SOME FUNCTIONAL AND CONSTRUCTIVE PARTICULARITIES OF WIND TURBINES

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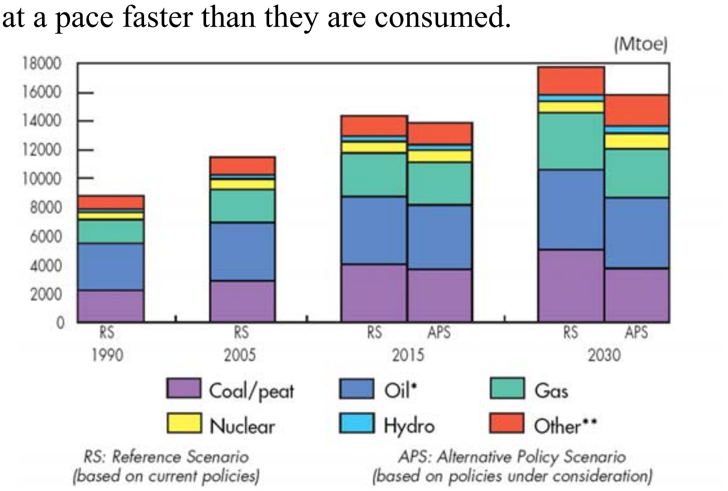
Abstract:

The main drivers behind wind energy are our energy security, energy necesity,emision reduction, air quality, and economic development.Wind energy is not a luxury its a necesity. The present paper presents a general overview of wind turbines clasificatin, the main advetages and disadvantages of the main types of existing tubines. Balade materials and rotor weight reduction. The use of magneatic bearings whit ferrofluids in order to decrease friction and allowing the turbine to operate at very low wind speeds.

Keywords: wind turbine, wind energy,magneticbearing

1. INTRODUCTION

In an increasingly globalized economy the energy strategy of a country is done in the context of developments and changes taking place worldwide. Energy statistics show that, 2030 will be about 50% higher than in 2003, and oil will be around 46% higher. Certain known reserves of oil can sustain current levels of consumption only until 2040, while natural gas until the year 2070, while world coal reserves provide a period of 200 years even at an increased level of operation. Forward-looking statements show economic growth, which will involve an increased consumption of resources energy. From the point of view of primary energy consumption worldwide, and evolution prediction the statistic made by the International Energy Agency (IEA) shows for next decade a rapid increase in the share of renewable energy sources, and natural gas. Unconventional energy sources have taken and will continue to earn a share of growing energy systems in the world, both because of the effort to research and economic policy. Primary energy sources called renewable in general, are those from natural sources, available in virtually unlimited quantities or regenerated by natural processes, at a pace faster than they are consumed.



**Other includes combustible renewables & waste, geothermal, solar, wind, tide, etc.

Fig.1 *Evolution of global energy demand (Source: OECD / IEA 2008)*

2. WIND TURBINES CLASSIFICION

Classification of wind turbines can be achieved by several criteria, some of which recall are: electrical power supplied, the orientation axis of the main shaft, the placement of blades and the location of the turbine sitting.

Acourding to size and generated pover

- Small Turbines generating power under 100kW, used primarily for domestic use,in isolated places, etc.;
- Medium to large scale turbine generating power above 100kW up to a few MW used to supply electricity in the electrical grid.

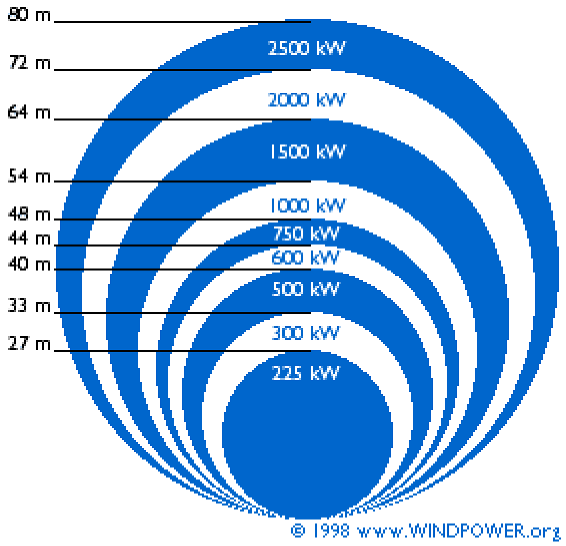


Fig.2 *The interrelation between the generated power and swept rotor area (Source www.windpower.org)*

