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Comparison between Cast Iron Drive Units and DBS Fabricated Steel Drive Units

DBS Drive Unit

Typical Cast Iron Drive Unit

Design Comparison

	Cast Iron Drive	**DBS Fabricated Drive**
General	Typically use worm gearbox, cast iron final gear with replaceable steel strip liners and ball bearing	Always use planetary gear, forged alloy steel final gear and four point contact precision bearing
Primary Reducer	Helical or worm gear-motor	Helical gear-motor
Connection between the Primary and Intermediate Reducers	Chain & sprocket	Direct drive shaft
Intermediate Reducers	Worm type reducer	Planetary type reducer
Lower Pinion Bearing Support.	Yes	No
Final Main Gear	Spur gear ductile iron or cast Iron	Spur gear forged alloy steel 4340 – induction hardened for maximum strength and durability
Pinion Gear	Spur Steel Gear	Spur gear induction hardened for maximum strength and durability
Main Bearing	Steel bands (strip liners) and balls.	4 point contact precision bearing.
Housing	Cast Iron	Fabricated steel ASTM A36
Shear Pin Protection	Yes	Yes
Torque Gauge Indication	Yes	Yes
Alarm & Cut Off Switches	Yes	Yes

Advantages of the DBS Fabricated steel drive unit.

1. **No Chains, Sprockets or Guards:** DBS drive units are all direct driven, no chains, sprockets or guards. Efficient and maintenance free. Safe – No exposed rotating components.

2. **Efficient and Heavy Duty Intermediate Reducer:** DBS drive units use highly efficient (92%) planetary gearboxes. Worm gearboxes used by cast iron drive units are not efficient (70% or less). The Planetary gearbox is a heavy duty gearbox designed to produce high torque and have high capacity output shaft Timken taper roller bearings to handle the radial forces between the final gear & pinion. Planetary gearbox spur gears have infinite theoretical life per AGMA standards. Worm gears have a 25,000 hour life per AGMA standards.

3. **No Lower Pinion Support Bearing:** Cast Iron drive units have bearings placed below the pinion to support the pinion and handle the radial forces between the main gear and pinion. These bearing are prone to fail, exposed to contamination due to wear particles and condensation. This is typically a major failure problem with cast iron drives. DBS drive units do not have a lower support bearing. The planetary gearbox heavy duty output shaft bearings eliminate the need for a lower pinion bearing support.

4. **Superior Main Turntable Bearing:** Cast Iron drive units have "Strip Liner" bearings which are steel bands inserted into the main housing. This bearing system has a short life because of the low hardness of the steel bands. Balls have a much higher hardness, Rc 55 – Rc 60 riding on steel bands with hardness of Rc 30 – Rc 35 causing accelerated wear on the steel bands. DBS drive units use a precision 4 point contact bearing with nylon spacers, minimizing the pressure applied across the bearing and avoiding direct ball to ball contact. The DBS bearing has a life that is 400 times more than the strip liner bearing design.

5. **Less Maintenance:** DBS drive units have very low maintenance. Except for the final reducer which includes the main gear and pinion, all reducers are semi-fluid greased filled. The lubricant in the primary reducer is recommended to be replaced after 5 years and the intermediate reducer to be replaced after 10 years. Cast iron drive units require replacing balls and strip liners several times during the life of the drive unit. Replacement of the balls and steel bands are very difficult tasks to perform in the field and many times they are done in a shop. The DBS drive unit does not require replacing the main bearings. The life expectancy of the DBS bearing is in excess of 100 years.

6. **Superior Main Gear Housing:** Steel plate is better than cast iron. Cast iron may have inclusions and imperfections, is not ductile and prone to cracking. ASTM A36 steel plate yield properties allow bending without breaking. Cast iron is simply not as good or as strong as steel. Note that modern gearboxes and machine tools made today no longer use cast iron and use fabricated steel. Castings are becoming difficult to obtain in North America due to environmental issues. There is no definitive corrosion resistance advantage between painted cast iron and steel. Furthermore, entire clarifier mechanisms are made from carbon steel, typically ASTM A36.

7. **The DBS Gear has more strength and durability:** Due to the limitation of cast iron material, based on AGMA standards, the main gear has much less capacity than the forged alloy steel gear used in DBS drive units. Most cast iron drive unit capacities are overstated. The surface durability is generally one half of the torque rating stated and completely ignored.

8. **More reliable and precise Torque Gauge:** The DBS torque gauge is highly accurate and has a large diameter face (6”) for easy visual reading. The torque gauge indicates real units of torque and is made of stainless steel construction. The torque gauge system of a cast iron drive unit, which measures the thrust movement of the worm gearbox high speed shaft, is inaccurate, unreliable, and susceptible to temperature changes and requires periodic recalibration. Torque indication is 0-100%, 1,2,3,4, or a color range (green, yellow, and red).

