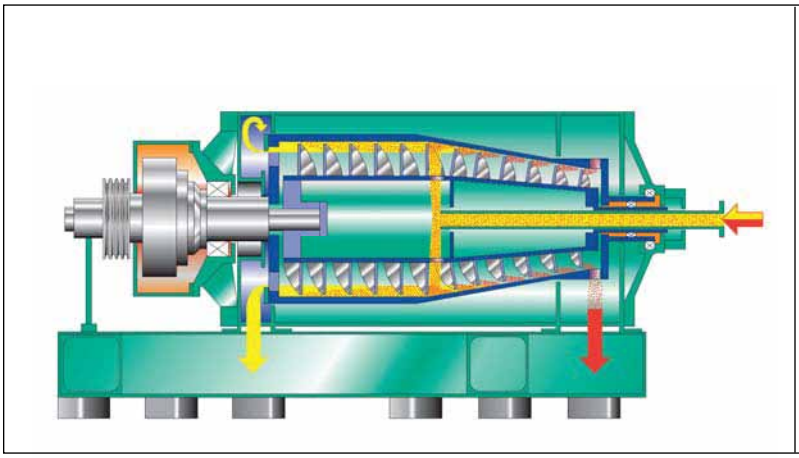


Figure 1—Decanter (closed-bowl) centrifuge.

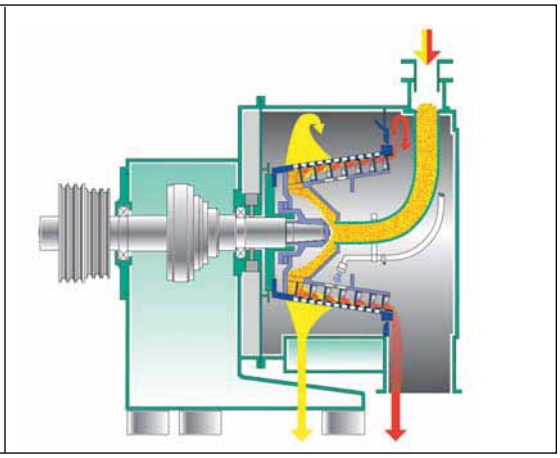


Figure 2—Screen (open-bowl) centrifuge.

Gear Drives

USED IN CENTRIFUGE APPLICATIONS

STEFANIE BURNS AND CHRIS MAYR, SUMITOMO DRIVE TECHNOLOGIES

Sumitomo Drive Technologies may not have the centrifuges that Kevin Costner is promoting in the Gulf Oil Spill (*Ed.'s note: The film actor's company, Ocean Therapy Solutions, has developed a device—the V20 Centrifuge—that purportedly can separate oil from water to a purity level of 99.9 percent.*) However, we do provide centrifuge drives that will do just that. How do these drives work? It can be as simple or complex as you like it to be. Centrifuges use a cylindrical motion to force the solids away from the liquid. This concept is being used in the Gulf BP oil spill to separate oil from seawater.

The marketing information provided about these applications is very limited, and the user generally does not have an in-depth understanding, even among engineers, and therefore take information as presented at face value. In order to make better purchasing decisions about centrifuge applications, one must understand the concept of centrifuges and the drives that operate this equipment.

Sumitomo is only one of many that make a gear drive suitable for centrifuges. We offer two different designs of centrifuge gear drives that will break away solids from liquids, i.e.—a decanter (closed-bowl design) and a screen centrifuge (open-basket design). The design preference is dependent on the OEM's equipment design. But for either type, you will need a gear drive to operate the conveyor within the centrifuge.

Decanter centrifuge (Fig. 1). Decanters are closed-bowl type applications providing a housing and bowl that operate at different speeds.

A decanter needs a bowl with a completely closed drum. Inside this bowl is a worm conveyor, with both the drum and the conveyor driven by a gearbox. The bowl is connected to the gearbox housing and the conveyor is connected to the output shaft of the gearbox. It is called a decanter because the liquid pours out as if from a wine decanter; and in the other side there is a solid discharge (similar to wine sediments) that is transferred to the smaller end of the bowl with a conveyor. Inside, the product under process is mixed with liquid and solids, e.g., saltwater, muddy water or oil and water (it just has to be mixed weights).

