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EFFECT OF TEMPERATURE ON DRILLING MUD IN SUBBA OIL FILED

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صدق الله العلي العظيم

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ABSTRACT:

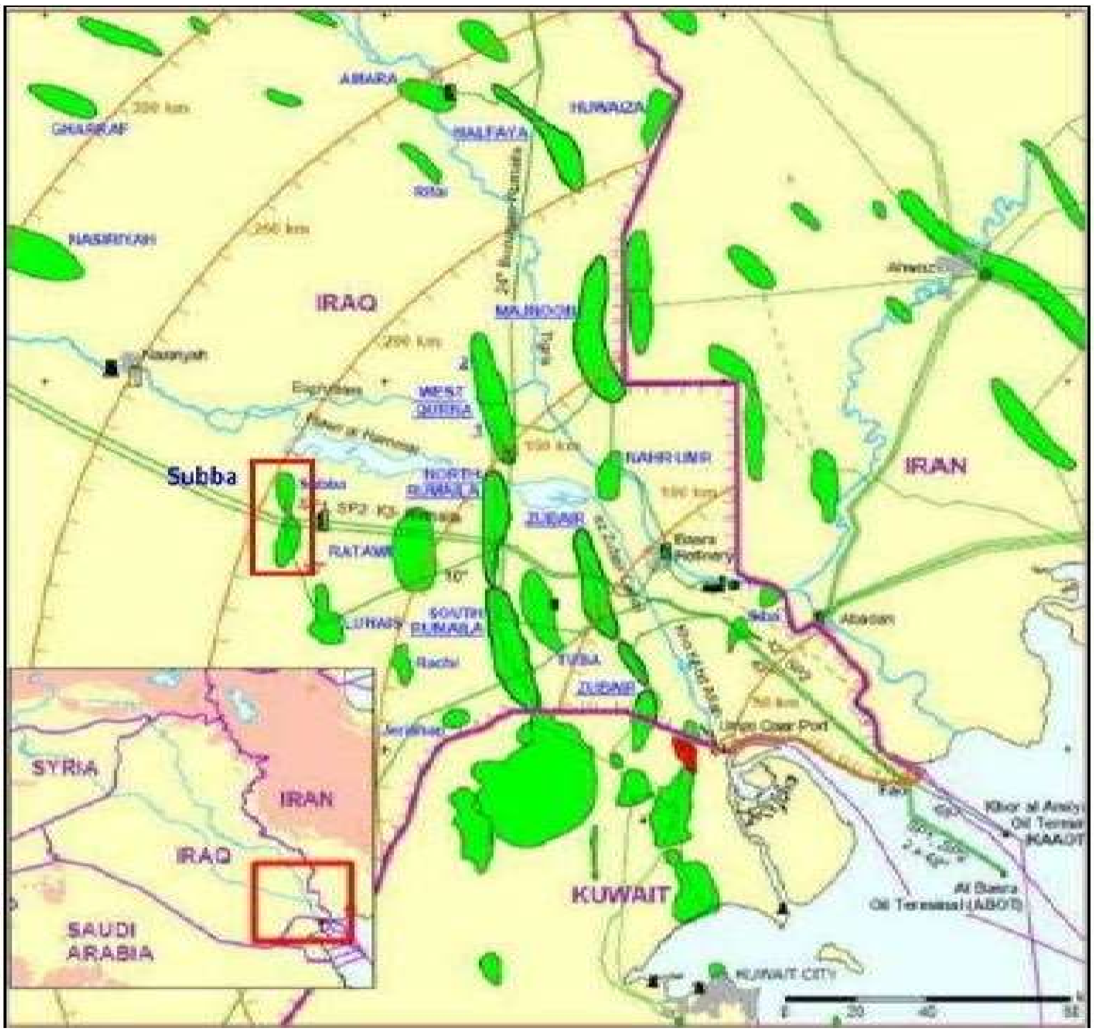
To meet the increased global demands on oil and gas exploring deep and ultra-deep wells is increasing rapidly. Drilling at such faces a wide range of difficult challenges and issues, one of the challenges is the negative impact on the rheological properties of the drilling fluids when exposed to high temperature high pressure (HT/HP) conditions. For a successful drilling operation, the drilling engineer must have a good estimate for the values of rheological properties of drilling fluids, such as viscosity, density, yield point, gel strength etc. in this work, experiment was conducted on water-based mud, from ambient condition to very high temperature and pressure. In this paper, the effect of elevated pressure up to (500 psi) and elevated temperature up to (200 C) on the rheological properties of water- based mud has been presented.

