SELECTING THE RIGHT CENTRIFUGE – THE JARGON DEMYSTIFIED

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Contents

1. INTRODUCTION

Decanter centrifuges provide a highly versatile and reliable option for a large variety of separation processes. They are commonly used for the following applications:

- The separation of solid-liquid suspensions (two-phase separation),
- The separation of solid-liquid-liquid suspensions (three-phase separation),
- The thickening or dewatering of separated solids,
- The clarification of a liquid phase or liquid phases,
- The sizing of solids,
- The sorting of solids.

As mining houses and refineries have become more aware of the potential of these machines, so the market for centrifuges in hydrometallurgical applications has become more competitive. This has led to manufacturers putting out more marketing information to promote their machines. With even comparative reports being published, the information provided becomes more and more difficult to evaluate. As the client, whether it be an engineering firm or mining house, generally does not have in depth understanding of what influences effective operation of a centrifuge, such information may at times be taken at face value. While this may initially lead to marginally reduced capital costs, it is unlikely that the machines chosen in this manner will in the long run provide the client with optimal performance.

It would, therefore, appear more apt to provide the clients with a basis of knowledge which would allow an informed choice to be made. While several very good books have been published on the subject of centrifuge performance and choice[1,2], these texts are generally quite long and overly detailed. They also tend to focus more on the functioning of different types of equipment and the selection of suitable separation equipment, rather than the issue of choosing between the machines on offer by different manufacturers. The average engineer simply does not have the time to go through all of this information.

This paper strives to provide sufficient information on what needs to be considered when evaluating centrifuges against each other. The focus is on decanter centrifuges, but most of the principles raised would apply to other centrifuge types as well. In order to keep things simple, whatever formulae are discussed, are presented in their simplest and most directly applicable forms. More detailed information on the formulae can be obtained from the author.

The aspects which should be considered when choosing a centrifuge can be grouped into the following catagories:

- Physical parameters
- Operational and control parameters
- Long term parameters

2. PHYSICAL PARAMETERS

There are a number of factors which affect the separating ability of a centrifuge. These are typically determined by the physical parameters such as the geometric design and the rpm's at which the unit spins. The main ones to consider are as follows:

- Centrifugal force
- Suspension volume
- Retention time
- Beach angle
- Clarifying area
- Equivalent clarifying area

Finding common ground when comparing centrifuges is made extremely complicated by the complexity of the internals of a centrifuge, and the fact that each manufacturer uses the internal dimensions, as shown in Figure 1a and 1b, in a different way to calculate various parameters. In most cases the various values are also calculated using measurements which are not necessarily available to the engineer assessing the machines being offered. It is, therefore, critical when making a comparison that the same formulae are used for each of the centrifuges being considered, rather than simply accepting a manufacturer's value for such parameters. The formulae presented here are, therefore, adaptations of those in common use, utilizing those measurement which are usually available.

