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PUMPS STEAM TURBINES BUILDING & FIRE WASTEWATER SERVICE

PUMP CLINIC 26

ORIGINS OF SEALLESS PUMP TECHNOLOGY

INTRODUCTION

The origins of seal/less magnetically driven pumps date back to 1933 when the first known patent was granted in the UK.

Early commercial development of the magnetic drive pump was pioneered by Geoffrey Howard of HMD Pumps Limited, UK in the late 1940's and a few years later by Franz Klaus in West Germany.

This development was in response to a need for 100 percent containment of diphyl heating fluids. At that time, development of mechanical seals had barely started, and all dynamic seals were prone to leakage, especially at elevated temperatures. Two companies pioneered the use of magnet-drive pumps; Imperial Chemical Industries in the UK and Bayer in West Germany.

For the first 30 years, their application was limited essentially to pumping life threatening or extremely hazardous fluids. Because of the higher cost of the equipment, and possibly the stigma of some unsuccessful or unreliable products that came on the market, seal less pumps tended to be considered categorically by many as the solution of the last resort.

However, by the 1970's enough experience had been gained in the chemical processing industries to bring some engineers to the conclusion that the magnet drive pump had been developed to the point that it had become the most economical solution in many process systems.

ORIGINS OF SEALLESS PUMP TECHNOLOGY

1933 (UK): First known dated patent for design of a seal less magnetically-driven pump. (Only low power chrome and cobalt steel magnets were available; not commercially viable)

1939 (UK): First known patent for design of a seal less motor-driven pump (Used wet stator motor)

1941 (UK): First known production of seal less motor drive pump. (Wet stator design; proved to be commercially viable)

1947 (UK): First commercially viable magnetically driven seal less pump. (AlNiCo magnets used; synchronous; required a soft start due to low magnetic powers)

1950-1953 (UK, USA, Europe): First known patents for seal less motor pumps with dry motor windings. (Dry stator design; tagged as "canned motor" commercially viable product)

1958 (UK): First known "induction" magnetically driven pump (Higher power magnets available; also known as "torque ring")

MAGNET DRIVE PUMPS

THEORY OF OPERATION

The magnet drive pump, while unique when compared with conventionally designed centrifugal pumps, is a simple combination of standard components and proven concepts. Figure 1 depicts a typical magnet drive pump with a separately mounted electric motor drive. In this installation, the base, the electric motor and the motor coupling are identical to parts used in conventional pumps The differences between magnet drive pumps and conventional pumps occur in two areas:

1) Driving torque is transmitted magnetically rather than mechanically.

2) The impeller shaft rides in bushings housed within the pump enclosure rather than be bearings mounted externally.

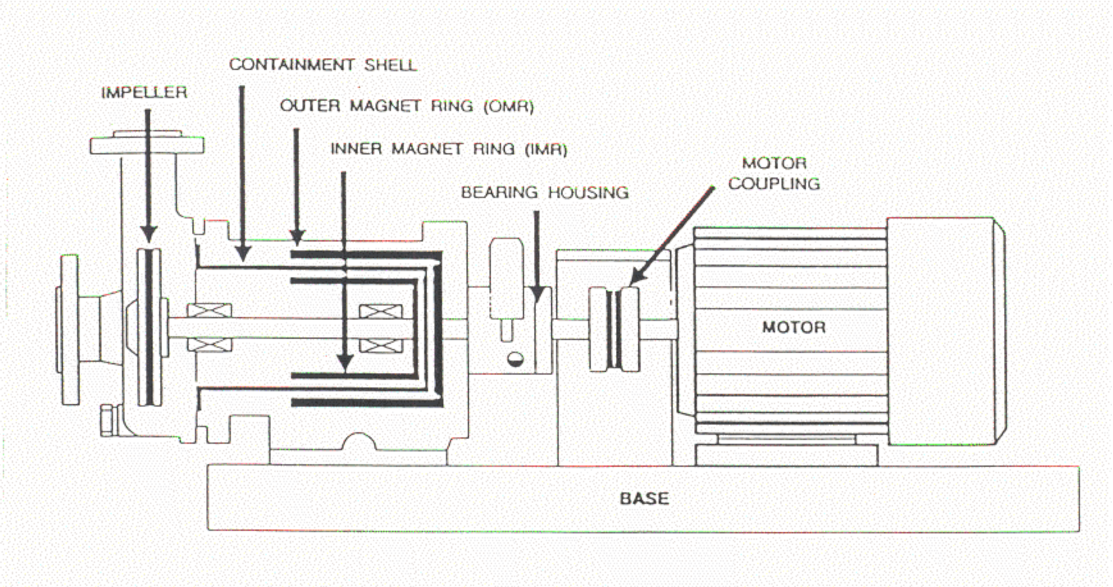


Figure 1

In Figure 1, the drive motor is coupled directly to the outer magnet ring (OMR) by the motor coupling. The overhung load of the OMR is carried by bearings in the bearing housing. Figure 1 also shows that the pump impeller is mounted on the same shaft as is the inner magnet ring (IMR). (NOTE: In models with a non-synchronous drive, this is called a torque ring rather than an IMR because it does not contain magnets as we shall see later in this discussion). The impeller drive shaft is carried by two bushings which are within the pumping enclosure. You will note that the pump enclosure is formed by the pump casing and the containment shell.