INTRODUCTION:

The global growth in hydrocarbon demand is driving oil and gas industry to drill deeper reservoirs. One of the challenges in such environments is to maintain desirable rheological properties of the drilling fluids. Those properties can be highly influenced and altered by many factors in deep drilling. Raising pressure and temperature are among the most significant factors. Hydrostatic pressure is a function of depth, increases with increasing drilling depth. The elevated temperature might be introduced from geothermal sources.

STUDAY AREA:

Subba oil field is stay in the southern of Iraq about 12 km to Luhais oil field (Fig.1). The dimensions of the field are 7 km and 30 km long. It consists of two domes separated by saddle. The small dome locates in the north while the large dome locates in the south.



Fig; Location of Subba oil field in Iraq

BACKGROUND:

It is evident that significant amount of oil and gas lie within the deep formations. Temperature and pressure, however, increases with increasing depth and, therefore production form such type of zones involves several challenges to petroleum engineers in term of drilling, completion and production. Among these challenges is the changing of the rheological properties of drilling fluid. Understanding the rheological characteristics of the drilling fluids under elevated temperatures and pressures is essential for petroleum engineers. The success of any drilling operation, to a large extent, depends of the proper selection and monitoring of the drilling fluid system. The ability of a fluid to perform a specific function is dependent on tis rheological properties. This requires a reliable model of how the rheology of the fluid changes with changing in temperature, and pressure. Despite considerable researches and laboratory studies over the past decades there is relatively little systematic understanding of how the flow behavior changes with downhole conditions. The rheology of the fluid is influenced by many factors including temperature, pressure, shear history etc. Globally, 87 % of industry players are involved in HTHP assets in some capacity and some 60% of these are expecting to put in place as HTHP program within the next two years. HPPHT operation is defined as wells that have an initial reservoir temperature more than (300 F) and reservoir pressure more than (10,000 psi) or an initial reservoir pressure more than (300 psi), studied rheological properties of water-based mud under HPHT conditions where the temperature reached up to (266 F) and (8700 psi). studied the effect of HPHT on the viscosity of oil-based muds and water-based muds. All these studies showed that changes and alterations occurred in the properties of rheological fluids when they subjected to these conditions, and these changes will have a negative impact on the function of drilling fluids. This work focused on investigation the rheological behavior of water-based mud with different properties at HT/HP conditions using Fan 35A and M50 viscometer. Capable of measuring drilling fluid up to (200C0) and (500 psi) higher temperature and higher pressure. Understanding the effect of these two factors is crucial for the purpose of designing and acceptable drilling fluids that can function properly in such environment.

There are several limitations that caused developing HT/ HP water- based drilling mud a necessity. First, using oil-based muds is prohibited in many countries around the world (for example, USA, Europe) due to environmental reasons. The second, one is due to high gas solubility in oil based muds increases the risk of getting kicks and, hence, requires more cautious control procedures. For these reasons, formulating water- based mud capable of enduring HT/HP conditions became inevitable.

DRILLING FLUID FUNCTIONS:

specified that to minimize the cost of fluids and to ensure an efficient drilling program, the fluid properties must be maintained continuously during the drilling operation. In addition, the high temperature and high pressure conditions faced in ultra-deep oil and gas drilling environments pose major challenges for the fluids used in these environments reduces drilling efficiency by slowing the rates of penetration and creates sever problems that leads to leaving behind most of the oil unrecovered. A selected drilling fluid must offer a host of functionalities, which include:

1- Control subsurface pressures, maintaining well control.
2- Remove drilling cuttings from beneath the bit and circulate them to the surface.
3- Maintain wellbore stability, mechanically and chemically.
4- Cool and lubricate the drill string and bit.
5- Allow adequate formation evaluation.
6- Provide a completed wellbore that will produce hydrocarbons.
7- Suspend or minimize the settling of drill cuttings or weight material when circulation is stopped yet allow the removal of drill cuttings in the surface fluids processing system.
8- Form a low permeability, thin and tough filter cake across permeable formation.

The performance of these functions depends upon the type of formation being drilled and the various properties of the drilling fluids.

MATERIAL AND METHODLOGY:

Fan 35A and M50 Viscometer, is used as the main viscometery device in this study, as shown in (Fig. 1). This system uses a rotor and bob geometry for rheology parameters measurement and applicability approved for applications in petroleum industry. One type of water-based mud chosen to carry out an experiment, this mud is actually drilling fluids have been used by oil industry. The name of the water- based mud is water-based drilling fluids. Table 1 shows the properties of the mud sample.