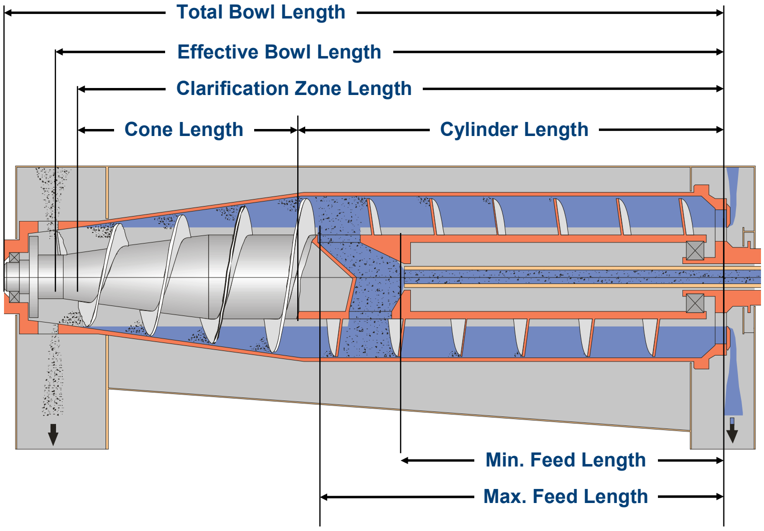

Figure 1a: Internal measurements of a decanter centrifuge

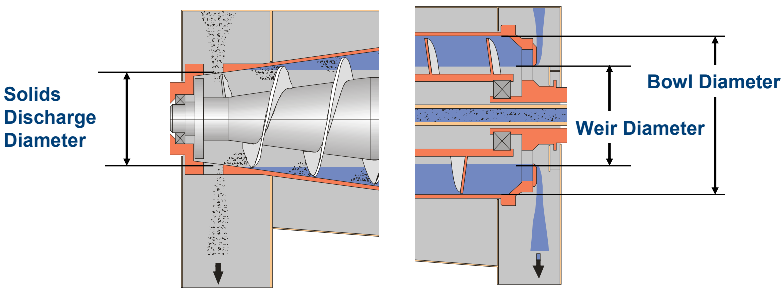

Figure 1b: Internal measurements of a decanter centrifuge (contd)

The measurements and parameters which an engineer will need to carry out a comparison between different centrifuges are the following:

D_B	=	Inner bowl diameter (m)
D_W	=	Weir diameter (m)
L_{cyl}	=	Cylindrical length (m)
n	=	bowl speed (rpm)
α	=	cone angle (^{o})

2.1 CENTRIFUGAL FORCE

This is the most obvious parameter which comes to mind when considering the action of a centrifuge. The maximum centrifugal acceleration, developed inside a centrifuge is a function of its radius and angular rotational speed. More commonly the term G-force or G-value is used instead of acceleration. The G-force is defined as the multiple of the gravitational constant that is obtained in the centrifuge.

A formula for approximating the G-force at the bowl periphery is:

$$G = n^2 . D_B / 1800$$

G	= G-force
n	= bowl speed (rpm)
D_B	= Inner bowl dia. (m)

Consequently the centrifugal acceleration or G-value will increase with the bowl diameter and bowl speed.

Within a particular manufacturer's range of centrifuges, the larger ones will generally run at lower G-forces than the smaller ones, as there are structural limitations to running larger machines at high G values. When comparing machines offered by different manufacturers this is, however, not always the case as the large unit offered by one manufacturer may well run at higher G's than the smaller one offered by the other.

A larger decanter running at the same G-force as a smaller one will give better separation. This means that when comparing two centrifuges of different diameters but similar bowl speeds, the larger unit will generate more G-force and can be expected to provide better separation. This is of particular importance when dealing with ultra fine solids, or the separation of liquid phase with similar densities.

Flottweg's centrifuges are rated to operate at their full design speed, but it is important to note that some manufacturers' machines have an operational speed which is significantly lower than the stated design speed. One should be certain that the correct values are compared.

2.2 SUSPENSION VOLUME

The suspension volume of a decanter can be considered as the total content of the liquid zone in the bowl. This volume may change in relation to the "weir plate" diameter.

The suspension volume (V_S) consists of two components: the volume contained in the cylindrical section (V_{cyl}) and the volume contained in the conical section (V_{cn})

It can be calculated as follows:

$$V_{cyl} = \pi/4 . (D_B^2 - D_W^2) . L_{cyl}$$

$$V_{cn} = \pi/8 . (D_B - D_W)/\tan \alpha . ((D_B^2 + D_B . D_W + D_W^2)/3 - D_W^2)$$

$$V_S = V_{cyl} + V_{cn}$$

D_B	=	Inner bowl diameter (m)
D_W	=	Weir diameter (m)
L_{cyl}	=	Length of cylindrical section (m)
α	=	cone angle (^{o})

The effect of the suspension volume in a decanter centrifuge can be compared to that of a SX settler where a larger settling volume generally leads to a better degree of separation. In a decanter the same hold true for the suspension volume. All other parameters being equal, a larger suspension volume results in better separation.