The driving torque of the electric motor is transmitted to the pump impeller by the magnetic coupling of the OMR and the IMR (or torque ring) without breaching the pumping enclosure. It is this magnetic coupling which replaces the mechanical seals of conventional centrifugal pumps.

MAGNETIC COUPLING

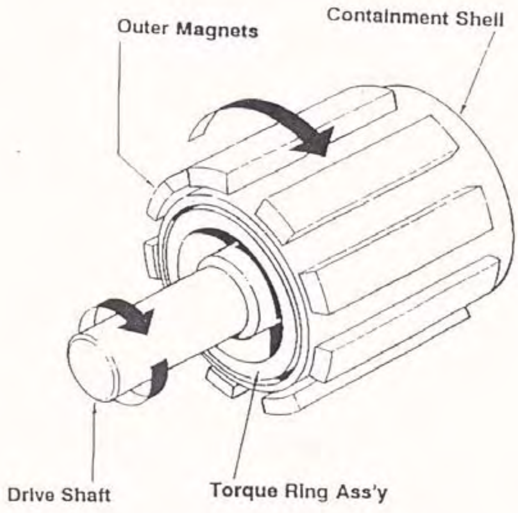
Before the theory of magnetic couplings as applied to sealless pumps can be examined, review of the fundamentals of magnets and electromagnetism is needed. Recall these basic principles:

1. Magnets have a north pole and a south pole. When two unlike poles are near each other, they are attracted. When two like poles are near each other, they are repelled.
2. When a magnetic field is moved past an electrical conductor which is in a closed loop, an electric current will flow in that loop.
3. When an electric current flows in a closed loop, an electromagnet is created with a north pole at one end of the loop(s) and a south pole at the other end of the loop(s).
4. An electromagnet is formed even if the "core" material is air. The electromagnet can be made stronger by inserting grain-oriented silicon steel into the "core" area.
5. Electromagnets behave just like permanent magnets with respect to the laws of attraction and repulsion.

TORQUE RING DRIVE

With these principles in mind, examine how the torque ring drive operates. The power supply shaft carries magnets secured to a rotating cylinder (also called OMR). The driven shaft has a steel hub or core in which a series of copper bars or rods are imbedded around its periphery, much like an induction motor rotor, except sheathed with a high alloy metal for corrosion resistance.

When the power supply shaft is rotated, the magnets sweep past the copper bars and induce electrical currents in the core. Remember, however, that our electromagnetic currents are induced or generated by the magnetic field sweeping past the conducting circuit. Therefore, there must be a slightly slower speed in the driven shaft (torque ring) than in the power supply shaft (OMR). The difference in speeds is called "slip".



INDUCTION DRIVE COUPLING
(Rare Earth Outer)

FIGURE 2

Figure 2 is a schematic representation of the torque ring coupling. The outer magnet assembly is driven by a separately mounted motor. The OMR consists of a number of permanent magnets securely attached to a cylindrical frame, evenly distributed to provide a uniform magnetic field. The torque ring is made of a mild steel core with an outer facing of stainless steel or other metal compatible with the pumpage. Beneath this layer, a conductive metal (copper bars) is placed to provide an electromagnetic coupling circuit.

The containment shell is an extension of the pump casing (pressure casing) and therefore is a pressure containing component which completes the sealing off of the pumpage from the external environment. Thus the torque ring operates in the process pumpage while the OMR operates in the ambient atmosphere surrounding the pump. When the outer magnet ring rotates, the magnetic field passes through the containment shell, through the copper of the torque ring, through the mild steel beneath the torque ring and then returns to the OMR to complete the circle. The rotating magnetic field produces eddy currents in the copper and these eddy currents create electromagnets which tend to follow the rotating magnetic field which created them.

In the torque ring shown in *Figure 2* a series of parallel copper strips are laid parallel to the pump shaft. In practice, these strips are separated and tied together at the ends, much like the "squirrel cage" of an a.c. motor. This is called a rodded torque ring. In any case, the copper conducting path(s) in the torque ring are firmly connected to the mild steel cylinder which, in turn, is solidly attached to the pump shaft.

