY CONCENTRATION
OF
GOLD
FROM CYCLONE FEED
IN
GRINDING CIRCUITS
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Introduction

The use of gravity concentration in gold milling flowsheets is well established. In the past, a typical approach was to treat the entire mill discharge with a mineral jig. Water, necessary for classification, was added through the jig hutch. Jig concentrate was tabled to form a smeltable product. Recently, enhanced gravity concentration devices have been developed which require less maintenance and have better metallurgical performance than jigs. These devices have a unit water demand such that the water balance around the grinding circuit would be affected if the entire mill discharge were treated. In addition, unit capacity cost of an enhanced gravity machine is higher than for a jig and the feed requires screening. Today, conventional wisdom dictates that the enhanced gravity device is connected to a fraction of the cyclone underflow stream. This is not the location in the circuit that will result in optimum recovery of gold by gravity.

The 'Old' Way

Treating the entire mill discharge had some compelling advantages:

- Every particle discharged from the mill was exposed to gravity concentration at least once. Most dense particles saw gravity concentration many times.
- Gold was subjected to the gravity concentration device in its coarsest state, i.e., as soon as a particle was discharged from the mill it saw the gravity concentration device.

There were also some disadvantages:

- The gravity circuit had to process 3 or 4 times the new feed rate to the mill (the entire circulating load).
- Much of the feed material was fine and therefore thought to be unrecoverable by gravimetric means.
- Security of high-grade gold concentrates was a large problem, particularly in the third world.

Current Conventional Practice

Arguments for the current practice of treating a fraction of cyclone underflow with enhanced gravity concentration machines are:

- Cyclone underflow contains the greatest opportunity for gravity concentration since it is the highest grade. (Please refer to flowsheets included.)
- Recovery across the enhanced gravity device will be improved by the absence of slime.
- Free gold that escapes from grinding circuits via cyclone overflow will all be recovered by downstream processes without incurring additional cost.
- Installed enhanced gravity concentration capacity should be minimized and this is best done by using a fraction of cyclone underflow.
- Coarse gold will follow the laws of probability and eventually find its way to the gravity concentration device after several trips through the grinding mill.



These arguments need to be critically examined:

Cyclone Underflow

The schematic flowsheet of the case with no gravity circuit shows that the cyclone underflow stream has the highest feed grade. This is misleading since all of the streams are considered to be homogenous. By taking advantage of the natural concentration that takes place in even the most turbulent pipelines, it is easy to bias the grade of a fraction of the cyclone feed stream so that the majority of the free gold units report to this fraction. By optimizing the concentration effect, it is possible to elevate the grade in this stream far above that found in cyclone underflows in the same circuit. Therefore, the greatest opportunity for gravity concentration is not cyclone underflow but a biased fraction of cyclone feed.

Slime

Although slime is deleterious to metallurgical performance in gravity concentration devices, its effects are an inverse function of the gravitational field applied. In gold grinding circuits much of the free gold can lie in the finer size fractions and is amenable to concentration using enhanced gravity. Treating only a fraction of cyclone underflow means that much of the free gold will bypass the gravity concentration circuit and report straight to cyclone overflow. Treating even a fraction of cyclone feed, properly biased, will result in higher recovery through an enhanced gravity concentration circuit.

Downstream Processes

In theory, downstream processes such as froth flotation and cyanide leaching will recover all of the free gold that escapes from the grinding circuit. In reality, circuit upsets and short circuiting mean that it is impossible for this to be so. In addition, there is always an incremental price to pay for downstream processes. Whether it be additional mass to concentrate for flotation (pulling harder) or additional carbon handling cost in leaching, nothing comes for free in mineral processing. Where there is gravity recoverable gold, it is important that it be maximized, as the unit operating cost for a gravity circuit is much lower than that for any other process.

Minimizing the Size of the Gravity Concentration Circuit

Many process engineers view gravity concentration in gold grinding circuits as a nuisance and a security risk. In part, this is probably due to the chequered history of enhanced gravity concentration, and the inability to predict the impact a gravity circuit will have on overall performance of a given plant. In the past, there have been many failed attempts to produce equipment of this type. Today, there is a choice of suppliers of reliable, proven machines and the physical principals behind their operation are becoming better understood. Further, today's machines are sufficiently reliable and automated that they can be placed in a secure enclosure. It is now necessary to consider gravity concentration not as a nuisance that must be tolerated but as a powerful tool to increase productivity. Although more work is required to predict precisely the performance of a gravity concentration circuit before a plant is constructed, we can predict whether a plant will derive some benefit from gravity concentration. Unfortunately, for the reasons discussed herein, current practice does not do justice to gravity concentration.