2.3 RETENTION TIME

Retention time is a parameter most engineers can relate to quite well. Unfortunately it is quite a complicated issue in the case of centrifuges. Different phases are discharged, and as there may a build up of the solid phase in the machine, the retention time should take this into consideration. In most hydrometallurgical applications one does, however, deal with quite dense solids, so the solids generally make up a relatively small percentage of the volume of the feed.

Each manufacturer will also calculate retention time in a totally different manner depending on how they interpret the flow of fluid through the internals of their centrifuge design. So any calculation will be an approximation at best. As long as the same approximation is used, this can still give a sound basis of comparison between different decanters.

The suspension volume provides a reasonable approximation as the basis for calculating the retention time of the centrifuge, giving an approximation of the time which the slurry resides in the centrifuge under the effect of centrifugal forces. The retention time can be calculated as follows:

$$T_R = 3600.V_S/Q$$

T_R	=	Retention time (sec)
V_S	=	Suspension volume (m^3)
Q	=	Volumetric feed rate (m^3/h)

The longer the retention time, the better the separating efficiency of the centrifuge. As can be seen, the larger suspension volume leads to a higher retention time.

This does, however, not give any indication whether the available retention time is actually enough to achieve the desired degree of separation. The actual retention time required for each particular sludge will be different and is affected by parameters such as:

- Particle size
- Relative densities of the phases
- Viscosity of the liquid phases
- Ratio of phases

This is where the manufacturer’s experience with the particular application becomes important. Where an application is new, it would be prudent to carry out laboratory spin tests or even pilot plant trials to obtain a clearer indication of how a particular slurry behaves under centrifugal forces.

For a given feed rate with no change in the speed at which the centrifuge is operated, the retention time of a centrifuge can be varied by changing weir settings, thereby increasing or decreasing the suspension volume. This can be achieved by either installing static weir plates of different diameters, or in more technologically advanced machine by means of an adjustable weir. This gives such machines much greater flexibility.

A further adjustment which can affect the retention time of the solids in the centrifuge is the differential speed between the bowl and the scroll. Slowing down the scroll relative to the bowl means that the solids are conveyed more slowly from the centrifuge. This generally results in a more compact and dryer cake and a clearer centrate.

2.4 DIAMETER AND LENGTH

Decanter centrifuges are generally constructed with specific length to diameter ratios (L:D). Usually values of 2, 3 or 4 are common. For two machines with the same diameter, the longer unit will have a larger capacity for conveying solids and provide a greater suspension volume for settling out fine solids.

When comparing a short, large diameter machine with a long, smaller diameter machine, things are not quite so simple. In spite of all its internal complexity, a decanter centrifuge is still a pipe through which liquid flows, and as such subject to the same problems one can expect with pipes. If the linear velocity increases, so will the turbulence. So while the smaller diameter machine may have a longer clarifying zone, its smaller diameter will result in greater turbulence for a given volumetric flow rate, which will negate some of the clarifying effects.

Some manufacturers will offer significantly smaller diameter machines than their competitors, claiming that they can achieve the same flow rates through these machines. While the flow rates may be achievable, it is highly unlikely that the same separation performance would result.

2.5 BEACH ANGLE

When solids are transported along the beach of a decanter (the conical section), there is a force acting on the solids in the direction of the liquid pool, named the SLIPPAGE FORCE (S) as shown in Figure 2. This force depends on the value of the difference between the specific gravity of the solid and the surrounding medium. This means that the slippage force increases considerably when the solids pass out of the liquid pool onto the beach where they are surrounded by air.