Incidentally, the greater the "slip" in torque ring speed, the greater the eddy current flowing and the greater the torque. If a pumpage has high viscosity when it is cold, the eddy-current drive will provide high starting torques and will also provide greater heating of the pumpage (copper losses are higher at higher "slip" levels). This heating of the pumpage will be an advantage in liquids with high viscosity at cooler temperatures, getting the pumping operation under way more quickly than would be the case for a synchronous drive.

SYNCHRONOUS DRIVE

Figure 3 shows a schematic representation of the synchronous drive coupling. Just as with the eddy-current coupling, the outer magnet assembly is driven by a separately mounted motor. The differences between torque ring and synchronous coupling occur within the inner ring. In the synchronous coupling, the IMR contains the same number of magnets as are mounted in the OMR.

The number of magnets is determined by the torque which must be transmitted. Thus, when the outer magnet ring rotates, the inner magnet ring rotates in synchronism with the outer magnet ring. The absence of "slip" means that the magnet to magnet coupling drive has a higher speed than the torque ring coupling drive.

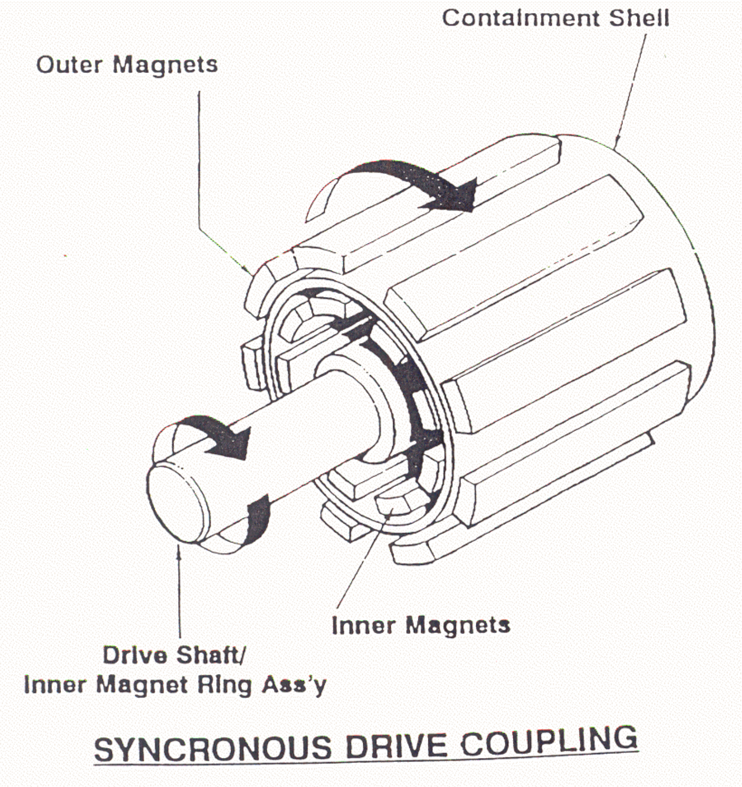


FIGURE 3

The inner magnet ring is mounted on the same shaft as the pump's impeller. The containment shell is an extension of the pump casing and thus the IMR operated in the process pumpage while the OMR operates in the ambient atmosphere surrounding the pump. The OMR is enclosed by a coupling housing to protect it from dirt and to shield operating personnel from the high speed OMR.

MAGNETIC COUPLING DESIGN

	TORQUE RING	**SYNCHRONOUS**
Internal Composition	Steel / Copper Rods	Magnets
Principal of Operation	Slip	Synchronous
Limitation	Power	Torque

ADVANTAGES OF TORQUE RING DRIVE

- Temperature capabilities to 450°C
- Excellent abuse factor ("slip" provides high resistance to decoupling)
- High starting torque characteristics
- Ferrite particles in pumpage do not build up
- Well suited to cold (viscous) start
- Inherently provides a "soft start"

ADVANTAGES OF SYNCHRONOUS COUPLING

- Output speed = Input speed (no slip)
- Compact design: Greater power capability in smaller envelope than torque ring drive
- Maximum efficiency at design flow (no slip)
- Allows compliance with dimensional/performance standards (due to no slip)

MAGNETIC PERMANENCE

There are three conditions which can alter the magnetic strength of permanent magnets. They are undue physical abuse, excessive temperatures and powerful extraneous magnetic fields.