Coarse Gold

It may seem trite to point this out, but coarse gold does not remain coarse after experiencing many trips through a grinding mill. Researchers have found that, during milling, gold is actually smeared onto other particles and flattened into shapes likely to report to cyclone overflow upon discharge. Gold like this is much more difficult to recover gravimetrically than if it occurs as a three dimensional particle with a relatively large mass. For this reason, it is imperative that the gravity concentration circuit has the opportunity to see the free gold in its coarsest possible condition. Treating a fraction of cyclone underflow reduces this opportunity when compared to a biased fraction of cyclone feed.

The 'Falcon' Way

The 'Falcon' way combines the best features of the 'Old' way and current conventional practice by maximizing the probability for a coarse free gold particle to report to the gravity concentration circuit the first time it is discharged from the grinding mill yet does not involve treatment of the entire stream. It also provides a better feed grade than for cyclone underflows.

The 'Falcon' way was developed after retrofitting a number of plants with enhanced gravity concentrators. In essence, the cyclone feed pipeline is arranged so that an outlet under pressure is installed on the bottom of the line at the end of a long straight section that is either horizontal or inclined. Since the outlet is under pressure, the material being conducted can be elevated to a screen above the outlet point without using a pump. This may seem trivial until the operating costs for a pump to handle grinding circuit materials is evaluated. In addition, the overall height of a new plant can be reduced since the sizing screen can be at the same elevation as the cyclone cluster.

