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## Evaluation of kinetic and electrical of drilling fluid as basic fluid in drilling process

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### Abstract

The heating properties of nano drilling fluid are very important in the upstream and also downstream fields. Experiments are held to investigate the effect of ferric oxide nano particles on the thermo electrical properties of drilling slurry. The main purpose of this study is to improve the thermo electrical properties of drilling slurry by nano ferric oxide. The objective of designing drilling fluid for extreme and deep environment (HPHT wells) is to develop high performance drilling fluid system in well bore to achieve zonal isolation. So, the thermal conductivity, electrical conductivity and overall heat transfer coefficient are investigated in this paper. Results show the behavior of nano drilling fluid in the conduction mechanism can followed by polynomial with order 3th. The experimental results show the heat transfer with two mechanisms of convection and conduction can increase with increasing the percentage of used ferric oxide. This characteristic can be introduced in the novel drilling fluid.

**Keywords:** electrical conductivity; thermal conductivity; drilling fluid additives; high performance drilling fluid system.

### 1. Introduction

During a well cementing operation purpose should be achieve zonal isolation (Nediljka *et al.*, 1994) [16]. That belongs to the slurry design, to ensure the best quality of cementing especially at high temperature environment such a HPDFS Silica Fume (SF) use as a cement slurry additive to reduce the density of cement (Siddique and Khan, 2011). SF increase slurry performance and control hydrostatic pressure during drilling cementing. This mixture used as primary source for a hydraulic seal in the well bore as secondary application is used for remedial operations including depleted zone closing, splits and leaks repair (Nediljka *et al.*, 1994) [16]. The function of SF is allows a well to reach full production potential besides producing a blocking effect in the oil well. It is also responsible to prevent gas migration and highly effective for proper placement and decrease permeability for better control of weak zones (Siddique and Khan, 2011). Compressive strength of concrete containing SF is proved higher strength; as increase the concentration of silica fume it improves stress resistance in the early development and reduces the free water (Mehta and Gjorve, 1982 and Shadizadeh *et al.*, 2010) [12, 17]. The thermo electric and also, the rheological properties of drilling fluid play important role to determine the workability of slurry, fineness (Shahriar and Nehdi, 2012) [19]. The mixing process is very important parameters for thermal and rheological behavior of drilling slurry, the criteria of designing slurry depends on formulation, thermal conductivity, density, plastic viscosity, shears tress, yield point and gel strength for enhance durability and toughness for drilling slurry (Shahriar and Nehdi, 2011) [18]. Cement grout is used for sealing geothermal wells for is olatezones drilling fluid operation. The electrical and rheological behaviors of drilling slurry are important for the drilling process; it will be optimum to predict correctly about slurry placement (Bannister, 1980) [3]. Drilling slurry is concentrated suspensions of small and heavy particles so thermal and rheological measurements are suffering to the disruption of drilling operation (Miranda *et al.*, 2010) [13]. The thermo electrical properties and the rheology of Oil Well drilling fluid (OWDF) should be considered when it applied on the originally and primarily casing drilling. Therefore, fundamental knowledge of OWDF slurry rheology is necessary to evaluate the ability to mix and pump grout, remove mud and slurry placement optimization and to predict the effect of temperature on the slurry pit (Shahriar and Nehd, 2011) [18]. Incomplete mud removal can result in poor drilling fluid bonding, zone communication and ineffective stimulation treatment (Bannister, 1980) [3]. A rheology is study related to the flow of fluids and deformation of solids under