PHYSICAL ABUSE

Mechanical stress or shock has long been known to demagnetise steel bars. Modern high coercive force permanent magnets such as is used in magnet drive pumps, however, are generally insensitive to these mechanical degradations. Generally, a mechanical stress large enough to demagnetise modern permanent magnets would have to be so great that it would physically damage the magnet. For practically all applications, mechanical stresses can be ignored as contributing to instability.

HIGH TEMPERATURES

In early magnetic materials, changes in magnetic structure could occur at room temperatures. Today's magnetic materials vary in sensitivity to very high temperatures. AlNiCo magnets such as used in torque ring drives have Curie Temperatures (level above which they are useless as magnets) from 800°C to 900°C. Samarium Cobalt magnets begin permanently losing strength at around 350°C (depending on grade). Neodymium-Iron-Boron magnets begin permanently losing strength at around 120°C (again, depending on grade). In general, sintered "rare earth" magnetic materials' flux density is inversely related to their ability to withstand temperature.

HIGH MAGNETIC FIELDS

To effect a magnet, a magnetic field must be stronger than the field used in the initial formation of the magnet. Since the fields used to create the magnet drive pump magnets are stronger than any fields found in plant environments, this mode of demagnetisation is all but eliminated.
In other words, the magnets used today in magnet drive pumps are PERMANENT magnets.

CONTAINMENT SHELL DESIGN

CONSIDERATIONS IN MAGNET DRIVE PUMPS

DESIGN CRITERIA

- Containment shell design is influenced by:
- Pump working pressure/temperature
- Internal bearing support system
- Minimising magnetic coupling losses

Engineers responsible for preparing specifications for sealless pumps sometimes critically review the design and manufacture of the containment shell to ensure a level of integrity in the pressure vessel boundary. Specifications generally dictate;

- Conformance to relevant pressure vessel codes (eg. ASME VIII, AS)
- Minimum containment shell tube thickness
- Corrosion allowance
- Number of welds
- Avoidance of externally applied loads that would cause undue stress on the containment shell

EDDY CURRENTS

As the inner and outer components rotate, eddy currents are created by the rotating magnetic field cutting through the stationary containment shell, resulting in losses and reducing the overall drive efficiency. These eddy currents are a function of;

- Speed^2
- Length of magnets in rotor
- Diameter^2 of containment shell
- Thickness of containment shell
- Field strength^2
- Resistivity of shell material
- Number of magnets

The resistivity of containment shell materials commonly used is 80 x 10-3 ohm cm for 316 Stainless Steel and 130-3 ohm cm for Hastelloy C. This variation in resistivity between materials will result in a 62.5% increase in losses for the stainless steel assembly over the Hastelloy C design. Temperature losses similarly increase.

CONSTRUCTION MATERIALS

Several materials in addition to stainless steel and Hastelloy C are readily available for containment shell design to match the pump application. They include: Hastelloy B, Alloy 20, Inconel 718 and various space age alloys such as Nimonic 75 and Nimonic 90 for extraordinarily severe pressures.

Recent advances in the manufacture of ceramic and plastic materials for pressure vessel containment have introduced these materials into magnetic drive pump design. Use of these materials effectively eliminates eddy current loss. However, the thickness required for the containment shell to contain design pressure, along with manufacturing tolerances, can result in drive size increases up to 50%.

Corresponding increases in viscous frictional losses and material performance limitations have limited their application in magnet drive pumps.

WELDED CONTAINMENT SHELL DESIGN

Historically, manufacturers of magnet drive pumps have manufactured containment shells using plate for the containment shell flange/shells and rolled tube for the shell tube.

Three welds are required to manufacture the containment shell. All welds are performed by qualified welders and thoroughly inspected with qualified procedures from an independent body.

Extensive fixturing and further non destructive testing (NDT) procedures are carried out to ensure the integrity of the containment shell. However, one disadvantage of using welds in the manufacturing process is that it may be considered a weak point in the component and a source for corrosion susceptibility.

HYDROFORMED (STAMPED) CONTAINMENT SHELL DESIGN

An alternative is the hydroformed containment shell. During the forming process, a plate of the material specified is shaped by an external load, and several forms are required to achieve the final design. Also, because the material work hardens during the process, it is necessary to heat treat the component prior to final sizing.

The final fabrication is completed using only one weld. Potential problem areas in this design include uniformity of thickness and accommodation of the increased length due to rounded end shape.