Acording to design

- horizontal axis turbines (the most widespread);
- vertical axis turbines

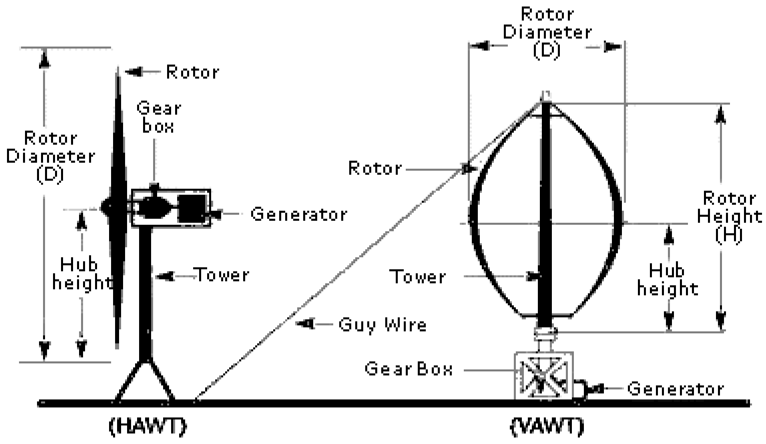


Fig.3 *(HAWT) horizontal axis turbine (VAWT)vertical axis turbine (Source www.ecoecopowerdhome.com)*

At present all commercial turbines that are linked to the electric network is built with typical rotor propeller on a horizontal axis (the main shaft of the horizontal axis).

The goal of the rotor is to transform the wind linear movement in to rotational motion used to

drive a generator.
Acording to blades placement
• Against the wind the wind (wind first encounters blades and nacelle) - upwind"
• In the wind (the wind meets the first nacelle and blades) - downwind.

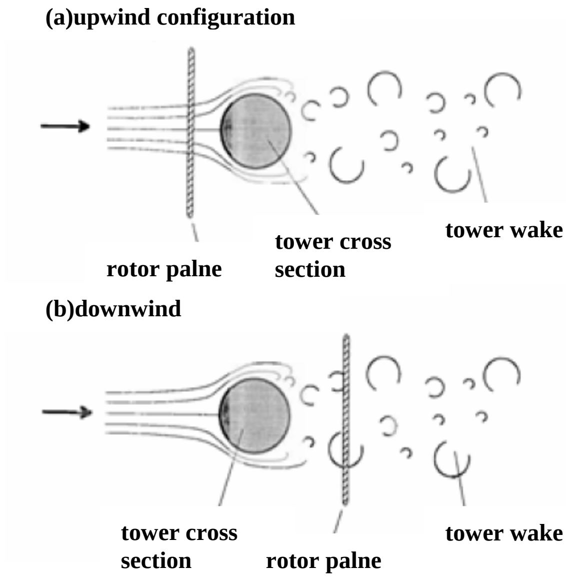


Fig.4 *The disturbed flow behind the tower results in highly unsteady aerodynamic blade forces which in the final end is the main cause of low frequency noise (illustration from Wagner5).*
According to turbine sitting they can be offshore and onshore

3. THE MAIN ADVANTAGES AND DISTAVANTEGES

Horizontal axis turbines

Advantages

- Heaving a step by step pozitioning mechanism to adjust the position thus maintaining an optimum angle of attack. Adjustment of the distance offers greater control so that the turbine can yield up regardless of day or season.
- Using the tower the turbine can reach higher speeds, due to the fact that winds speeds increase along with the altitude. For example, in some areas at every 10 meters in altitude wind speed increases by about 20% and the power output with 34% .
- High efficiency because blades are perpendicular to the wind direction, receiveing power throughout a complete rotation.

Disadvantages

- Towers high up to 90 meters are difficult to transport, the transport represents 20% of the cost of equipment.

- High turbines are difficult to install, useing very expensive high cranes that need certified operators.
- Requires construction of massive towers to support the blades weight and the heavy gear box and generator.
- Refelections from high turbines can affect radar systems used in comercial and military. The rotor blades cause a Doppler efect amplified by the nacelle and structural tower.
- Height makes them visible from the distance on large areas, creating an imbalance of the landscape.
- Various downwind turbines are suffering from fatigue and damage of structures caused by the turbulency that occurs when the blade is passing by in front of the tower (this is why most designs are upwind, the wind meets the first rotor and the tower)
- Horizontal turbines require an additional control mechanism for rotating the rotor and nacelle depending on wind direction.