9. **DBS drive units use commercial components:** Commercial components are easily available across the country. Cast iron drive units use proprietary components and do not offer other alternatives. The customer has no choice but to go back to the manufacturer for parts resulting in extensive delivery times and steep prices.

10. **The DBS shear pin is designed to be replaced very easily.** Unlike the Cast Iron drive units, the shear pin is located above the primary speed reducer and is as simple as removing a cap with two screws and a snap ring.

11. **Many options are available:** Many options available with the DBS drive unit are not available with cast iron drive units, such as 4-20mA transmitters for remote indication of torque, reversible with torque overload protection, stainless steel housings, and condensate control units.

12. **Detailed Operation & Maintenance Manuals:** DBS O&M Manuals include all information regarding every component used in the drive unit providing the original manufacturer's name and part number, down to the smallest of components such as bearings and seal.

13. **10 Year Warranty on Main Gear & Bearing:** DBS is the only drive unit manufacturer that offers a 10 year warranty on the main gear and bearing.

A Comparative Study of the Life and Durability of Cast Iron and Forged Steel Clarifier Drive Gears and Bearings

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Introduction

Water treatment clarifiers and thickeners were among the earliest commercial devices to utilize large diameter anti-friction bearings and gears. The successful performance of these bearings and gears while operating continuously in adverse outdoor environments is a tribute to those early designers and manufacturers.

Those early manufacturers were constrained by the manufacturing technology that was available in the early 1900s. At that time, the only economical way to manufacture a large diameter gear or bearing was to make an iron casting. This method of manufacturing clarifier drives was successful, and is still used today by some manufacturers on their light duty clarifier drives.

Large diameter bearings and gears were used in these early drive units for two reasons. The first was that a large diameter gear was necessary to produce the torque required for driving a clarifier or thickener. The second reason was that the simple bearing used to support the cast iron gear had to have sufficient diameter to keep the center of load of the clarifier mechanism within its ball path. If, due to overturning moments, the center of load were to fall outside the ball path the gear would tilt up in the bearing raceway causing high point loads on the gear and precipitating early gear and bearing failure. In many clarifier designs the need for the large diameter bearing was of prime importance as can be seen in some job specifications that specify the ball path diameter, not gear size or actual torque requirements.

Today, due to many advances in manufacturing technology and metallurgy, there are modern bearings and gears that can be used in clarifier and thickener drive units that offer superior life and reliability to these mechanisms. This paper will compare the most common and economical of these gear/bearing units with the traditional cast iron gear and bearing.

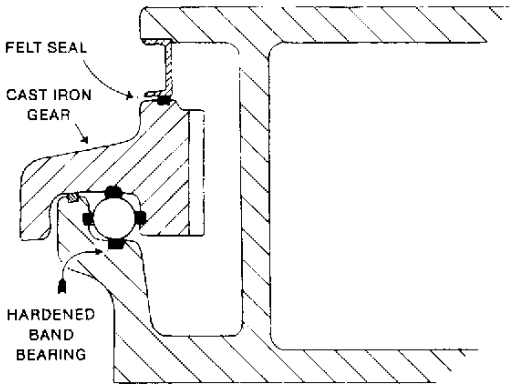

FIGURE 1 - CAST IRON DRIVE WITH INSERTED RACEWAY BEARING

Bearing Comparison

The traditional cast iron drive unit uses an inserted raceway construction bearing. This bearing (fig. 1) is made up of four hardened steel bands that are inserted in grooves machined in the cast iron drive housing and gear. This bearing uses a full complement of bearing balls – that is no spacers between the balls to prevent ball-to-ball contact.

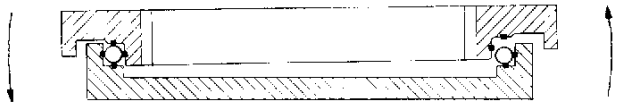

FIGURE 2 - CAST IRON DRIVE GEAR CAN LIFT OUT OF ITS RACEWAY CAUSING PREMATURE BEARING AND GEAR FAILURE IF SUBJECT TO AN OVERTURNING MOMENT

This type of bearing is very inexpensive to manufacture, however, it has several weaknesses. First, the bearing can handle only compressive and radial loads whose resultant is compressive and whose line of action (fig. 2) is within the diameter of the bearing raceway. Second, the bearing has wide tolerances which lead to inconsistent loadings in the bearing and on the gear teeth. Third, due to the simplicity of the bearing design, the life is relatively short, usually 100,000 hours (Approx. 11.5 years) in clarifier service.