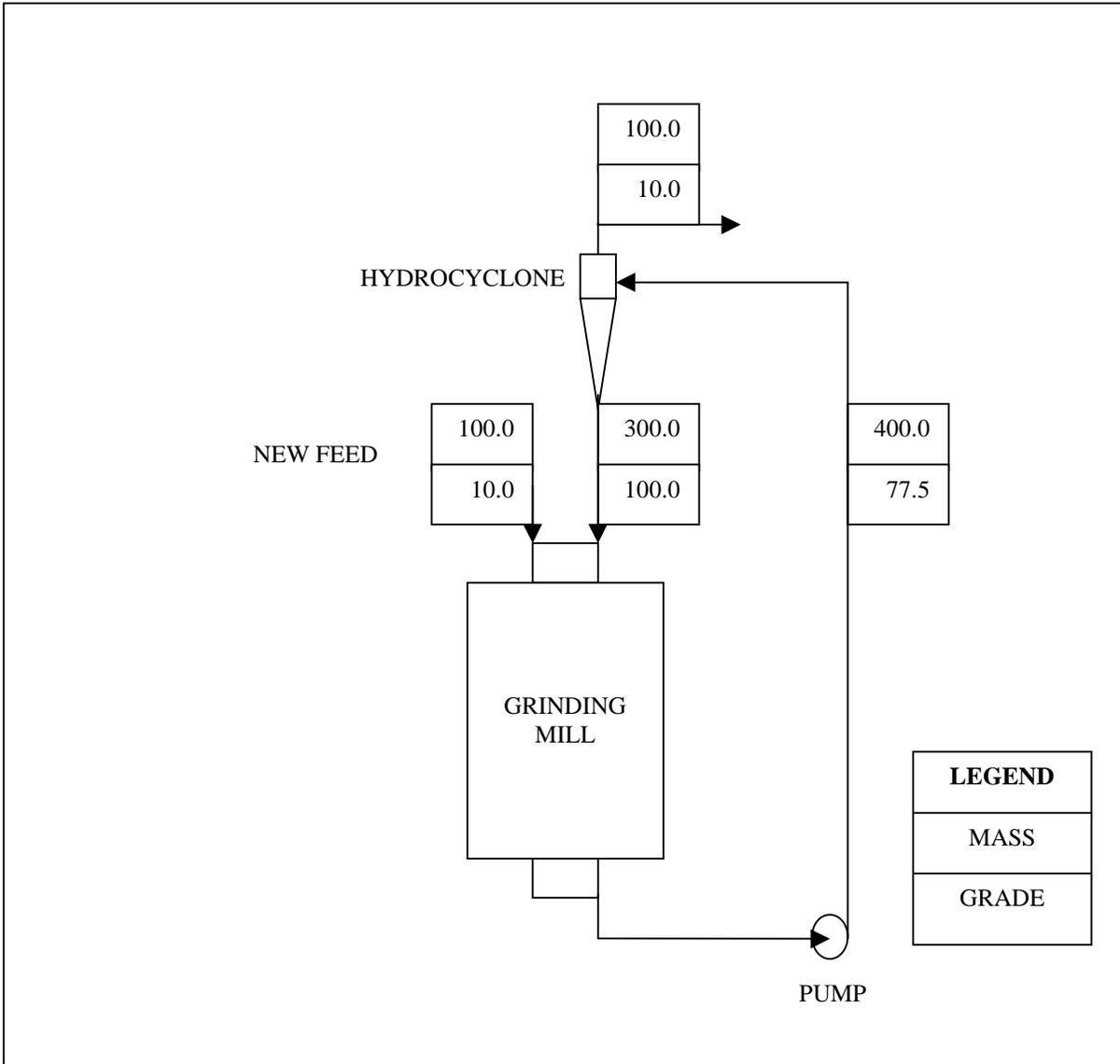
Plant Experience

The Elvington Mine near Harare installed a Falcon Concentrator in the 'Falcon' way and achieved the following results:

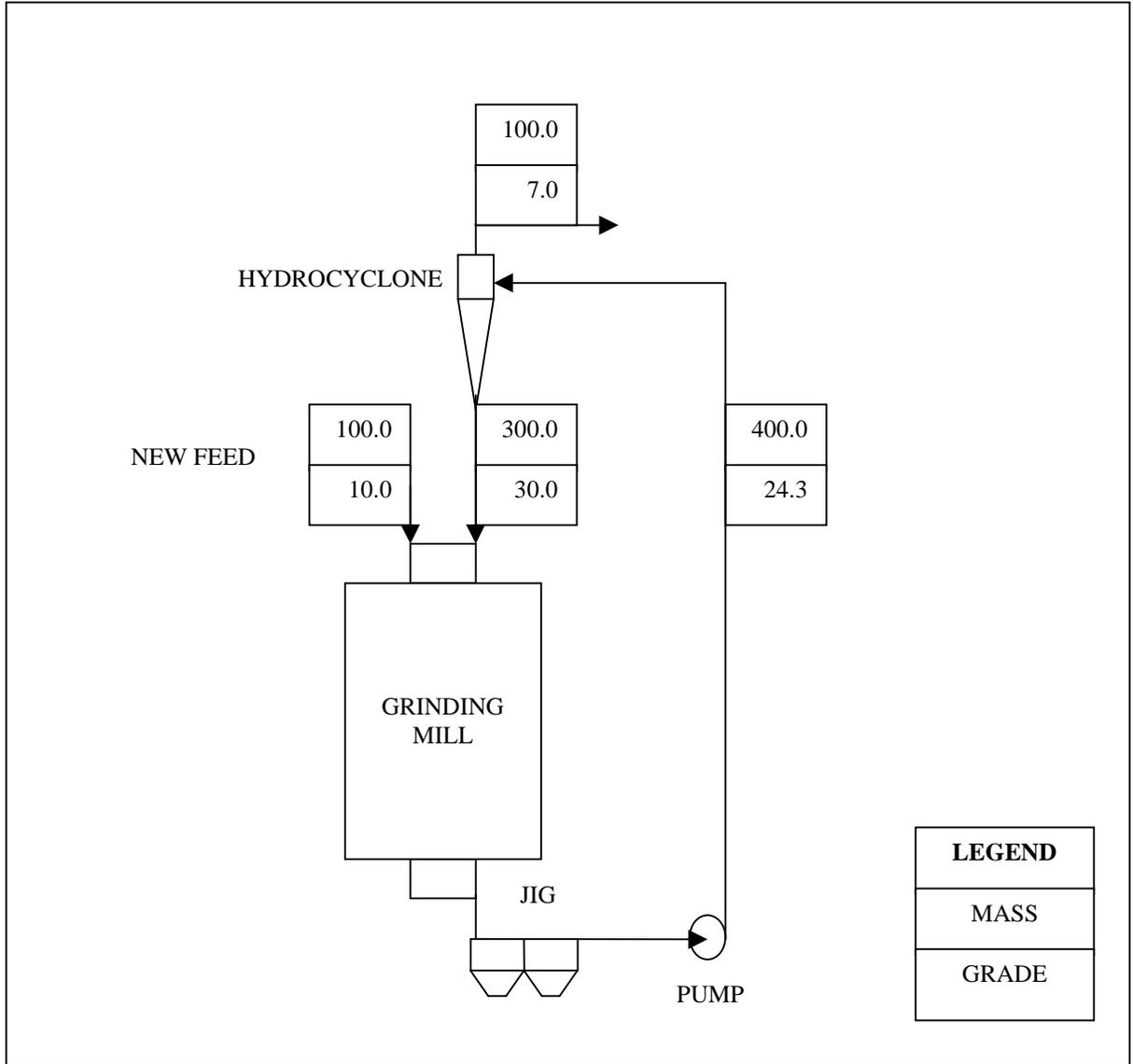
- ◆ Previous recovery (leach only): 76%
- ◆ New recovery (leach + SB21): 88%
- ◆ Leach Tails (Leach only): 0.64g/t
- ◆ Leach Tails (leach + SB21): 0.40g/t (reduced by 31%)
- ◆ Increase in gold recovery: **5kg per month**