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stress and strain. In shear flows, fictitious parallel layers of liquid past each other in response to a shear stress to produce a velocity gradient, in term of to shear rate, which is equivalent to the rate of increase of shear strain (Guillot, 2006) [7]. The property of drilling slurry is complex which has the appearance and interactions between the additives (Banfill and Kitching, 1991) [2]. The chemical composition of drilling fluid, particle distribution, test in g methods, size shape, W/DF ratio, mixing time and temperature (Frittella *et al.*, 2009) [5]. The drilling slurry is viscous plastic materials that exhibit yield stress and tension below the yield stress ultimately slurry behaves as a rigid and solid (Mirza *et al.*, 2002) [14]. The Bingham plastic and power-law model is widely used to describe the rheological properties of drilling slurry measurements. Frittella *et al.* (2009) [5] that can be determined the properties of drilling fluid flow i.e., plastic viscosity, yield point, friction characteristics and gel strength (Harris and Service, 1991) [8]. The concentration and form of solid particles has a significant impact on the thermo electrical rheological properties of the OWDF slurry to yield stress and plastic viscosity of drilling paste usually increase as the cement becomes finer and increases the stability of slurry (Boukhelifa *et al.*, 2004). Equivalent Circulating Density (ECD) is important factor to understand the flow behavior, flow rate, annular velocity and differential pressure; for that purpose number of computer simulation software is available to predict the ECD. The displacement efficiency is achieving the maximum mud displacement. A standoff value of the percentage of casing centralization in the wellbore, job operation time for proper thickening and Reynolds numbers base on laboratory methods is measuring rheological properties to understand flow behaviors (Labibzadeh *et al.*, 2010) [11]. These parameters will be evaluating the drilling fluid pump-ability and drilling paste grout with strength correspond to behind the casing to increase efficiency and displacement. High flow rate may cause fracture the formation there should be investigated the current effective equivalent cement density (Hodne, 2007) [9]. Maximum drilling fluid or colloids or emulsions as a non-Newtonian liquids in plastic or behave in such circumstances is that the gel analysis function of the intermolecular forces. The initial 10-sec and 10-min gel strength measurements gelation indications of the gel that will occur after the flow is stopped and the drilling fluid remain static (Teodoriu *et al.*, 2008). When circulating drilling mud and fluids during cementing operations abnormal results in bottom hole, which may cause challenge to the integrity and safety. Soliman *et al.* (2008). To maintain hydrostatic pressure of the fluid column below the fracture gradient but above the pore pressure and designing drilling slurry to improve efficiency and displacement without causing any form of collapse to the formation for this condition to focusing on ECD and rheological properties (Stephen and Samuel, 2008). The oil well drilling paste

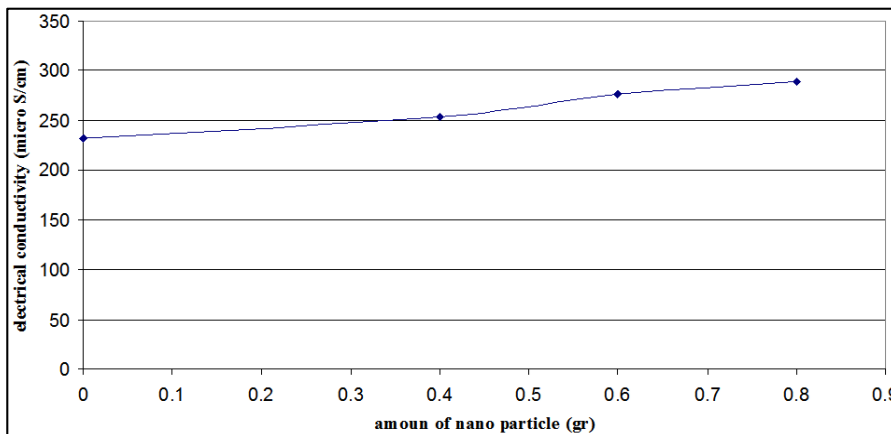
compositions are typically used for sealing subterranean zone at High Temperature and High Pressure (HTHP) such as the annular space in oil well between the surrounding formation and casing (Shahriar and Nehdi, 2011) [18]. The slurry blend consists of cement class G with additives and water. The productivity of an oil well is significantly affected by the quality of drilling pasting between the well casing and the surrounding strata (Teodoriu *et al.*, 2008). The drilling slurry flow ability and stability are major requirements for successful oil well cementing (Kulakofsky and Vargo, 2005) [10] because the drilling paste is the most active component of the slurry and usually has the greatest unit cost. Its selection and proper use are important in obtaining an effective, for long term integrity of the well (Williams *et al.*, 1999). Portland pastes can be used for cementing around the casing of oil and gas wells having deeper depth wells usually require special oil well drilling pastes (Teodoriu *et al.*, 2008). There are currently eight classes of API Portland drilling pastes designated A through H that are arranged according to the depths to which they are placed at pressure and temperature to which they are exposed (Harris and Service, 1991) [8]. In oil well drilling industry class G and H type well drilling pastes are well known for deep wells; because in addition other than calcium sulfate and water both shall be inter-ground or blended to the clinker during manufacturing of this oil well paste. Therefore with addition of ample quantity of additives such as retarders and dispersants can change their setting time to the cover wide range of well depths, pressure and temperature (Kulakofsky and Vargo, 2005) [10]. In this study, the silica fume used as extender, as it is function to reducing slurry density also light slurry is used to control hydrostatic pressure during cementing operation. This slurry has greater strength to use in weak and unconsolidated formation.