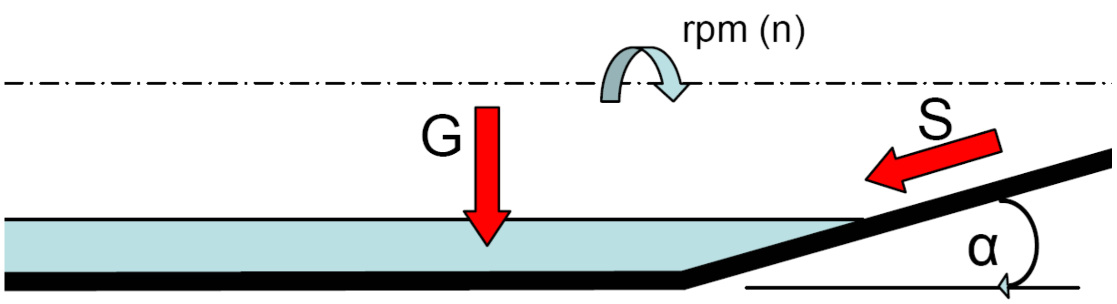

Figure 2. Slippage force on the beach of a decanter centrifuge

For a given set of feed densities the slippage force can be calculated as follows:

$$S = G \cdot \sin \alpha$$

G = Gravitational force generated by the centrifuge
α = The cone angle of the centrifuge

Centrifuge with a small cone angle generate lower slippage forces than ones with a steep cone angle. A small cone angle is desirable when the solids do not compact well and have a soft texture such as in the case of digested sewage sludge.

A low cone angle also is advantageous when dealing with highly compacted solids which require high torque to convey. A lower cone angle results in a lower wear rate on the scroll.

Steeper cone angles are suited to materials which are conveyed easily by the scroll. They also result in a greater pond depth.

2.6 CLARIFYING AREA

This is a parameter which is often used to make one centrifuge appear more effective than the other. The clarifying area in square meters is the wetted surface of the bowl interior. The problem with this value is that every manufacturer uses a different formula to calculate it. There is no common standard formula for this parameter. The results obtained by the various formulae in use vary significantly, as can be seen in Table 1[3], where the clarifying area for 73 cm diameter decanter with a 4:1 length to diameter ratio is calculated.

Table 1: Clarifying area based on the formulae used by different manufacturers

Origin of Formula	Calculated Clarifying Area (m^2)
Flottweg	3.89
Manufacturer A	4.73
Manufacturer B	4.61
Manufacturer C	4.10
Manufacturer D	5.81
Manufacturer E	6.52
Manufacturer F	5.50
Sokolov	5.50
Trawinski	5.10

The results vary dramatically. If the clarifying area is to be compared, it is critical that the same formula is applied to each centrifuge. Of these formulae the one used by Sokolov[4] is the simplest and as long as this formula is used for all of the cases, it provides a reasonable basis for comparison of the equivalent clarifying area.

$$A_C = \pi . D_B . L_{Cyl}$$

A_C = Clarifying area (m^2)
D_B = Inner bowl diameter (m)
L_{Cyl} = Cylinder length (m)

In theory, the greater the clarifying area is, the more effective the separation of the centrifuge. In practice the clarifying area is not a precise measurement and can at best be used as an indication, with little bearing on the actual performance of the centrifuge.

2.7 EQUIVALENT CLARIFYING AREA

This is a value which aims to put the effectiveness of a centrifuge into terms which are easier to visualise. Essentially a centrifuge can be likened to a settling pond in which high G forces are applied to improve the settling characteristics of the phases. One could visualise this pond being wrapped around a screw conveyor or scroll as shown in Figure 3[5].