Vertical axis turbines

Vertical axis wind turbines are not as efficient as the more common horizontal axis wind turbines, but they are more efficient in low wind situations. They tend to be safer, easier to build, can be mounted close to the ground, and handles turbulence much better. There are two main types of VAWT - the Darrieus which uses lift forces generated by blades, and the Savonius which uses drag forces The commonest VAWT is a Savonius VAWT which is an extended version of an anemometer (wind speed measuring tool). VAWTs can offer up to 30% efficiency and they work equally well no matter which direction the wind is coming from.

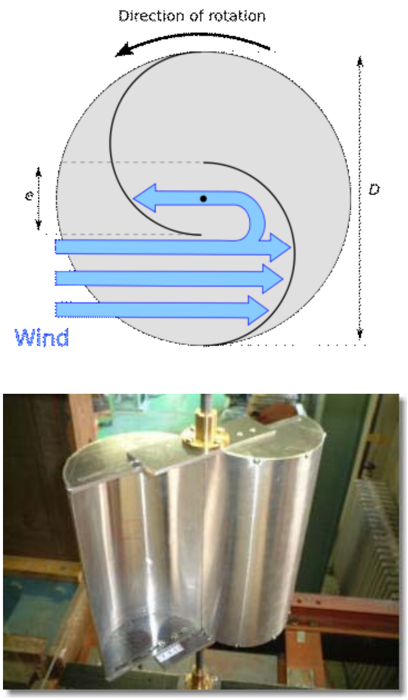


Fig. 5a *Savonius wind turbine*

Fig. 5b *Darrireus wind turbine*

Advantages:

- The rotor and gear box can be put on the ground, their placement on a tower is no longer necesary

- The rotating orientation mecanism used for the adjusment of the turbine position against the wind is no longer necessary.
- Due to the turbine location near the ground maintenance is more accessible
- Vertical wind turbines require startup speeds lower than wind turbines horizontal axis. They usually begin to produce electricity at speeds of 10 km/h
- There are more silent
- They are built in areas where construction prohibited high structures.
- Turbines with vertical axis being located closer to the ground can take advantage of locations such as highlands, hill tops, mountain ridge , where a funnel effect is created increaseing the wind speed

Disadvantages:

- Wind speeds are low at small distances from the ground and at the bottom of the rotor.
- The efficiency of the turbine is not impressive
- The Darrieus turbine needs a starting boost at startup, this is just a minor inconvenience for a turbine connected to the network, in this case the generator can be used to create the momentum needed to start by useing energy from the power network
- You may require safety cables secure the position.
- The weight of rotor is an additional burden on the bearings. At the replacement of the rotor's bearings it is necessary to dismantle rotor an both horizontal and vertical axis wind turbines. For vertical axis wind turbine means the dismatheling of the entire structure, if they were not designed effectively.

4. THE IMPORTANCE BLADE DESIGN AND MATERIALS

In the figure below we have a schematic representation of the basic aerodynamic principles of a horizontal axis wind turbine. So baseicly when the wind passes over the both sufaces of the airfoil shaped blade , it passes more rapidly over the longer (upper) side of the airfoil.This creates a lower pressure area above the airfoil. From the preasure difference between the two surfaces, results in a force kown as aerodinamic lift. In the case of an aircraft wings this force is responsible for lifting the aircraft off the ground. In the case of wind turbine blades which are constraind to move in a plane with the hub as center, the lift force causes the rotational movement of the blades. In addition to the lift force, we have the drag force perpendicular to the lift direction and occurs when a moving object redericts the up coming airflow. As a primary objective of wind turbine design the blade must have a high lift-to-drag ratio, whitch varies along the lenght of the blade to optimize the wind turbine energy output at various wind speeds.

