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Full Length Research Paper

Field application of adding formate salts exertion on the water based drilling fluid properties enhancement: an experimental comparative analysis

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Due to the fact that there is a wide range of drilling fluids, it is difficult to discuss drilling fluid composition that is completely accurate for all mud types in all drilling situations. The approach taken here is description of drilling fluids as two-phase systems. Formate base fluids have been utilized in a wide variety of drilling operations in terms of its applicant and lower expenses rather other fluids. These types of fluids have a number of benefits. One of the main aims of these fluids in comparison with the conventional high pressure high temperature (HPHT) and completion fluids is to minimize the damages in the formation. Furthermore, they maintain the properties of these additives on high temperatures, reduce the resistant of hydraulic flow, utilize less potential energy for differential striking processes and reduce the rate of corrosion which are preferred for use in well operations. Formate-based fluids could be administered among deep layers of drilled hole, shaly layers and those formations which include gas and salt. Therefore, this experimental procedure was done at a temperature of 260°F over a period of 14 h. For these tests, six types of salty formate fluids were made by different polymers. All samples formulation regarding their type and amount of water used in preparing fluids and the volume of salts used were simultaneously kept constant.

Key words: Salty formate fluids, high pressure, high temperature.

INTRODUCTION

The use of drilling fluids dates back to third-century Egypt, where quarry boreholes were drilled to depths of 20 ft using water to soften the rock and assist in cuttings removal. The use of drilling fluids to do more than aid in cuttings removal was proposed in the late 1800s, with clay, bran, grain and cement with water being used to

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produce a plastic material that would plaster the borehole wall and reduce caving tendencies. Later, it was discovered that high-density materials such as iron oxide (hematite), lead oxide (galena) and barium sulfate (barite) could be used to formulate pumpable fluids with densities of 15.0 to 18.0 ppg to control formation pressures (Gao and Yin, 2006; Downs, 1991, 1992). With the growing awareness of the relationship between mud properties and mud performance, and the realization that controlling these properties was important economically, the drilling fluids industry was born (Downs, 1993; Howard, 1995; Clarke-Sturman and Sturla, 1988). The solutions to drilling problems represented by the birth of this industry created problems. For example, the use of high-density weighting agents created the need for more effective viscosifiers for suspension; these often caused excess viscosity, which required thinning without affecting suspension.

The search for drilling fluid additives to solve new problems has, over the years, resulted in the development of over 2000 trade name drilling fluid additives. Many of these products are the same materials with different trade names (Downs et al., 1994; Chenevert, 1998; Hallman et al., 2002; Mackey and Hallman, 2001).

Estimating the appropriate amount of pressure drop is of great importance for drilling procedures due to the following reasons (Hallman and Bellinger, 2003; Messler et al., 2004; Gao and Towler, 2010; Gao et al., 2010):

1. To optimize the pressure drop on the drilling bit in order to get a maximum impact on the formation, and thereby increase the rate of penetration.
2. For optimizing of the flow rate in the annulus, the area between the borehole wall and the drill pipe, to get a better transport of drilled cuttings to the surface as well as to maintain a proper hole cleaning.
3. To avoid fracture of the formation crossed due to the underestimation of the annular pressure drop.
4. To detect any unexpected changes of the standpipe pressure, due to changes in the hydraulic drilling circuit (that is, washout, plugged nozzles and fluid kick) and make opportune decisions to restore the original conditions.
5. To better design the mud pumps available on the drilling rig.

In addition to the reasons mentioned above, the drilling of ultra-deep wells with high temperatures and pressures influence the rheological properties of the drilling fluids in several ways (Hands et al., 1998). Physically, decreases in temperature and increases in pressure both affect the mobility of the system and lead to an increase of apparent viscosities and viscoelastic relaxation times. The effect of pressures is expected to be greater with oil-based systems due to the oil phase compressibility (McKay et al., 2000).

METHODOLOGY

Field description

The properties of drilled well are illustrated in Table 1.