The liquid runs via centrifugal force at high rotational speed of the bowl towards the larger diameter, and the solids are pushed to the smaller diameter of the bowl. In this tapered area, the solids slowly come out of the liquid and are dried before being disposed. The gearbox is creating differential or relative speed between the conveyor and the bowl. Through this relative speed, the solid transportation works and we are able to separate the liquid from the solid. The gearbox rotates together with the bowl and is driven by a belt drive from the main motor. The bowl operates at the same speed as the gearbox housing, while the input shaft connected to the conveyor is operating at a different speed, creating centrifugal force.

Screen centrifuge (Fig. 2). Screen centrifuges have an open bowl, or what

we call a screen basket. The bowl itself has holes. The basic function is the same—the screen basket (or bowl) is fixed to the gearbox housing and the conveyor belt drive is fixed to the output shaft—both operating at different speeds to create the centrifugal force.

The bottom line: What is centrifugal force? Quoting Schwarz, "This is the most obvious parameter to use when considering the actions 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 (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. The centrifugal acceleration (G-Force) will increase with the bowl diameter and the bowl speed." (Ref.1).

Some manufacturers differentiate themselves by offering smaller-diameter machines, claiming they will achieve the same flow rates as larger-size diameters. While the flow rates may be achievable, it is highly unlikely that the same separation performance will result. The diameter is key when looking for the capacity of conveying solids to provide greater suspension volume for settling out solids. (Ref.1).

Purpose of a gearbox in a centrifuge application.

Typical
Application:

$T_{conveyor}$ = 5,000 Nm
$n_{conveyor}$ = 2,525 rpm
n_{bowl} = 2,500 rpm

1. Centrifuge without gearbox:
   $P_{conveyor}$ = 5,000 x 2,525 / 9,550
   = 1322 kW

2. Centrifuge with gearbox:
   Relative speed = $n_{conveyor} - n_{bowl}$
   = 2,525 – 2,500
   = 25 rpm
   $P_{conveyor}$ = 5,000 x 25 / 9,550
   = 13.09 kW

The centrifuge gearbox allows running the centrifuge with the practicable power requirement. The main power portion is the energy in the rotating mass of the bowl and the conveyor.

Selection of gearbox. Now that you realize you need a gearbox, you must first obtain from OEMs the following information in order to select the proper one:

1. Torque (T_2)
   - This is the torque needed for the conveyor.
2. Rotational Speed (n_3)
   - Rotational speed of the bowl.
3. Relative Speed ($n_2 - n_3$)
   - Speed between the conveyor and the bowl.
4. Is the conveyor faster or slower than the bowl?
   - A gearbox can do either. This is usually a design preference from the OEM (centrifuge manufacturer).
5. Lubrication System
   - Grease Lubricated
   - Oil Bath Lubricated
     * Closed System without Oil Reservoir
     * Open System with Oil Reservoir
   - Oil Circular
   - Oil Once-Through
6. Draft Design
   - A draft design is usually provided from the OEM in order for the gearbox manufacturer to suggest a proper size and type.