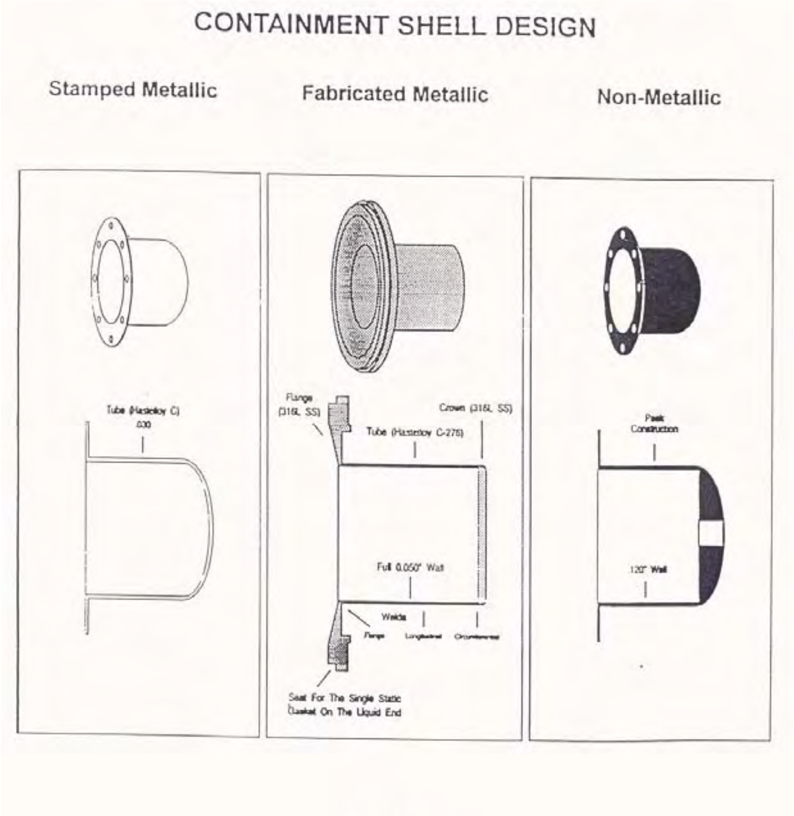


FIGURE 4

	Metallic	Non-Metallic
Typical Materials of Construction	Hast-C / 316SS	Ceramic, ETFE, Polypropylene, PTFE
Eddy Current Losses	Yes	No
Temperature Sensitivity	Low	High
Pressure Sensitivity	Low	High
Abrasive Sensitivity	Low	High

OUTER MAGNET RING CONSTRUCTION

CHALLENGES OF OMR CONSTRUCTION

Outer magnet rings are subject to a variety of stresses including rapid rotation, torque loading, and attraction to the inner magnet ring. The two primary challenges in OMR construction involve (1) retention of the magnet in the outer assembly and (2) fragility of the magnet material - rare earth magnetic materials widely used today are sintered powders with little inherent strength.

DISADVANTAGE OF ADHESIVE BONDING

For rare earth assemblies, the easiest and cheapest way to secure magnets is with an adhesive. While acceptable for many applications, severe problems can result if repeated temperature cycling occurs or if the adhesive is contaminated by exposure to certain process liquids or solvents.
If the adhesive bond fails, magnets can drop from the assembly and act as a cutting tool, attacking the containment shell. The result will be dramatic: vibration from loss of balance; heat rise from mechanical friction; trepanning and ultimate breaching of the containment shell; costly shutdown and repairs. Since there is no method for monitoring the integrity of an adhesive bond, failure cannot be predicted.

MAGNET MATERIAL BRITTLENESS CAUSES FAILURE

Another potential source of trouble is the inherent brittleness of the sintered, low- strength rare earth magnet material. If roughly handled during pump or OMR assembly, this material easily chips and flakes. This will almost certainly happen if OMR removal occurs prior to the removal of the inner magnet ring. An undetected chip could become dislodged during use and cut the containment shell, with similar results to those described for adhesive bonding failure.

MAGNET RETENTION

Some manufacturers with rare earth OMR assemblies have the magnets mechanically retained in the body and totally enclosed. The magnets cannot be seen, and it is not possible to damage them. Should the magnet become damaged while the OMR is being assembled, all flakes and chips will be fully enclosed. There are no components that can degrade, and any mechanical damage to the assembly can easily be seen by the assembler.
Other manufacturers use epoxy or other compounds as means of retention. A potential issue with this process is that epoxy degradation and loss of strength may cause magnets to dislodge form the OMR.

BUSHINGS AND BEARINGS

Possibly one of the reasons that magnet drive pumps have not been more fully utilised is the concern of some engineers over having bearings (bushings) in the process fluid. Recognising that the application of these pumps is presently on relatively clean liquids of low viscosity, a category into which the majority of pumping applications fall, it may be reasonable to make comparisons between "bushing and shaft life" in a magnet drive pump and "shaft, mechanical seal and antifriction bearing life" in conventional sealed pumps in order to quantify this concern. This would seem to be functionally correct way to make one comparison between sealed and sealless pumps.