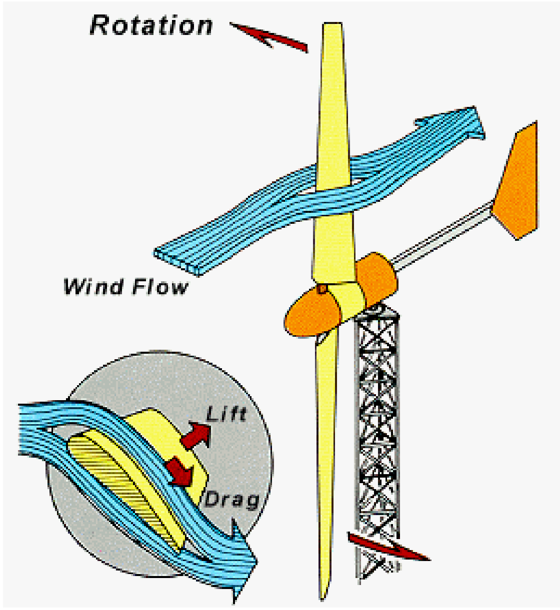


Fig.6 *The basic aerodynamic operating principles of a horizontal axis wind turbine(Source:www.awea.org)*

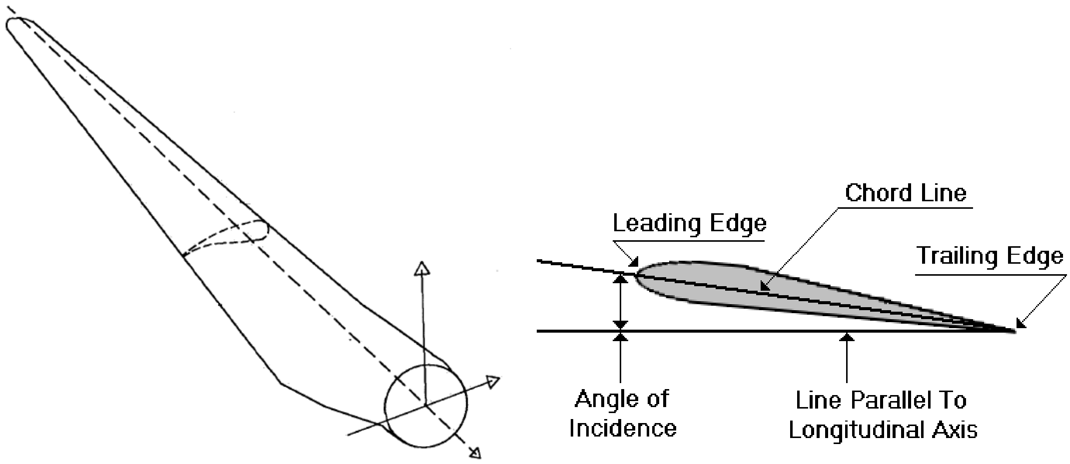


Fig.7 *The Cross section of an airfoil(Source: www.risoe.dk)*

Due to the tendency to increase dimensions of the blade systems in order to increase the power gneneration, most modern rotor blades on large wind turbines are made of glass fibre reinforced plastics, (GRP), i.e. glass fibre reinforced polyester or epoxy. There is a wide range of materials and manufacturing techniques utilized in the wind turbine industry today. The material combinations used are predominantly composite laminates with embedded threaded steel rods in the root section connecting the blade to the hub in a bolted connection Polyester, vinyl ester and epoxy resins are common, matched with reinforcing wood, glass, and carbon fibres. Some designs integrate carbon- and glass fibre as well as birch and balsa wood. A wide range of manufacturing processes are also utilized in blade manufacturing, encompassing: wet lay-up, pre-preg, filament winding, pultrusion, and vacuum infusion.Steel and aluminium alloys beeing to heavy they are only used for small wind turbines and vertical axis wind turbines subtypes. Current manufactured wind turbine blades have a diameter up to 80 meters and it will reach a larger diameter in a very short period of time. The new materials enable the manufacturing of larger stronger blades.