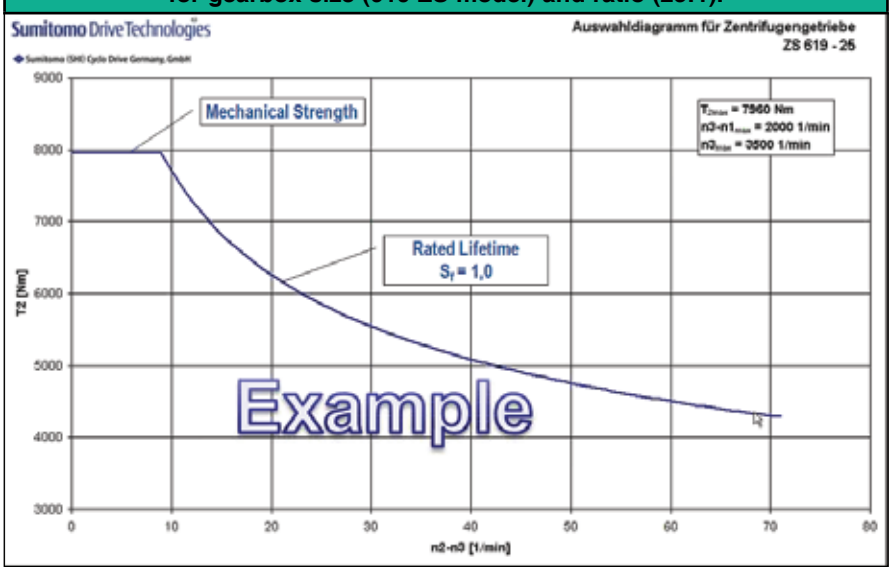
Following is the required information to calculate the proper gearbox:

- n_1 = rotational speed of high speed shaft
- n_2 = rotational speed of slow-speed shaft and conveyor
- n_3 = rotational speed of gearbox housing and bowl
- n_2–n_3 = relative speed between slow-speed shaft with conveyor and gearbox housing with bowl
- n_3–n_1 = relative speed between gearbox housing and high-speed shaft
- $(n_3–n_1)/(n_2–n_3)$ = relation between relative speeds (= ratio i of the gearbox)
- $–i$ = slow-speed shaft and con veyor are faster than bowl
- $+i$ = slow-speed shaft and conveyor are slower than bowl
- T_2 = torque at slow-speed shaft and conveyor

Example—Table 1. Here is a selection diagram that shows the available torque over the differential speed for a certain gearbox size (619 ZS model) and ratio (25:1). It shows the maximum torque (8,000Nm) and maximum-input, relative speed (2,000 rpm), as well as the maximum bowl speed (3,500 rpm). If we divide the maximum-input relative speed by the ratio (2,000/25), we are then able to produce up to a 70-rpm differential speed on the output side. This diagram is limited by the mechanical strength at the maximum torque and by the rated life of the eccentric bearing (in this case, service

continued

Table 1—Selection diagram—available torque over the differential speed for gearbox size (619 ZS model) and ratio (25:1).



factor = 1.0) in that it has a B10 life of 8,000 hours. If we continuously run the machine at 40 rpm and a little over 5,000 Nm, then we have a rated life of approximately 8,000 hours. This is the philosophy behind selecting the correct product.

Sumitomo's centrifuge drives—Table 2. Sumitomo offers a variety of gearboxes that are used in both decanter and screen centrifuges. The balanced housing is connected with the bowl and turns at the bowl speed. The output shaft of the centrifuge reducer is connected to the conveyor and transmits the torque that is needed for the solids transport. The input shaft can be locked by a torque arm or driven by a backdrive motor to provide the necessary relative speed.

The flexible lubrication system allows grease lubrication as well as oil lubrication—depending on a user's requirements. Mounting dimensions can be designed to fit into all applications.

Sumitomo offers four different main types of drives available that meet users' specifications for centrifuges:

ZS is a single-stage cyclo drive centrifuge reducer for most applications when the conveyor turns faster than the bowl.

The ZSPN and ZSPV are both double-stage centrifuge drives with a cyclo drive stage and a planetary stage for higher ratios. ZSPN provides the conveyor slower than the bowl (positive ratio); ZSPV provides the conveyor faster than the bowl (negative ratio).

The ZSPR is a very special double-stage centrifuge drive with a cyclo drive stage and a differential planetary stage. This version allows variable relative speed over the full control range of the motor with either a slower or faster conveyor.

Also available is the purely planetary ZSP as a double- or triple-stage design. This type is mainly used for applications with high bowl speed and high differential speed.