The minimum rated life of ANSI B73.1 pump bearings is 17,500 hours at maximum load. Mechancial seal life varies widely, but two to three years of life would generally be considered excellent. Feedback from many maintenance engineers has painted a picture of the combination of bearings and seals seldom approaching two to three years of life in the real world.

Compare this experience with the operating experience of magnet drive pumps. Spare parts order records of one manufacturer and field reports support the conclusion that average bushing life is three to five years in typical magnet drive pump service. Ten years operation with original bushings has been achieved in a number of instances. Perhaps some of the concern over internal bushing life comes from over 25 years of experience with canned motor pumps where inherent close clearances cannot provide the longer term wearing capability which is common in magnet drive pumps.

By far the most common bushing material in use in magnet drive pumps today is special plain carbon. Bushings are sometimes pressed but most often are an interference fit to handle higher temperatures, pinned for the highest temperature services. Carbon is consistent in performance with a fluid and has good lubricating qualities that will normally enable a pump to survive a period of dry running, provided it is short enough so that the pump itself is not damaged. (Dry running is a fact of life with most pumps at one time or another). With essentially no binder to be attacked, carbon is suitable for all but a few services throughout the range of magnet drive pumps. Bushings are provided with spiral grooves of about 1/8 in diameter on the ID to permit solids to pass through the bushings. They are combined with hardened shaft journals, except where bushings are lightly loaded and the hardening is not required to obtain satisfactory shaft life.

Acids such as sulphuric acid and nitric acid do not attack plain carbon, but electrolytic damage makes many carbons unsuitable. Filled PTFE versus 316 SS has proven to be satisfactory in these services (although not as consistent as carbon), has good lubricating properties and will survive short duration dry running. Shorter maintenance intervals must be planned when this material is initiated because of the inconsistency cited. PTFE bushings may be carbon filled, glass filled or mica filled, each having different chemical compatibility. The temperature range of PTFE as bushing bearing is limited to 120°C whereas carbon is suitable for the full range of magnet drive service, -40 to +450°C.

For abrasive service, unusually high bearing loads, and corrosive services where PTFE is inadequate, silicon carbide bushings and journals are recommended. They have the advantages of extremely high load capacity compared with carbon or PTFE, and they are more tolerant of solids and abrasive materials. The negative aspects of their use are:

1. Higher cost
2. Complexity of detail design, because of the need to provide for different coefficients of thermal expansion with this very brittle material

and most significantly,

3. The inability to tolerate even a short period of dry running, which makes it much less abuse resistant than other materials described. Fragments of a failed silicon carbide bushing can cause extensive damage in a pump.

However, it has generally been accepted that silicon carbide offers the best long term bearing material for applications other than high temperature and has become the most widely used bearing material in HMD pumps.

INTERNAL BEARING MATERIAL

	Carbon Graphite	**Teflon**	**SIC**
Dry running capability	Good	Good	Poor
Solids handling capability	Fair	Poor	Excellent
Thrust handling capability	Fair	Poor	Excellent
Complexity of design	Low	Low	High
Cost	Low	Low	High

COUPLING RECIRCULATION SYSTEM

INTRODUCTION

The recirculation flow for any magnet drive pump has three basic functions. These are:

1. Removal of the heat generated from magnetic losses
2. Lubrication of the internal radial and thrust bearings
3. Thrust balancing of the free floating rotating assembly

If the liquid being pumped is "dirty", recirculation flow must perform a fourth function.

4. Removal or flushing of solids through magnetic coupling and internal bearings.

To successfully meet these requirements, the recirculated pumpage must remain in the liquid phase at all points within the magnetic coupling area.

The determining factors for preventing phase change are the mass flow rate, heat capacity, and localised pressure at any point within the coupling. The type of recirculation flow design will have impact on the variables of mass flow rate and localised pressure.

AVAILABLE DESIGNS

There are two standard recirculation flow designs commercially available in magnet drive pumps (more specialised recirculation flow paths are available as an option);

a) Discharge-to-suction

Fluid flow enters the magnetic coupling area at a high pressure discharge point and returns to the bulk flow at the suction eye of the impeller.

b) Discharge-to-discharge

Fluid flow enters the magnetic coupling area at a high pressure discharge point and returns to the bulk flow at a point behind the rear shroud of the impeller.

Each design has its advantages and must be considered on an individual basis.