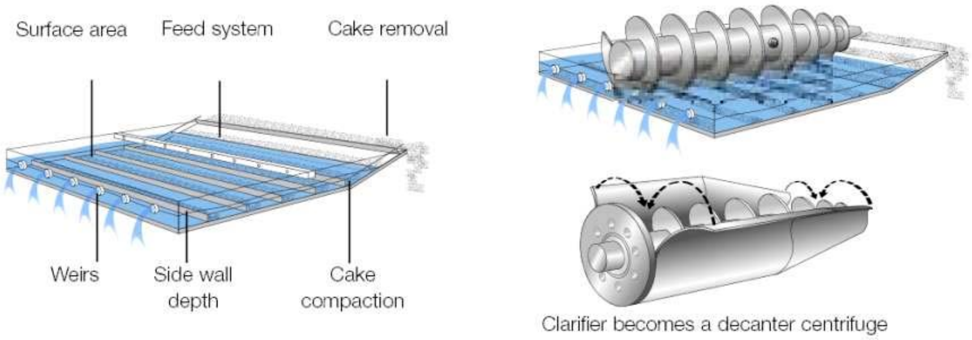

Figure 3: From settling pond to decanter centrifuge

In order to get an idea of the relative settling capacity of a centrifuge, one can calculate the Equivalent Clarifying Area or Sigma value (Σ)

$$\Sigma = A_C.G$$

Σ	=	sigma value (m^2)
A_C	=	Clarifying area (m^2)
G	=	G-force (m)

This Σ can be seen as the equivalent surface in square meters of a static settling pond required to produce the same separation result as the centrifuge.

Resubstituting the previous formulae gives:

$$\Sigma = (\pi.\ n^2.D_B^2.L_{cyl})/1800$$

As can be seen, the effect of the diameter of the bowl is more pronounced than that of the length of the bowl. Increased bowl speed and increased length of cylindrical section of a centrifuge will tend to improve the settling of fine solids, resulting in a clearer liquid phase, but this is of little relevance when the solids settle easily.

Given two machines generating the same G forces, the one with the larger diameter would tend to be more effective in achieving separation, assuming that both machines are properly designed for the given application.

On the other hand, a larger diameter leads to thinner phase layers in the centrifuge which can make precise phase separation more difficult, particularly if one of the liquid phases is only present in small quantities. This can be overcome by control systems such as adjustable weirs.

As Σ is dependent on the clarifying area, it is also prone to the same multitude of values as different manufacturer's formulae come into play, as shown in Table 2. This tends to be abused as a marketing tool to make one manufacturers machine look better than the next. Any quoted values for the machines of different manufacturers should therefore be treated with caution.

Table 2: Equivalent clarifying area based on the formulae used by different manufacturers

Origin of Formula	Calculated Equivalent Clarifying Area (m^2)
Flottweg	7395
Manufacturer A	10946
Manufacturer B	14211
Manufacturer C	7798
Manufacturer D	16196
Manufacturer E	19485
Manufacturer F	15113
Sokolov	16984
Trawinski	12712

3. OPERATIONAL AND CONTROL PARAMETERS

As should be apparent from the previous chapter, the physical parameters do not provide a very reliable basis for comparison. They definitely need to be viewed in conjunction with the operational parameters. The operational parameters provide numerous options which may be desirable or essential for a particular application. The one which can be most easily evaluated are:

- Drive system
- Power consumption
- Weir control
- Specific field experience

3.1 DRIVE SYSTEM

There are several aspects of the drive systems which should be considered, depending on the requirements of the application. The more important ones are:

1. Variable frequency drive control
2. Independent scroll and bowl control
3. Soft start ability

Variable frequency drive (VFD) control is particularly desirable in applications where fluctuations in the feed composition and feed rate expected. Such a drive system makes it possible to vary the differential speed of the scroll and the bowl online. This adjustment can be used to achieve effects such as a dryer cake discharge or a clearer centrate discharge as it effectively increases or decreases the length of the path that material is forced to travel through the centrifuge. Less sophisticated systems would achieve this adjustment by changing the drive belts on the centrifuge. This can be quite time consuming and is not an option when variations occur frequently.