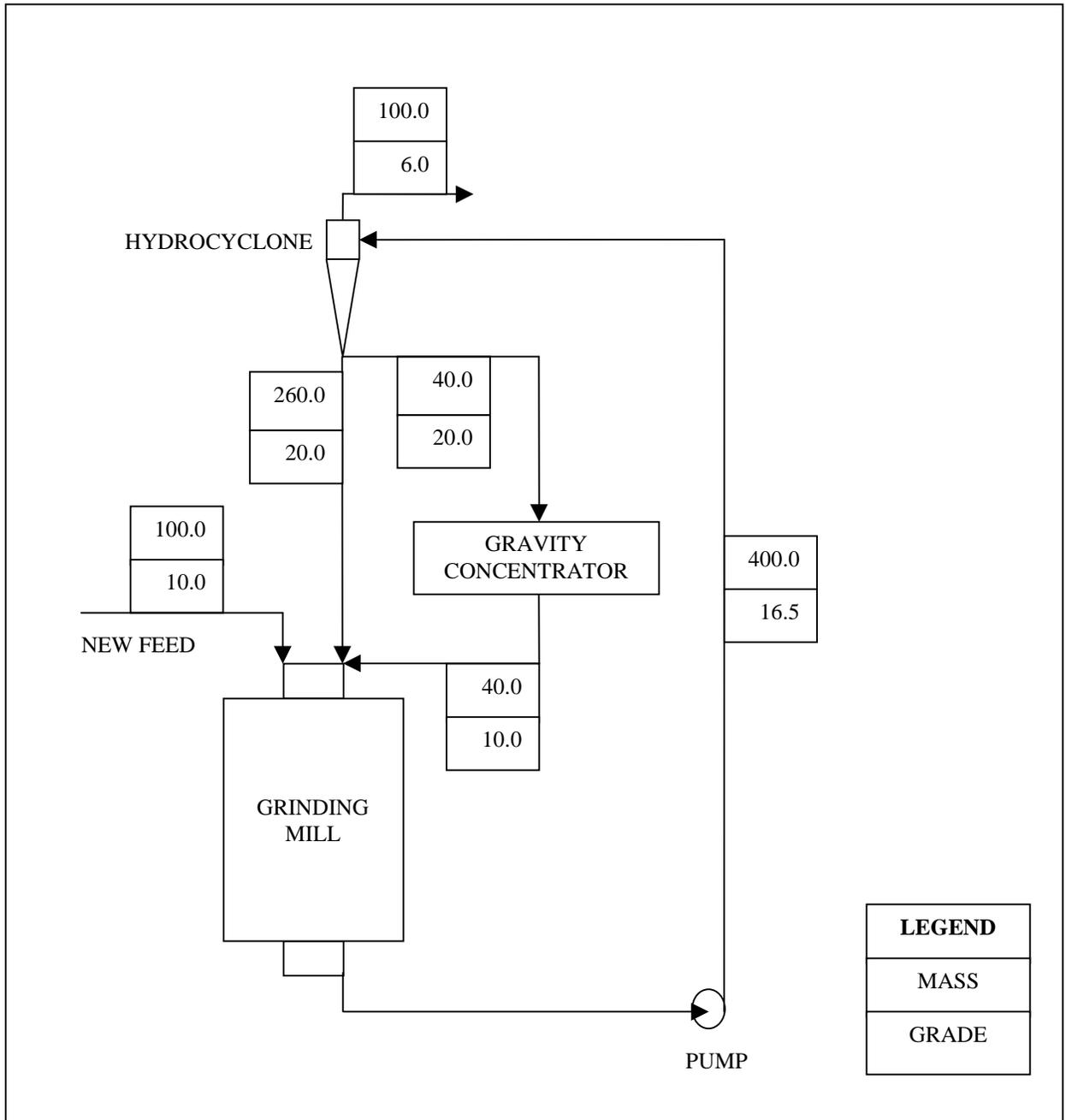
This equates to approximately US\$44500.00 increase in revenue per month, yielding a machine payback of ± 1 Month and an entire installation payback of just less than 2 months.