Laboratory tests

Drilling fluid design

Materials that were used in formulation of formate sample muds were used for evaluation of the compatibility of different polymers. Component of each formate sample are illustrated in Table 2. The materials used for this study are:

1. Shale sample
2. Fresh water
3. Hamilton beach mixer
4. Mud balance API filter press
5. Variable speed rheometer
6. Marsh funnel.
7. Fann V-G meter
8. pH meter.

Marsh funnel for measuring apparent viscosity

The marsh funnel viscometer and graduated cup are routinely used to measure viscosity. Results are used only as an indicator of change in flow properties. The marsh funnel is 6 inches in diameter at the top, 12 inches long, and tapers to join a tube 2 inches long with an inside diameter of 3/16 inches. A 10-mesh screen was fitted across one-half of the top filters foreign matter and cuttings from the mud to be tested. The capacity of the funnel to the bottom of the wire screen is 1500 cc. Its dimensions are such that one quart of fresh water at a temperature of 70(±15°F) flows through the funnel in 26 (±0.5 s) (Figure 1).

Plastic viscosity (PV) and yield point (YP)

The result of the funnel viscosity test is called the funnel viscosity of the mud. The viscosity of a mud is made up of two variables: plastic viscosity (PV) and yield point (YP). These values, as well as timed gel strength, are measured with a direct-indicating viscometer, such as the rheometer. The rheometer is a portable rotational viscometer, powered by a manually turned crank that drives the spindle through a precision gear train. No electric power is required. Speeds of 300 and 600 rpm are selected by a shift lever. Rotation for gel-strength testing is accomplished by a knurled knob. The support standards telescope has a total height of 8½ inches, and the base is 4½ inches wide by 8½ inches long. The rheometer weighs 6 ½ lb (Figure 2).

RESULTS

The results are recorded in the API Standard Drilling Mud Report as follows:

1. The 300-rpm dial reading was subtracted from the 600-rpm dial reading. This difference was recorded as the PV in centipoise (cp) at X°F (or °C);
2. The PV was subtract from the 300 rpm dial reading. This difference was recorded as the YP in pounds per 100 square feet (lb. per 100 sq. ft);

Table 1. Interval well parameters.

Formation type	Member A compose of shale
Thickness interval depth	400 feet
Interval hole size	8 ½ inches
Fluid type	Formate based mud
Bit type	Mill tooth bit
Nozzle size	3*16/32 inches
String rotation speed (rpm)	100-130 rpm
Weight on Bit (WOB)	20-25klb

Table 2. Composition of the developed mud system.

Sample No.	Material	A	B	C	D	E	F
1	Water (sea) cc	350	350	350	350	350	350
2	Na_2CO_3 (g)	1	1	1	1	1	1
3	PAC-R (mg)	2	2	2	2	2	2
4	PHPA (PolyPlus) (g)	1	1	1	1	1	1
5	NaCl (g)	26	80	80	80	80	80
6	Formate Na (g)	20	20	20	20	20	45
7	Formate K (g)	18	18	18	35	35	-
8	$CaCO_3$ (g)	10	10	65	10	10	65

A: PAC-R; B: HT-PM; C: NaCl+K; D: PAC-R+ K; E: PHPA; F: HT-PM+NaCl.

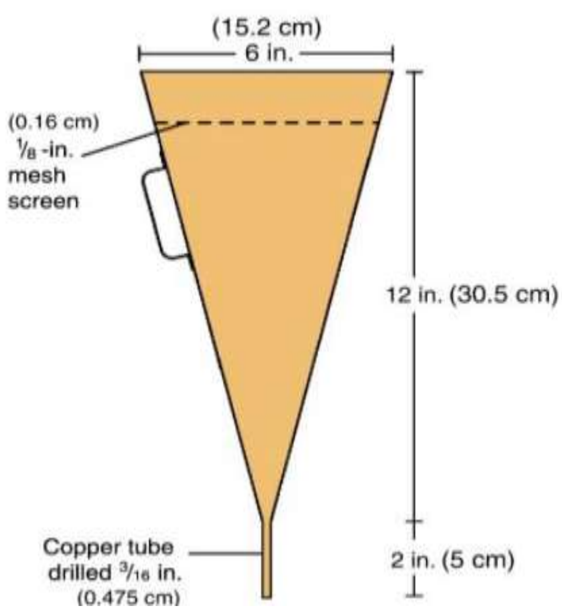

Figure 1. Marsh funnel for measuring apparent viscosity.