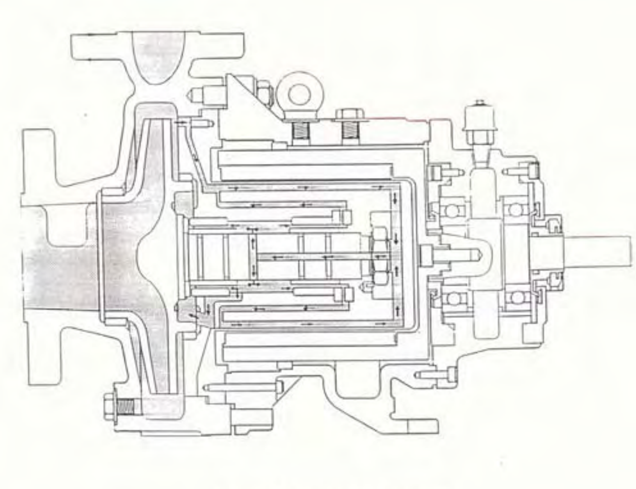
DISCHARGE-TO-SUCTION RECIRCULATION

The discharge-to-suction design *(Fig. 5)* involves pulling a slip stream from the high pressure point of the casing and returning it to the bulk flow at the suction eye of the impeller. The flow is routed to the suction through either the thrust balance holes in the impeller or, in certain designs, through a hole gun drilled along the axis of the pump shaft.

The recirculated fluid is driven by the differential pressure between the recirculation inlet and return locations. Additional pumping action is provided by the rotation of the internal magnetic coupling components.

The total dynamic head (TDH) generated by the pump provides the differential pressure that drives the recirculation flow. As the differential pressure increases, internal flow rate increases but at a decreasing rate. The internal flow will reach a maximum beyond which any additional increase in differential pressure will have negligible impact. This occurs when the friction losses begin to become the dominant factor effecting flow.

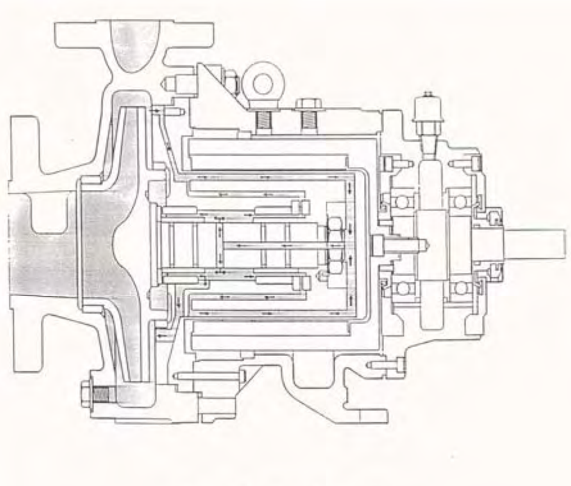
The observed internal pumping effects are primarily caused by the action of the inner magnet ring and thrust washers. These components operate at high speeds within tight clearances and behave as rudimentary impellers. Discharge-to-suction recirculation yields a flow pattern that is characterised by high fluid velocities. This high velocity profile provides advantages that will be discussed later in this analysis.



Internal Cooling / Lubrication

Discharge To Suction Recirculation

FIGURE 5



Internal Cooling / Lubrication

Discharge To Discharge Recirculation

FIGURE 6

DISCHARGE-TO-DISCHARGE RECIRCULATION

The discharge-to-discharge design *(Fig. 6)* involves pulling a slip stream from the high pressure point of the casing (discharge pressure) and returning this recirculation flow to the bulk flow at a point behind the rear impeller shroud adjacent to the impeller boss.

The recirculated fluid is driven by the differential pressure between the recirculation inlet and return locations, however, this pressure differential is not as great as that in the discharge-to-suction system. To insure proper cooling of the magnetic coupling, larger flow passages are provided. The rotation of the internal magnetic coupling components also provides additional pumping action.

Discharge-to-discharge recirculation yields a flow pattern that is characterised by high localised pressure and little interference with suction flow. These characteristics also provide advantages that will be discussed in the following section.

COMPARATIVE ANALYSIS

In comparing the benefits of discharge-to-suction and discharge-to-discharge recirculation, both systems remove the heat generated from the magnetic coupling and lubricate the internal radial and thrust bearings equally well. While discharge-to-suction recirculation creates a higher recirculation velocity due to its high "driving" differential pressure, its mass flow is comparable to that of discharge-to-discharge recirculation due to the latter's large flow path. Internal pressures in both systems are such that "flashing" at the magnetic coupling interface or internal bearings are avoided with most liquids.

Discharge-to-suction recirculation tends to have better impeller thrust balancing characteristics than the discharge-to-discharge system due to its routing of the flow through the impeller eye balance holes. This advantage is, however, minimal, and with the growing use of silicon carbide thrust bearings it is not a significant issue.