Advanced drive systems, such as Flottweg's SIMP drive, make it possible to carry out such adjustments on-line without interrupting the operation of the centrifuge. The adjustment is so sensitive that differential speeds can be controlled to within 0.1 rpm. This makes it possible for the operator to tailor the machines performance as and when required by the process conditions.

Fluctuating solids loads also create a risk of overloading the centrifuge with solids. This can lead to severe damage to the gearbox in a situation where the centrifuge becomes choked with solids. The VFD's can be operated on a torque control loop. This will monitor the torque on the scroll, which increases with increasing solids loading. At a maximum set point the system would speed up the scroll to discharge the solids more quickly, while at the same time reducing the speed of the feed pump to reduce the load. Such a system will prevent the centrifuge from ever getting chocked with solids.

Independent scroll and bowl control, as provided by the SIMP drive, also makes it possible to start the machine with only the scroll turning. This option is very useful in areas plagued by power failures, such as South Africa. If power fails during operation, solids remain trapped in the centrifuge. If these solids set in the unit it will be very difficult to discharge them if both the bowl and the scroll turn together. Re-starting the centrifuge with only the scroll running usually makes it possible to discharge these solids without having to strip the centrifuge.

Soft start ability is particularly useful on larger machines. Centrifuges can have quite large motors and the starting load on these motors can be significantly higher than the normal running load. A soft start system starts the centrifuge turning slowly and accelerates it to full speed over a period of 5 to 10 minutes. This negates the need to cater for high start-up power requirements.

3.2 POWER CONSUMPTION

There is a tendency to offer machines with low power rating motors. The lower power rating is implied to mean lower power consumption, which is seen as a selling point. While one machine may have a 17 kW motor and the other a 22 kW motor, this does not necessarily mean that the one will use less power than the other under normal operating conditions. Drawing an analogy from motor vehicles, just because Bugatti build a car that develops 1000 kW, it does not mean that it uses this power when cruising along a freeway at 120 km/h. In centrifuges the larger motor may have been selected to allow for load fluctuations and provide a system that will run more reliably over time. Particularly in applications where the feed composition tends to fluctuate significantly, spare power capacity in the motors and the ability to provide more torque ensures that the centrifuge is able to automatically absorb these fluctuations without problems.

Some manufacturers have taken to issuing marketing material which compares their motor size with that of the competition for a particular application, with the claim that their machine requires less power. Such comparisons are generalisations which have little meaning. Each manufacturer will typically have a range of motor sizes for a centrifuge model, and the actual one chosen will depend on the particular application.

As luck would have it, many mining and hydrometallurgical operations are to be found in very remote locations. This makes it useful if the motors and VFDs used to drive a centrifuge are easily sourced, standard models with representation around the world. This is not the case for all manufacturers as some have developed their own systems which can only be sourced from their own factory.

3.3 WEIR CONTROL SYSTEMS

This has become a vital aspect of centrifuge control. In the past decanter centrifuges were equipped with static weir plates, which could be exchanged to adjust the pond depth (and thus the retention time) of the centrifuge. Changing these weir plates required the machines to be shut down, and opened. This is a laborious process and really only suited to applications with little or no fluctuation in the feed composition.

More modern machines have weirs which can be adjusted externally without the machine having to be opened. The most high tech designs permit such adjustments to be made while the machine is in operation. Flottweg's impeller disc design allows step-less adjustment, which even permits the three phase separating Tricanter® to be operated as a two phase separating decanter. This gives the operator fine control over the machine and ensures that the best possible separation of phases can be maintained. Such control is critical for applications with highly variable feed consistencies such as SX crud. Not all manufacturers are able to provide such systems.