3. Initial (10 s) gel strength is recorded as the first peak dial reading; it is recorded as pounds per 100 sq ft (lb. per 100 sq. ft). Ten-minute gel strength is recorded in the same manner.

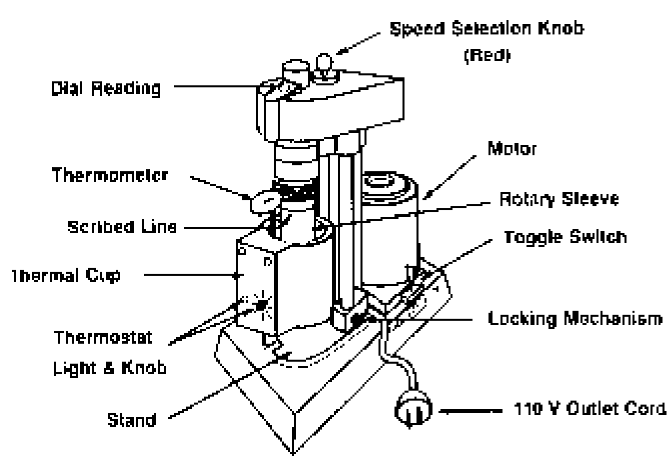

Figure 2. Fann Model 35 6-speed viscometer.

Figures 3 and 4 show the amounts of apparent viscosity and plastic viscosity after and before applying temperature in duration of 14 h for salty formate fluids. As shown in Figures 3 and 4, rheological properties such as yield point and plastic viscosity of the water-based drilling fluid with the presence of formate salts were fairly stabilized. It was observed that the desired rheological properties are obtained by using formate salt to avoid some problems in drilling operations such as filatures in