## 2. Materials and Method

The ferric oxide nanoparticles, a common ingredient has a huge variety of applications. This topic is proven that, the application of Fe<sub>2</sub>O<sub>3</sub> nano particles in low dosage is not toxic. So, this type of metal oxide is chosen as additive. The Rotational Viscometer (RV) is used to determine the viscosity of samples in the high temperature range of manufacturing and construction.

## 3. Results and Discussion

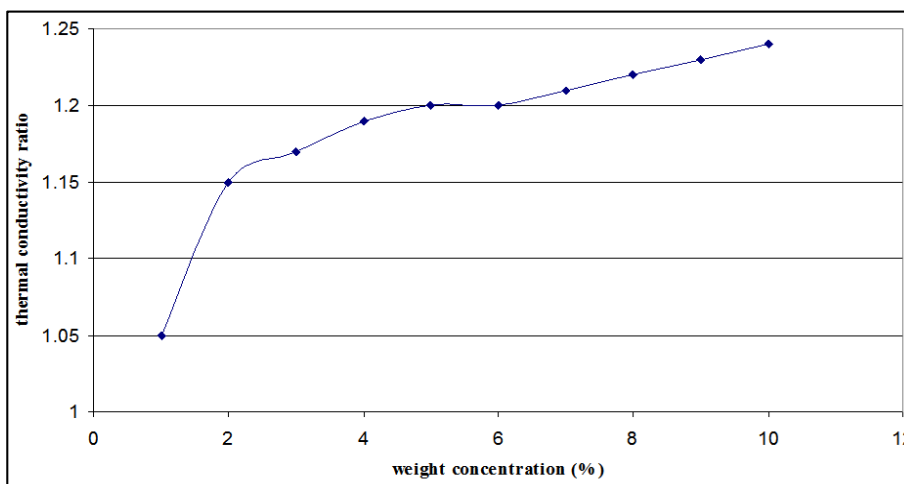
The experimental results are shown in this section of article. Important thermo electrical and rheological properties of slurry mud as a non-Newtonian fluid such as; electrical conductivity, thermal conductivity, overall heat transfer coefficient, yield stress, apparent viscosity and plastic viscosity are studied. The effect of amounts of nano particle, temperature and amounts of shear rate on the above parameters are reported in the following Figures.



**Fig 1:** The effect of nano particle percentage on the electrical conductivity.

The Figure 1 shows the relation between the amount of added ferric oxide nano particles and the electrical conductivity. The unit of electrical conductivity is reported as micro siemens per centimeter. The electrical conductivity is increased when the percentage of ferric oxide is increasing. Experimental results

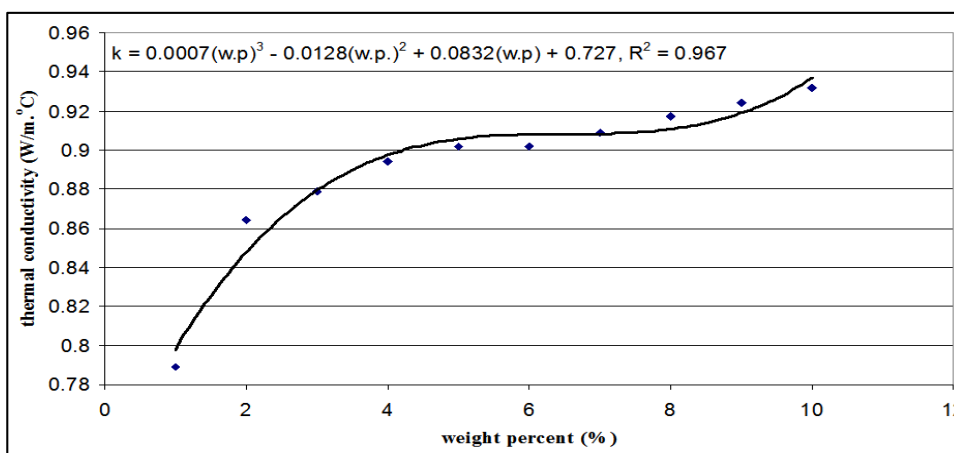
show the electrical conductivity can promote from 240 to 290, approximately. The relation between the amount of ferric nano particle and electrical conductivity is direct and this is related to the metal properties of ferric nano oxide as metal oxide nano particles.