The main object of this work to determine:

- To define the best rheological model for the relation between shear rate and shear stress of Glydril water-based drilling fluid.
- Identifying the flow behaviour parameters of the rheological models.
- Find out the effect of HT/HP on the rheological properties of water-based drilling fluid

The laboratory work have done based on the special type of water based mud which is called GLYDRIL mud, is an enhanced-polymer, water-based system that employs polyglycol technology. Glydril delivering a high degree of shale inhibition; wellbore stability; higher temperature higher pressure fluid loss control; and lubricity. Also it has low toxicity; relatively fast biodegradation; improve filter cake quality and pipe wetting capability. As a result Glydril mud the benefit of using are higher rate of penetration; fewer hole problem; fewer environmental concern and improve drilling efficiency.

The first step of the experimental work started with measuring viscosity by Fan 35A instrument as shown in Fig. 1 and measurement started by using M50 Viscometer as shown in Fig. 1. In order to find the effect of specific variables, (T and P), the pressure were kept constant with changing temperature from range between room temperature (25 C) to (200 C) with 25 C intervals. This allowed the analysis of the effect of temperature on viscosity of water-based drilling muds under HT/HP conditions and the pressure kept constant at (500 psi). During these experiments, plastic viscosity, yield point, and 10 sec, 10 min and 30 min gel strengths and density were determined and then plotted the data of shear stress versus shear rate in order to select a best rheological model to interpret the results that obtained from the laboratory measurement. Despite considerable experimental studies over the years, there is relatively little systematic understanding of how the flow behavior changes with down hole conditions. The rheology of the fluid is influenced by many factors including temperature, pressure, shear history, composition and the electrochemical character of the components and of the continuous fluid phase.

Figure 1 Fann 35A and M50 Viscometer Measurements

Table 1 properties of the Glydril water-based mud

Name of WBM	Density/ Mud weight lb/gal	PV @ 25 C⁰	PV @ 50 C⁰	PV @ 100 C⁰	PV @ 150 C⁰	PV @ 200 C⁰	YP @ 25 C⁰	YP @ 50 C⁰	YP @ 100 C⁰	YP @ 150 C⁰	YP @ 200 C⁰	Cake Thickness mm
Glydril	11.5	42.4	28	13.5	9.4	6.8	26.4	22.5	31.1	28.1	18.7	1.7

Note: PV and PY units are (cp and lbf/100ft^2) respectively.

These properties (viscosity, density, filtration, gel strength etc.) are affected by several factors which are including temperature, pressure, composition and the shear history.

RESULTS AND DISCUSSION:

According to the result obtained from the experiments, the role of HT and HP condition on different properties of this specific water-based drilling fluid is discussed below.

4.1 PLASTIC VISCOSITY AND YIELD POINT (PV and YP)

The PV and YP can be quickly calculated from the shear stress values measure at rates of 600 and 300 rpm. The PV in centipoise (cps) is calculated from the 600-rpm dial reading (θ600) minus the 300-rpm dial reading (θ300). The PV depends mainly on the concentration of solids and the viscosity of the base liquid.

The YP in (lb/100 ft2) is then calculated from the 300-rpm dial reading minus PV. Typical six speed shear rates are taken at 600, 300, 200, 100, 6, 3 rpm Hughes.

$$PV(cps) = \theta600 - \theta\,300 \quad \ldots\ldots\ldots\ldots \quad YP\left(\frac{lb}{100\,sqft}\right) = \theta300 - PV$$

Based on above definition, plastic viscosity represents the viscosity of mud when subjected to infinite shear rate. Figure 2 show that PV decreases with the increasing in temperature. As the temperature significantly increases up to 200 CO the PV value reduces to minimum values (≈ 6 cp). While, at 25 0C recorder the highest level nearly (43 cp). This reduction is independent on pressure and the pressure stay constant at (500 psi). Also Figure 3 illustrates that changing in pressure with time it is almost constant. Nonetheless, the effect of pressure on plastic viscosity was more apparent at temperatures lower than 250 F.