What is a "cyclo" drive stage? Sumitomo's cyclo drives are cycloidal reducers intended for gear drive applications. The cyclo's epicycloidal design has advantages superior to speed reducers using common involute tooth gears, in that cyclo components operate in compression, not in shear. Unlike gear teeth with limited contact points, a cyclo has two-thirds of its reduction components in contact at all times. This design enables cyclo speed reducers and gear motors to withstand shock loads exceeding 500% of their ratings while providing exceptional performance, reliability and long life in the most severe applications (Fig. 4 and Table 3).

Table 2—Sumitomo drives for users' specifications for centrifuges.

Type	Cyclo	Planetary	Stage	Shaft	Ratio	Rotating Direction Input/Output
ZS	X		1	3	-	Opposite
ZSPV	X	X	2	3	-	Opposite
ZSPN	X	X	2	3	+	Same
ZSPR	X	X	2	4	+/-	Same/ Opposite
ZSP		X	2 or 3	3	+/-	Same/ Opposite

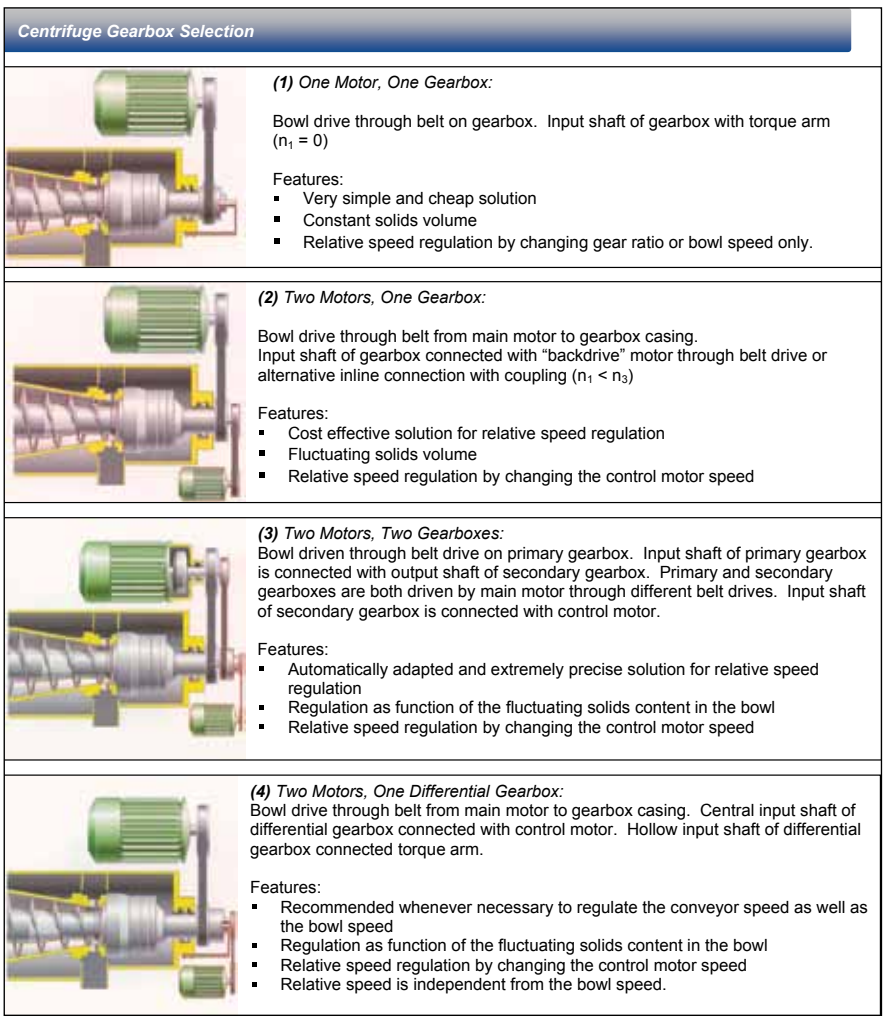


Figure 3—Centrifuge gearbox selection.

Conclusion

Centrifuges have been used in oil fields since the early 1950s. More recently, their role in the oil field has expanded to include environmental cleanup. Unfortunately, processing through a centrifuge alone will not solve the disaster in the Gulf. This is only a small portion of the oil separation process and will require further treatment.