There are, however, significant differences even within the selection of adjustable weirs on the market today. Depending on the applications requirements, it may be essential to understand exactly how the weir system in each case actually works. SX crud treatment is again a fine example as this particular application has the unusual feature of possessing four phases in most cases, instead of the expected three. The 4th phase builds up at the interface of the light and heavy phase within the centrifuge. As the object of crud treatment is to recover a clean organic solution, the 4th phase must, needs be, discharge with the aqueous phase. This is, however, only possible if the adjustable weir allows an off-take point to interface directly with both the aqueous phase and the 4th phase. Not all weir systems are able to achieve this.

3.4 SPECIFIC FIELD EXPERIENCE

This is particularly important in the hydrometallurgical field as the composition of ore bodies and processing methods differ so widely that a certain application in one part of the world may behave totally differently from the same application in another part of the world.

For example, Chilean SX plant have significantly less crud than those in Zambia. Factors such as flocculant addition, occurance of clay in the ore, agitation leaching instead of heap leaching all contribute to make this a very complex application. This means that successful references in Chile do not necessarily mean that the same can be achieved in Africa or Australia.

As the mining and metallurgical industry has such extremely diverse application, there will not always be references available for every particular application. Where references are supplied, these should be followed up on, as existing users of the equipment would be able to give unbiased opinions not only on what size machine would be the correct choice, but also on their experience with the performance of the unit and the service back-up.

Each centrifuge should be purpose built for the specific application. No centrifuge will provide a cure all, yet some manufacturers will offer the same machine for virtually any application. It is advisable to have some discussions with the manufacturer to establish whether or not he has sufficient understanding of the particular process requirements, and what features the centrifuge has that would optimise its performance in the application.

4. LONG TERM ASPECTS

The long term aspect are those who's importance will only become apparent during the life of the centrifuge. The most relevant ones are:

- Materials of construction
- Wear resistance
- Spare parts
- Capital expenditure

4.1 MATERIALS OF CONSTRUCTION

Engineering firms will often state which material of construction is to be used in the manufacture of a piece of equipment. While the material may be acceptable for items such a piping and tanks, it may be dangerous in the case of centrifuges. Centrifuge materials of construction have to have three primary properties: corrosion resistance, abrasion resistance and extreme structural strength. If the wrong choices are made, the results can be quite catastrophic.

An example of such a situation is an environment of low pH and high chloride, where SAF 2205 is a common material of construction. It is, however, still susceptible to a degree of pitting, crevice corrosion and stress corrosion cracking[6,7]. It is the stress corrosion cracking which is of particular concern. Failure due to this mode of corrosion in piping and tanks generally lead to leaks which need not necessarily present a major hazard. Crevice corrosion in the case of a centrifuge can lead to catastrophic failure, which can easily result in serious injuries. A better choice would be SAF 2507. This material is significantly more resistant to these modes of corrosion. It would typically increase the cost of the centrifuge by about 15 %, but this does not seem a great price to pay for added safety on a machine which can be expected to have an operational lifespan of 20 to 30 years.

A conscientious centrifuge design engineer will first look at the specification of the operating conditions rather than which material is asked for. Better material choices may result in higher prices. If one manufacturer provides a quotation in a stronger material of construction than another manufacturer, then it would be prudent to find out why, rather than just to go for the cheaper choice.

4.2 WEAR RESISTANCE

Certain components in a centrifuge are inherently wear items. These include the scroll, feed chamber and the various bushings around the discharge ports.

There are a variety of options for wear resistant materials, ranging from plasma spray coatings to tungsten carbide tiles and even ceramic inserts.

To the client the relevance of these options is not only their life span but also how easily they can be replaced when necessary. Ideally bushings should be field replaceable.

The geometry of discharge ports is also an issue. There is a tendency to think that tungsten carbide is the most effective wear lining. While tungsten carbide inserts are commonly used, they can only be produced in simple shapes with even thicknesses. This means that the shape of the discharge ports lined with tungsten carbide are not always optimal for the performance of the machine. Materials such as chilled cast metal can have more complex shapes allowing not only the shape and size of the discharge port to be optimised, but also thicker material to be used in the areas of greatest wear. In this manner one can provide bushings which are cheaper than tungsten carbide but actually last longer.