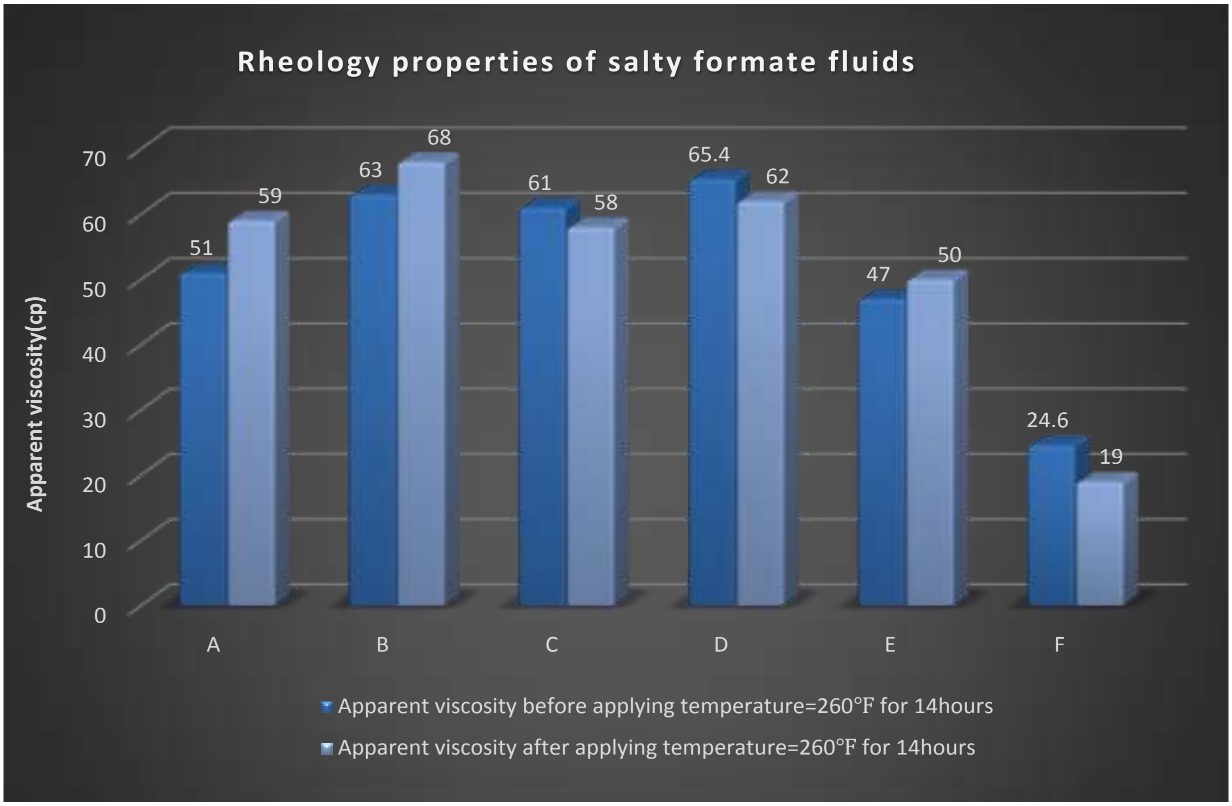

Figure 3. Apparent viscosity before and after applying temperature for salty formate fluids. A: PAC-R; B: HT-PM; C: NaCl+K; D: PAC-R+ K; E: PHPA; F: HT-PM+NaCl.

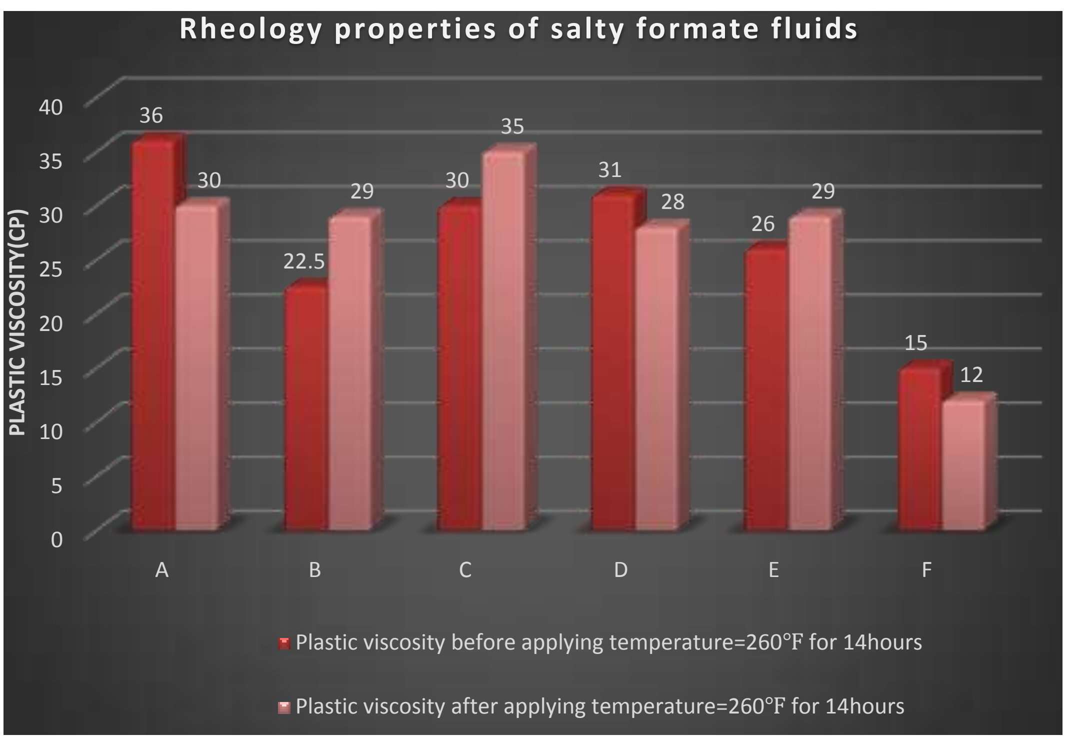

Figure 4. Plastic viscosity before and after applying temperature for salty formate fluids. A: PAC-R; B: HT-PM; C: NaCl+K; D: PAC-R+ K; E: PHPA; F: HT-PM+NaCl.