BP has already purchased over 30 centrifuge drives to clean up the oil spill in the Gulf. (Officials) say skimmer ves-

sels will pump oily water onto a barge where the centrifuges can process a total of 600,000 gallons a day, separating the gunk from the water.

Centrifuges are a technology that will continue to improve, develop and be used in all types of applications that require separation of liquid from solids.

References:

1. Schwarz, Nils. "Selecting the Right Centrifuge—The Jargon Demystified," Whitepaper.
2. Mayr, Chris. "Sumitomo Centrifuge Gearboxes—Training," June, 2010. Sumitomo (SHI) Cyclo Drive, Germany GmbH.

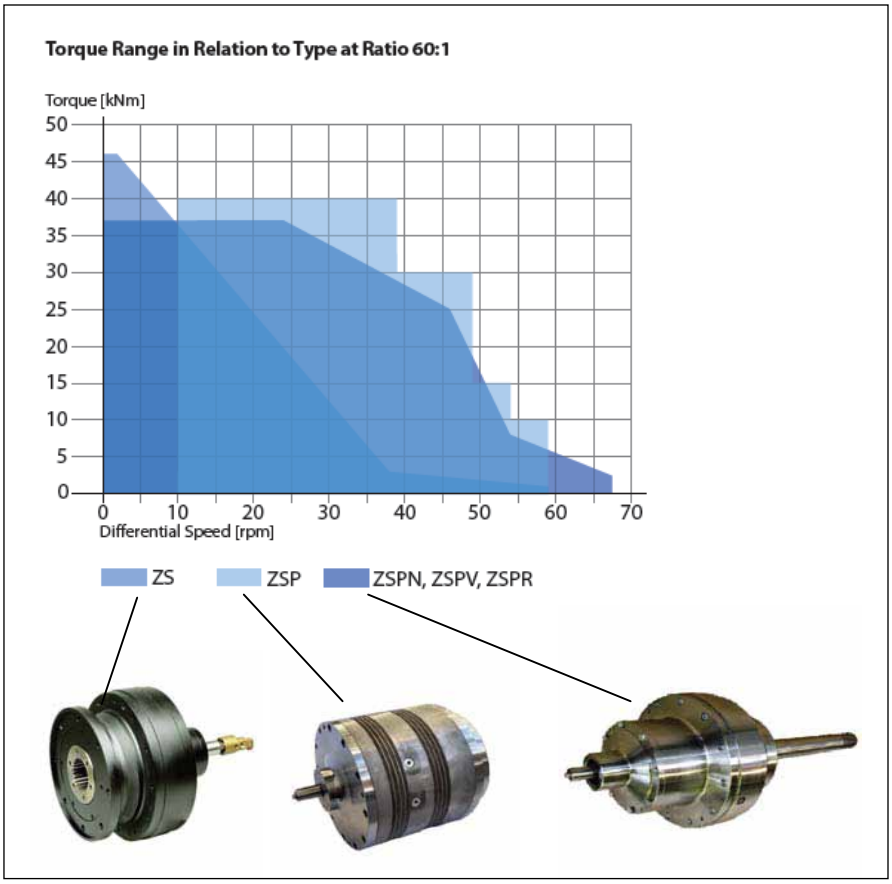


Figure 4—Torque range in relation to type at ratio 60:1.

Table 3—Selection of gearbox type.

	ZS	ZSPV	ZSPN	ZXPR	ZSP
Torque Range	3	2	2	2	1
Shock Overload	3	2	2	2	1
Lubrication	3	2	2	2	2
Bowl Speed	2	2	2	2	3
Relative Speed	1	2	2	2	3
Speed Variation	1	2	2	3	2
Diameter	1	1	1	1	3
Weight	2	1	1	1	3
Cost	3	2	2	1	1
	19	16	16	16	19

**** 1 = Good, 2 = Better, 3 = Best***
***** Sumitomo is the only centrifuge gearbox manufacturer who supplies a complete range of ALL possible types of centrifuge gearboxes.***