**Fig 2:** Relation between amount of nano particle and thermal conductivity ratio.

The amount of added ferric nano particles on the thermal conductivity ratio is evaluated in the Figure 2. The obtained results show the thermal conductivity ratio which is defined as thermal conductivity of nano drilling fluid per thermal conductivity of simple drilling fluid is increasing with the increasing the weight percentage of ferric oxide nano

particles. The nature of nano ferric oxide can promote the ability of drilling fluid in the transfer of heat. As we know, the ability of drilling fluid in the transfer of heat is a basic role of this fluid. So, the nano drilling fluid can role this character better than the simple drilling fluid.



**Fig 3:** The relation between the weight percent and thermal conductivity values.

The effect of ferric nano particles are evaluated in the Figure 3. The Figure 3 proves that the ferric oxide nano particle as metal oxide nano particle can increase the thermal conductivity values, severely. Results show the behavior of nano drilling fluid in the conduction mechanism can followed by polynomial with order 3th. The slope of this polynomial is positive and the regression of this curve is 0.967. Therefore,

the defined polynomial can be valid able to predict the thermal conductivity of nano drilling fluid in the different amounts of ferric oxide nano particles. The equation 1 can be illustrated the relationship.

$$K=0.0007 (w.p.)^3 - 0.0128 (w.p.)^2 + 0.0832 (w.p.) + 0.7271$$

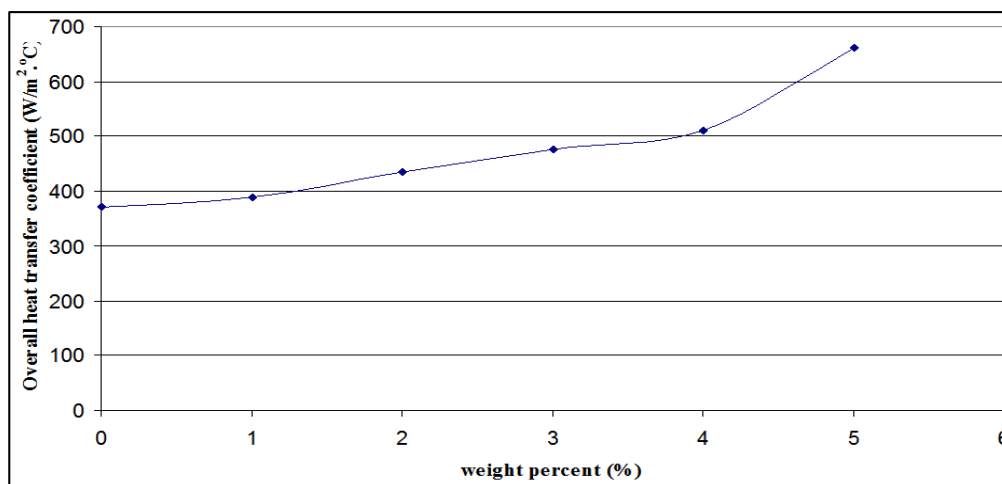


Fig 4: Overall heat transfer coefficient versus weight percent.

The overall heat transfer coefficient can determine the heat value which can be transferred from zone one to zone two. So, the overall heat transfer coefficient is measured in this section of work. The Figure 4 shows the relationship between the amount of ferric nano oxide particles and overall heat transfer coefficient. The experimental results show the heat transfer with two mechanisms of convection and conduction can increase with increasing the percentage of used ferric oxide. This characteristic can be introduced in the novel drilling fluid.

#### 4. Conclusions

The effects of nano particles on the thermo electrical and rheological properties of drilling fluid are investigated in this research. Thermal conductivity, electrical conductivity and thermal conductivity ratio are considered as the important thermo properties. The obtained results show the thermal conductivity ratio which is defined as thermal conductivity of nano drilling fluid per thermal conductivity of simple drilling fluid is increasing with the increasing the weight percentage of ferric oxide nano particles. Results show the behavior of nano drilling fluid in the conduction mechanism can followed by polynomial with order 3th. The experimental results show the heat transfer with two mechanisms of convection and conduction can increase with increasing the percentage of used ferric oxide. This characteristic can be introduced in the novel drilling fluid.

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