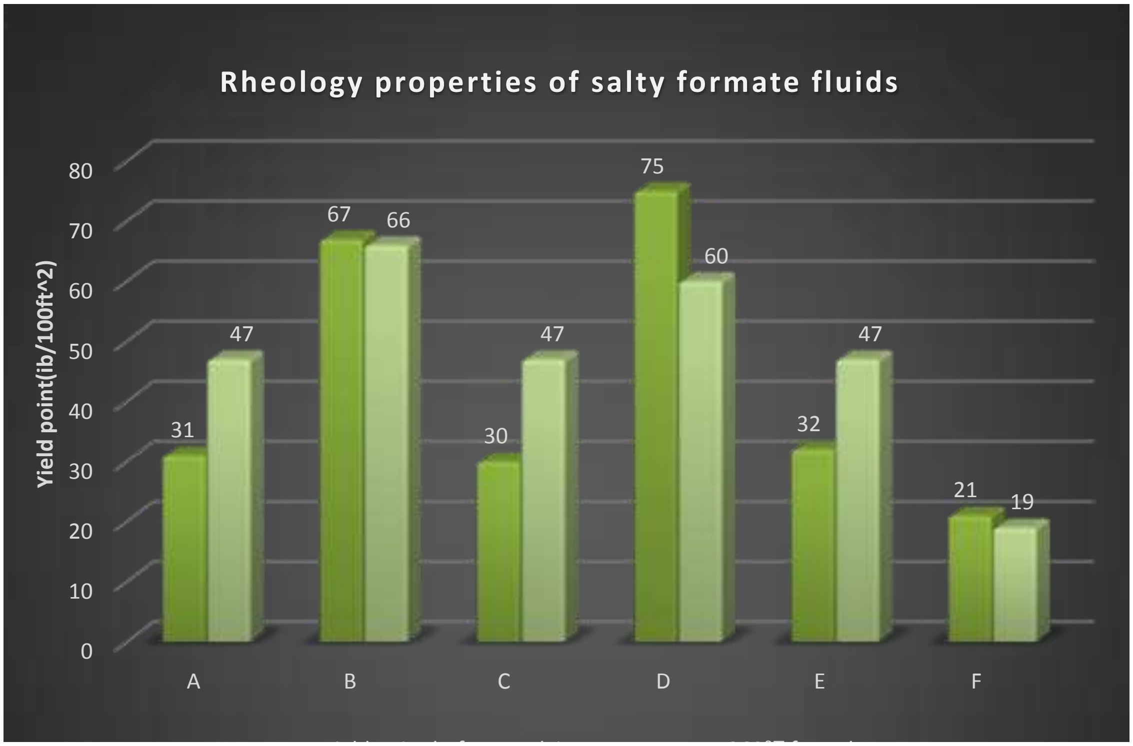

Figure 5. Yield point before and after applying temperature for salty formate fluids. A: PAC-R; B: HT-PM; C: NaCl+K; D: PAC-R+ K; E: PHPA; F: HT-PM+NaCl.

rig pumps. Figure 5 shows the amount of yield point after and before applying temperature in duration of 14 h for salty formate fluids.

Conclusions

In this research, adding salts with different concentration to the formate drilling fluids is experimented in an oil field. The results of the comparison of salty formate fluids with formate fluids demonstrated that formate fluids maintain rheological properties and fluid loss after applying temperature as compared other fluids. Experimental tests of mud pollution with several pollutants illustrated that mud rheological properties changes after it is polluted by several pollutants like cement and acids did not have a large volume.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

Abbreviations: OBM, Oil based mud; **PV,** plastic viscosity; **AV,** apparent viscosity; **WBM,** water based mud; **YP,** yield point; **API,** American petroleum institute; **PAC-R,** polyanionic cellulose- regular viscosity; **HT-PM,** high technology polymer materials; **PHPA,** partial hydrolyzed poly acryl amid; **Ca**CO_3**,** calcium carbonate; Na_2CO_3**,** sodium carbonate.