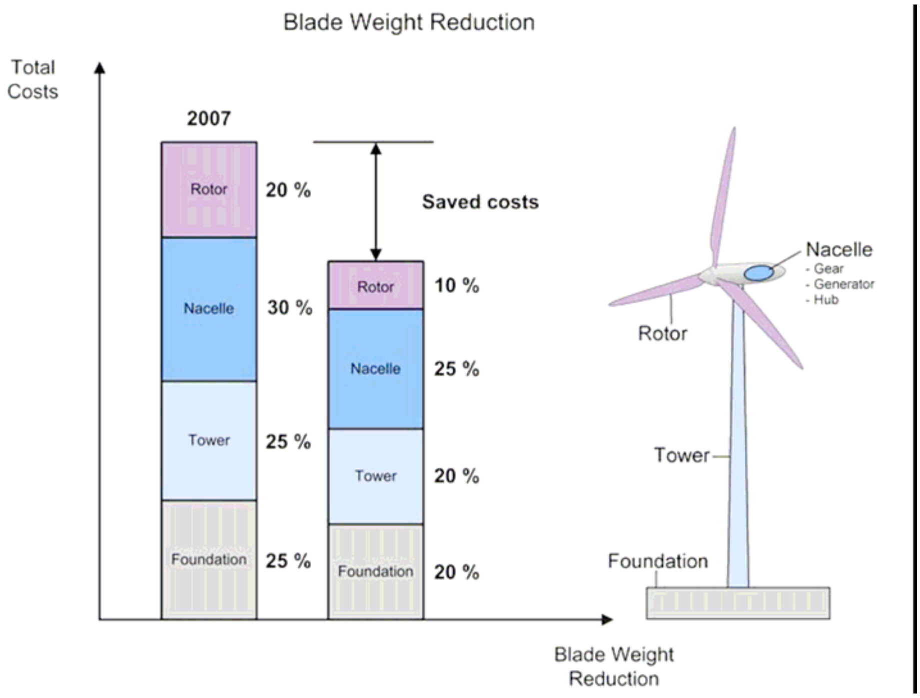


Fig. 8 *The figure shows the influence of blade optimization on the cost of an entire wind turbine. (Source: Jensen3)*

The components in an entire wind turbine are shown on the far right. The left column shows the relative costs of the various components of a current wind turbine. The column to the right indicates the relative costs of a future wind turbine with reduced weight of the blades.The cost of the rotor represents only a lower percentage (approx. 20%) of the entire wind turbine.

5. THE USE MAGNETIC BEARINGS WITH FERROFLUIDS

Turbine endowment with magnetic pillow bearings using magnetic fluids and/or permanent magnetes, this implies a reduction of friction and prolonging the operating time of turbines whit a semnificative distance on the maintnece graph. Magnetic fluids (ferrofluids) are dispersions of magnetic particles subdomenice (~ 10 nm) in a liquid base. The number of such particles is very large, a reference value is 10^{23} particles per cubic meter. These liquids have magnetic properties of common liquids, but also acts as a powerful magnetised material.One of the applications of magnetic liquids in magnetic liquid bearings , whose main advantage over ordinary bearings, is to eliminate the contact friction between the bearing parts. The operating principle of magnetic bearings is magnetic levitation. Magnetic levitation can be of two kinds: of 1decree and 2 decree.First decree magnetic levitation occurs when submergeing a body composed of magnetic material in a magnetic fluid in which is established a magnetig field from the outside. Although the body density is greater than the magnetic fluid, the effect is that the body is moving on to achieve a state of balance, the balance is achieved by a three-dimensional field of forces. The apparent body weight is balanced by the resultant force of the magnetic type forces.the second degree of magnetic levitation is referin to the „self-levitation" of a permanet magnet submereged (under certain conditions) in magnetic fluids. The self- levitation term is suitable because the source of the magnetic field is allsow the element on whom the fenomenon of magnetic levitation occurs.

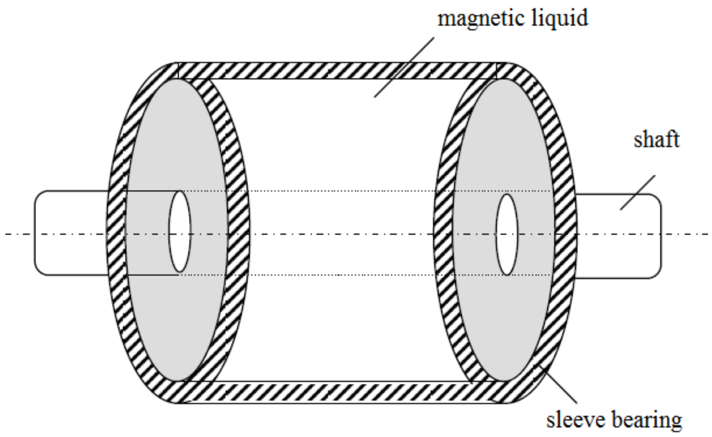


Fig. 9 *Cilindric bearing whit magnetic fluid(Source: Greconici 2)*

The cylindrical shaft is permanently magnetized, with a uniform magnetization heaving an ortogonal direction on the shaft axis plane. The space between the sleeve bearing and schaft is filled whit magnetic fluid. Accrding to second decree magnetic levitation the balance pozition is when the shaft axis coincides with the sleeve bearing's axis. For any other shaft pozition difrent from the balanced pozition, an magnetic force will try to bring the shaft in the balncend position.