Modern drive units utilize the four-point contact ball bearing. This type of bearing is widely used in many heavy duty applications such as excavators and cranes. These types of bearings are manufactured by several manufacturers and are relatively economical. In relation to the inserted raceway construction bearing, the four-point construction bearing has several important advantages. First, the four-point bearing can take compressive, tensile, and radial loads in any combination and the resultant load position has no effect on the performance of the bearing. Second, the tolerances within the four-point bearing are tight, usually approximately 0.003". Third, the life of the four-point bearing is very high, usually over 10,000,000 hours (approx. 1,000 years) in clarifier service.

FIGURE 3—FOUR POINT CONTACT BEARIN GCROSS SECTION

Figure 3 shows a typical cross section of a four-point contact ball bearing. These bearings are produced with or without gears cut on the inner or outer raceway forgings. The typical bearing unit is made from roll forged alloy steel heat treated to 250 to 300 BHN. The bearing raceway is machined in the forgings then hardened to approximately 60 Rc and ground to the proper

dimensions. The bearings balls are separated with nylon spacers that prevent adjacent balls from rubbing against each other.

These bearings typically employ a 60 degree contact angle, which means the bearings are intended for predominately thrust loads. This usually is the case when the bearings are used in cranes, excavators, and large clarifiers.

Gear Comparison

Cast iron gears have the advantage of being inexpensive and easy to manufacture; however, they have several weaknesses. First, the casting is subject to internal weaknesses from inclusions or blow holes that cannot be detected except by X-ray or ultrasonic inspection, which no clarifier manufacturers employ. Second, the mechanical properties of cast iron are generally low which can only be overcome by producing gears with sufficiently large faces or diameters to obtain the strength needed to handle the required torque loads.

Drive units that employ the four-point contact bearing will have the gear cut on the outer or inner race of the bearing. Producing a gear that is integral with the bearing has several advantages. First, the material used is a high quality alloy steel forging (usually AISI 4140) heat treated to 250 to 300 BHN. The use of a forging virtually insures uniform mechanical properties in the gear, and forgings offer superior grain formation for toughness and strength. These superior mechanical properties allow forged alloy steel gears to be smaller than a cast iron gear of similar torque capacity. Second, manufacturing the gear integral with the bearing produces a rigid structure which allows minimal gear movement outside of the rotational plane.

Conclusion

Modern clarifier and thickener drive units that use the four-point gear bearing unit have a number of important advantages over the traditional cast iron drive unit. These advantages add up to longer life of the drive through greater reliability. The four-point contact bearing can handle large overturning moment loads and thrust loads. Unlike inserted raceway bearings, the diameter of the ball path is of no consideration as long as the bearing has the capacity to support the clarifier mechanism. The gear that is part of the four-point contact bearing has superior mechanical properties in relation to cast

AGMA COMPARISON

Assume two gears are identical in all respects, except one is made of AGMA Class 40 cast iron (The highest grade) and the other is made of allow steel heat treated to 300 BHN. By comparing the AGMA formulas for surface durability – and strength – the superiority of the forged gear can be demonstrated.

1. AGMA SURFACE DURABILITY – 2001-C95

$$S_{ac} = C_p \sqrt{\frac{W_t C_a}{C_v} \frac{C_s}{d\ F} \frac{C_m\, C_f}{I}}$$

All factors will be the same except C_p and S_{ac}.

CAST IRON: $C_p = 2100$ $S_{ac} = 85{,}000$

FORGED STEEL: $C_p = 2300$ $S_{ac} = 135{,}000$

A comparison of the surface durability of each gear shows that the forged gear will have 210% higher surface durability than an identical cast iron gear.

2. AGMA STRENGTH – 2001-C95

$$S_{at} = \frac{W_t K_a}{K_v} \frac{P_d}{F} \frac{K_s K_m K_b}{J}$$

All factors will be the same except Sat.

CAST IRON: Sat= 13,000

FORGED STEEL: Sat = 47,000

A comparison of the strength of each gear shows that the forged gear will have 360% greater strength than an identical cast iron gear.

iron gears, therefore the gears can be smaller in diameter or smaller in face width. The net result is that a clarifier drive unit using a four-point contact gear/bearing will have superior gear mechanical properties, and the bearing which supports the clarifier mechanism will outlast the inserted raceway bearing in the cast iron drive by a factor of 100:1. The more rigid mounting of the gear will also be a strong factor in extending gear life, and the extremely long life of the four-point contact bearing eliminates the need to rebuild the clarifier drive every ten years or so, greatly reducing operating cost.