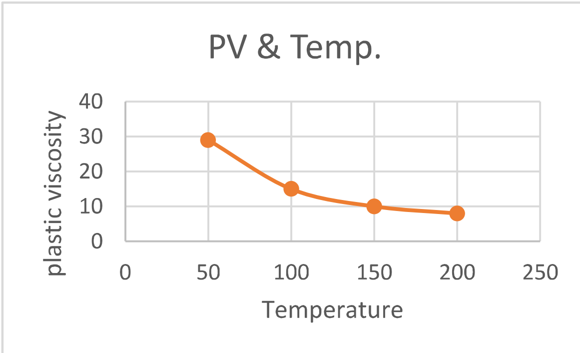


Figure 2

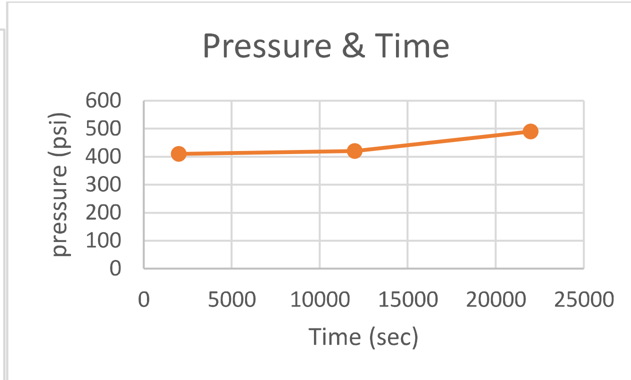


Figure 3

Temp.	PV
50	29.0
100	15.0
150	10.0
200	8.0

Time	Press.
2000	410
12000	420
22000	490

Table to show Pressure & Time (Figure 3)

Table to show Plastic Viscosity & Temperature (Figure 2)

Yield point is dependent upon the surface properties of the mud solids also the volume concentration of the solids. Yield Point could be used to evaluate the ability of a mud to lift cuttings out of the annulus. The carrying capacities of the mud depend on many factors such as annular and slip velocities, plastic viscosity, yield point and density. There fore measuring the viscosity and determining the yield point is a very important part of laboratory and field practice. Figure 4 shows that the yield point for the Glydril mud was generally decreasing with increasing temperature until a temperature 2000 C at which the YP decline suddenly to minimum values just below 20 lbf/100ft , the effect of pressure is more apparent at low temperature. This is a reason to use a constant pressure in this work.

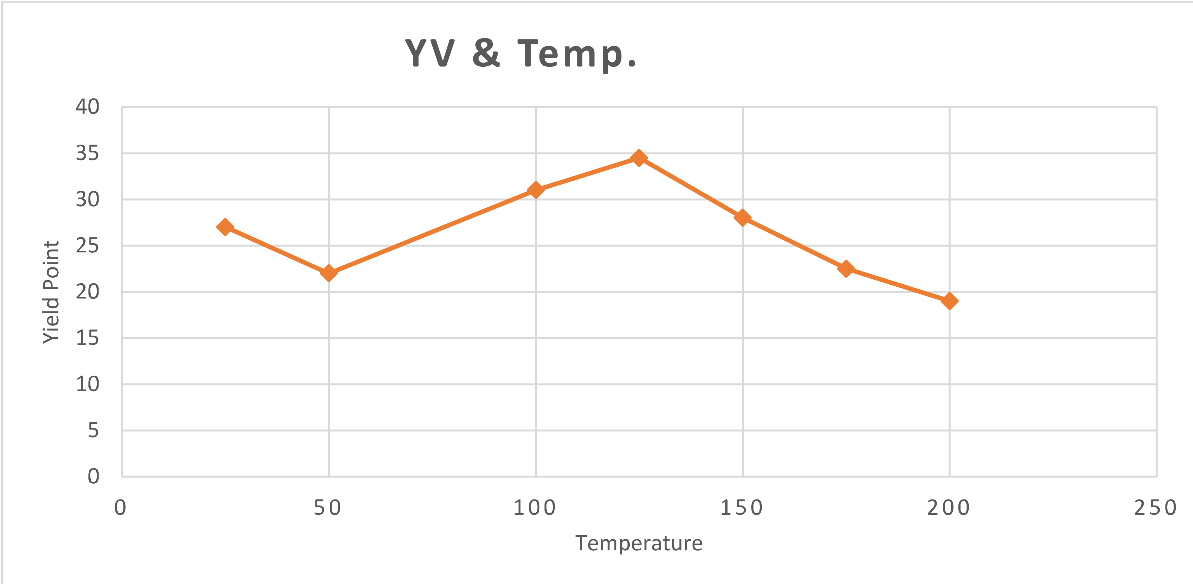


Figure 4

Temp.	YV
25	27.0
50	22.0
100	31.0
125	34.5
150	28.0
175	22.5
200	19.0

Table to show Yield Point value & Temperature (Figure 4)

4.2 VISCOSITY:

According to Awele these properties, describe the flow characteristics of a mud under different flow conditions. In order to predict or know the effects of this flow, it is important that the flow behavior of the mud at various points of interest in the mud circulating system are known. The categories of drilling fluid are determined by the fluid behavior when it is subjected to an applied force (shear stress).