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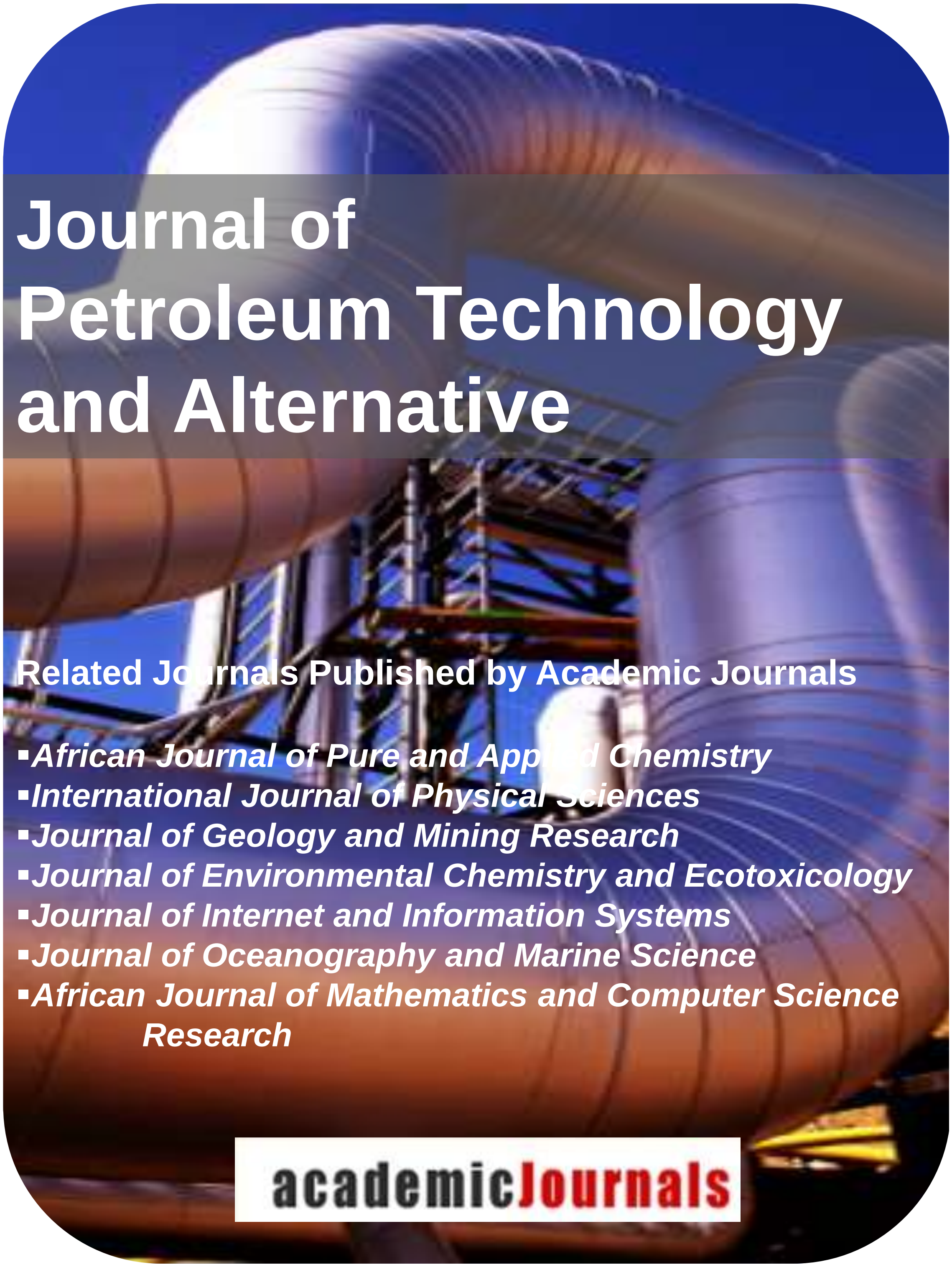
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