Discharge-to-suction recirculation also tends to flush solids better due to its higher velocities. In general, however, the handling of solids can be increased through the use of silicon carbide bearings, since these bearings are less affected by the abrasive nature of most commonly encountered solids.

A pump equipped with discharge-to-discharge recirculation typically requires less NPSH. Lower NPSH characteristics are achieved by routing the recirculation return flow to the rear of the impeller so that fluid flow through the suction eye is not interfered with.

Discharge-to-discharge recirculation also eliminates the chance of "flashing" at the impeller eye. Routing the recirculation return flow which has been heated by magnetic coupling losses and internal bearing friction to the low pressure, suction eye of the pump may cause flashing with certain fluids. By routing return flow to the higher pressure, behind the impeller, the potential for flashing is eliminated.

FUNCTIONS OF RECIRCULATION

- Removes heat from magnetic coupling
- Lubricates internal bearings
- Assists in balancing thrust loads
  ALSO
- Must pass solids contained within liquid

COMPARISON OF RECIRCULATION DESIGN

	Discharge to Discharge	**Discharge to Suction**
NPSHR	Low	High
Internal flow rate	Medium	High
Potential for flashing	Low	Medium

SOLIDS HANDLING CAPABILITY

The advent of silicon carbide bearings which will grind up particles of a lesser hardness has resulted in wild claims for the solids handling capabilities of sealless pumps. It is true that the presence of solids can be less problematic with silicon carbide bearings than with other bearing options such as carbon and PTFE. However, the upper percentage and size limits have changed little since these limits are dictated by non bearing-related parameters.

SOLIDS HANDLING

Many years ago, solids limit for the magnet drive pumps was uncertain and generally set at 1.5 percent up to 150 microns, based on two important considerations:

1. The appreciation that although solids and seal less do not mix, there is always some solids in the pumpage. The 1.5 percent figure was felt to be low enough to suggest caution but high enough to allow the presence of pipe scale and occasional pull over of filtrate or crystallate.
2. The result of some lab testing and tests carried out by customers on various pumps, indicate that wear to carbon bearings increases rapidly above 2 percent of solids.

In instances where solids larger than 150 microns were present in small quantities, a rough in line filter would be fitted on the feed (from pump discharge) to the magnetic drive.

PAST CONVENTIONS BEING RE-EVALUATED

Because of increased competitive pressure and a greater understanding of internal flow in the magnetic drive, re-evaluations of past conventions have been undertaken. Comprehensive test programs to establish definitive numbers for allowable percentage and size of solids have been carried out by various manufacturers.

These programs take into account the nature of solids; (ie: sticky or fibrous solids may block flow channels). As much information as possible on the type of solids should be obtained from the customers before pump selection is made.

Other considerations are that very abrasive solids will eventually wear metallic parts, that wear-resistant materials may require selection to give maximum pump life, and that wear in the impeller will be at a minimum when the pump operates near to its best efficiency (design) point. At low flows recirculation will accelerate wear, and at higher flow rates solids will increase wear because of velocity and incorrect incidence angles to impeller blades.

GENERAL GUIDELINES

The following guidelines are generally recognized but specific pump limits must always be confirmed with the manufacturer:

1. Between 3-5% solids

A standard pump fitted with silicon carbide bearings will handle between 3 and 5 percent solids to 150 microns. The limit on particle size is dictated by bearing clearances. Higher particle size may be screened out with a filter between the pump discharge and the magnetic drive.

2. Up to 30% solids

Up to 30 percent solids may be pumped up to 750 microns (wear ring clearances) if a clean flush is provided to the magnetic drive or if a closed-loop system is fitted (available only from a small number of manufacturers) to separate the magnetic drive from the pump head. For a clean flush, 10 to 25 l/m may be required for cooling. With a closed-loop system, 7 to 15 1/hr is required from a pressurised supply. Pumping solids of 30 percent concentration would dictate the use of hardened steel or iron if useful pump life is to be obtained.

3. Magnetic solids

For highly magnetic solids, the torque ring drive which does not have magnets immersed in the liquid is recommended. Modern magnets are extremely powerful and will attract ferrite particles which will build up between the inner magnet and containment shell. If the torque ring drive is not available for the particular model selected, then a magnetic filter may be fitted between the pump discharge and magnetic coupling.

4. Definitive data not yet available

All pump manufacturers would like to publish definitive data on the solids handling capabilities of their products.

However, there is considerable variety in size, hardness, chemistry, solubility, abrasiveness and flocculation of solid particles. Each solids handling application requires evaluation based in testing on experience.

Conventional pumps have generally been developed for specific applications on the basis of experience (ie: coal slurry pumps, paper stock etc). The same is true for the sealless market with customer/supplier cooperation to mutually resolve pumping problems in this difficult area.