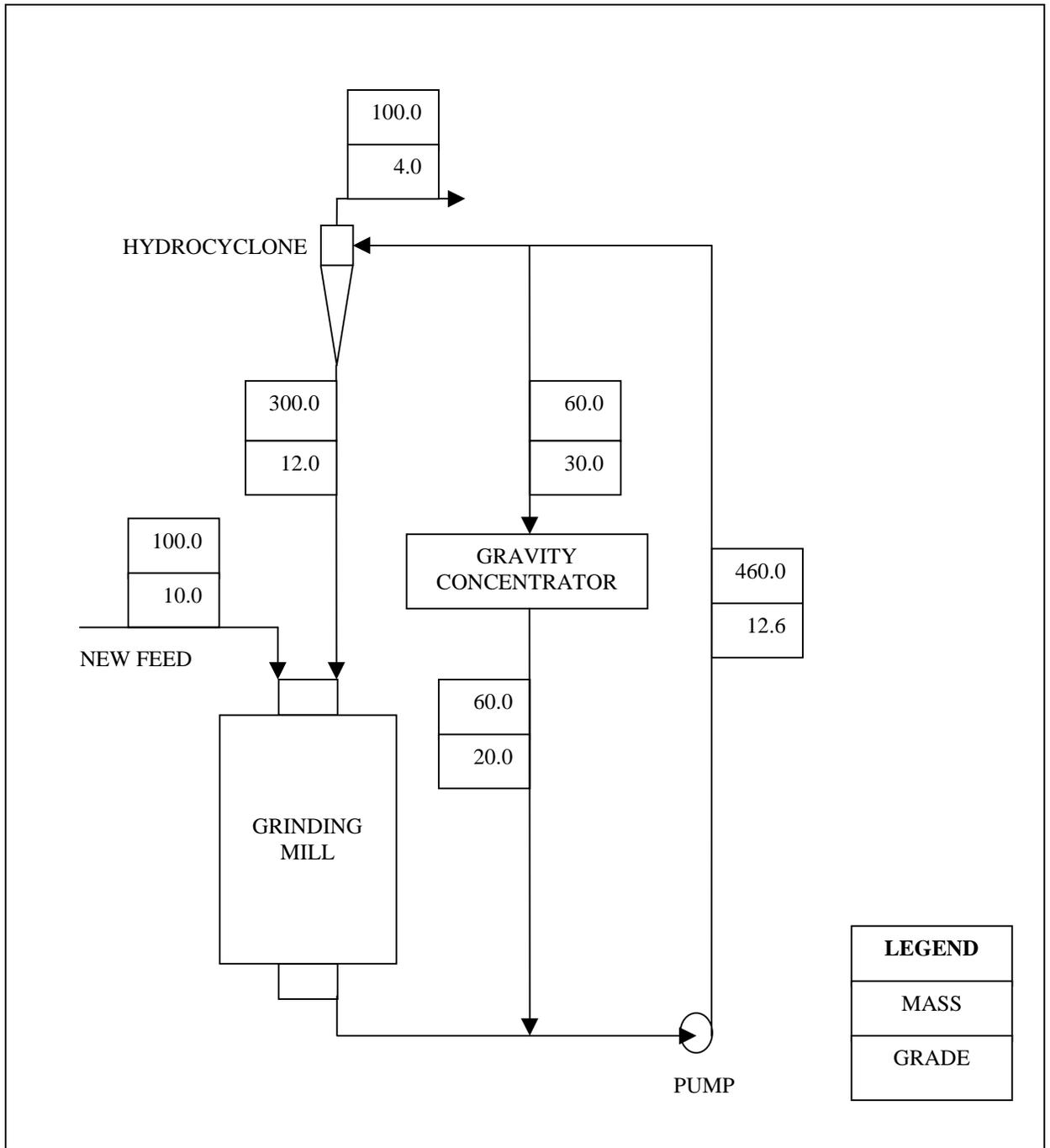


**HYPOTHETICAL GRINDING CIRCUIT
AT STEADY STATE
(NO GRAVITY CIRCUIT)**





**HYPOTHETICAL GRINDING CIRCUIT
AT STEADY STATE
(CURRENT PRACTICE @ 40% RECOVERY)**



**HYPOTHETICAL GRINDING CIRCUIT
AT STEADY STATE
(THE 'FALCON' WAY @ 60% RECOVERY)**