Alternating magnetic poles bearing with magnetinc fluid:
The bearing has alternating poles placed in the stator and the magnetic fluid in the clearence between stator and rotor conciderd non magnetic.

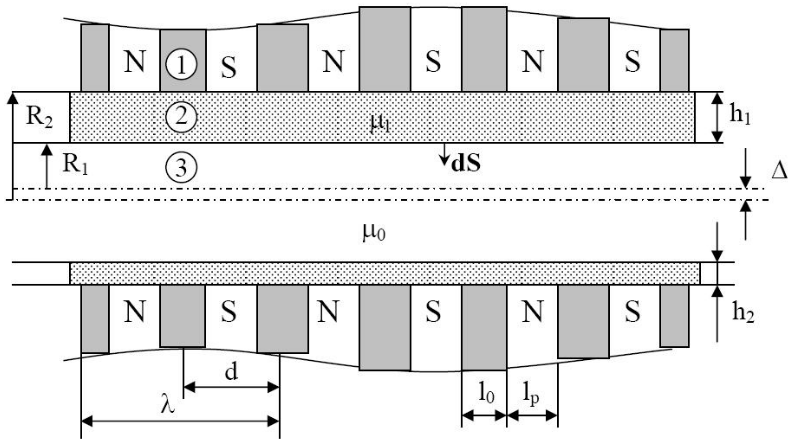


Fig.10 *Alternating magnetic poles bearing with magnetinc fluid(Source: Greconici 2)*

As we can see from figure 10 we can identify the following regions:

1- Stator of a R_2 radius where we have placed the magnetic poles in an alterneting sequence N-S-N...; the poles are permanent magnets whit constant radial magnetization;
2- The magnetic liquid which is considered to be of a constant magnetic permeability;
3- the rotor (the shaft) of a R_1 radius considered to be non magnetic and of a certain permeability

Δ is the deplasation of the rotor toward the stator. Due to the excentricity Δ, a force acts on bringing the shaft in the balanced position (when both axis stator's and rotor's coincide).

6. CONCLUSIONS

Our lives depend directly on energy and its consumption.Reneweable energies have been for years diadvantaged compared to fossil fuels and nuclear power. We currently notice a substantial growth in the wind energy sector worldwide. This growth is expected to be even faster in the coming years. A total of 8,484 MW wind power capacity was installed in the EU in 2008. This puts wind energy ahead of any other power technology for the first time. 36% of all new electricity producing capacity installed in the EU in 2008 was wind energy followed by natural gas (6,932 MW - 29%), oil (2,495 MW - 10%), coal (762 MW - 3%) and hydro (473 MW - 2%).(Source: AWEA and Platts Power Vision).

Concerns in the area of wind turbine optimization are obtaining performant rotation speed and transmission torque, and among others friction reduction in the rotor's bearings, respectively replaceing some metal components whith composite material components.

Obtaining a weight reduction by using composite materials blades, shock rezistant thus the entire wind turbine can benefit from such weight reductions through decreased dynamics loads and thus leave room for further optimization.

The use of composite materials which anisotropic materials leads to increased resistance to fatigue.

Dynamic qualities and economy of the turbine depend largely on the parameters of energy production and of the periods of time betewen maintenance.

The generated magnetic field in the bearings, exerts surface and volume forces on the magnetic fluid estableshing an additional preassure in proportion whith the preasure determined by the gravitational field, named magnetic preasure. The existence of this two forces has lead to a large variety of technical aplications.

In the case of a magnetic bearing when the concentration of the magnetic fluid rises, the interactions that occur between particles leads to deviations from the newtonian behavior.In addition to the hydrodynamic forces (of viscous origin) interactions of colloidal nature are developt (Van der Waals attractions , electrostatic interactions of particles, in the case of magnetic fluids bipolare interactions) as well as thermodynamic interactions, they become significant in magnetic fluids, where the size particle is less than 1 μm hence the Brownian motion becomes important.

The phenomenon of a force of magnetic nature,from the bearing, exerted per unit length, on the cylindrical shaft permanently magnetised ofa hydrostatic bearing with magnetic fluid creates a lot less friction than a classic bearing either with sliding or rolling.

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