The scroll is the major wear item and is considered a strategic spare part. A new scroll will take in excess of 8 weeks to manufacture, so it is best to have one in stock. When required, a qualified technician can swap out the scroll in a day and have the machine up and running again.

Generalised claims on the service life of wear parts are less than meaningless. There are simply too many factors playing a roll in the wear of a scroll or bushing to be able to claim that the service life of one manufacturer's parts is significantly higher than that of the other.

A good example is that of two SX plants in Zambia. One runs its Tricanter in exemplary fashion and gets around 12 000 running hours out of a scroll. The other has not optimised its decruding operation and as a result feeds crud with a solids concentration vastly above design to the Tricanter. The service life of the scroll is only 4 500 hours in this case. This is simply one parameter of many which manages to totally skew the performance of the wear items.

4.3 SPARE PARTS

Apart from the ease of exchange of spare parts the other factor one needs to consider is their cost. It is quite common in the centrifuge industry for manufacturers to mark down the capital equipment and make up for it on the expensive spare parts. It would therefore be prudent for the client to request a quotation on running spares for two years operation, as well as on strategic spares such as the scroll and drives.

4.4 CAPITAL EXPENDITURE

Capital expenditure should be considered a long term aspect because of the long service life of centrifuges. Their costs needs to be seen in term of how long one will be relying on this particular piece of equipment.

This is what often makes or breaks the decision for a particular make of centrifuge. One of the makes on offer is more expensive, be it by 10 % or 25 %. The question that needs to be asked is "Why?". There are only so many aspect of centrifuge construction where savings can be made. The most important ones are as follows:

1. Labour cost: Some manufacturers are building their centrifuges in countries such as India and China, where labour costs are significantly lower, but quality control can be questionable.
2. Materials of construction: As mentioned before, one manufacturer may offer a higher grade of material than another. This can easily add 15 % to the cost of the unit. The client should be certain that he knows the reasons for this choice.
3. Spares costs: As mentioned above, the initial cost may be low because the cost of spares is high.
4. Size of the unit: As should be clear from the content of this paper, when it comes to centrifuges size definitely does matter, both in terms of performance and cost.

   Manufacturers are unlikely to offer units which are too large for an application as this would almost certainly price them out of the market. Ideally the machine should be able to comfortably handle the required throughput, and have a bit of spare capacity for production/feed fluctuations.

   What does tend to occur is that manufacturers will offer machines which are marginally sized to handle the required feed. This means they will function OK if everything runs smoothly, but are unlikely to have spare capacity to allow for the unexpected or for the inevitable increase in plant production.

   This practice is particularly common in applications where flocculant/polymer additions are required. An undersized centrifuge can still perform adequately if more polymer is added. Even if there are contractual penalties for exceeding the polymer targets, these are usually a small fraction of the cost of the machine. So some manufacturers will take this risk and pay the penalty if it comes to that. The sale has been made, but the client ends up bearing the added polymer costs in the long run.

5. CONCLUSION

There are many other factors which affect the performance of a centrifuge. The design of the scroll and the layout of its flights is a case in point. These factors are, however, much more complex and there is no simple way to provide a basis of comparison. The parameters presented in this paper are those most commonly used to gauge the capacity of a decanter centrifuge. By comparing them the client should be able to establish how the capacities of the offered machines differ. These parameters should not be seen as individually decisive indicators of performance, but combine to permit a more informed evaluation of what is being offered.

While a centrifuge is an expensive item, it is rarely a major component of the overall cost of an installation. It is, however, quite often a critical component. What needs to be kept in mind is that a centrifuge can easily have a lifespan in excess of 25 years. In some applications a centrifuge can have a payback period of under 5 months[8]. In light of this, is it really sensible to opt for the marginally cheaper option, simply on the basis of its price?

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