Direct indicating viscometer Fann 35A and Fann M50 in (Figure 1) is used to measure the viscosity at different shear rates to determine the rheology coefficients. The Fann 35A viscometer rotates with six different speed (RPM: 600, 300, 200, 100, 6, 3) and is designed for field and lab use. The Fann M50 is a higher temperature and higher pressure viscometer, it is able to measure the rheological parameters of the drilling mud at HT, HP designed for Lab.

Figure 5 shows the viscosity values at different rotor speeds for Bingham Plastic. The graphs shows that the lower the shear rate, the higher the viscosity for this model. Viscosity was decreasing with increasing temperature until a temperature value (200 C) the viscosity reached at minimal values for all different rotor speeds.

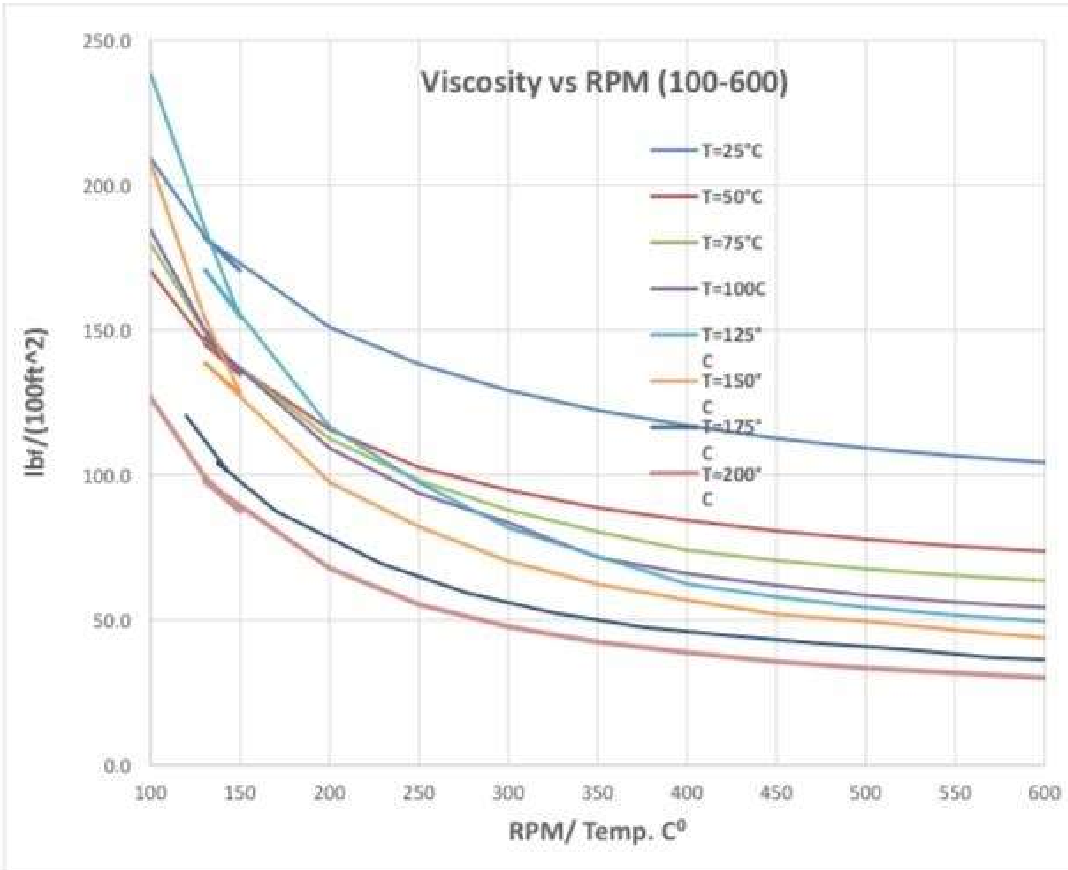


Figure 5 Viscosity versus RMP (100- 600)

4.3 GEL STRENGTH:

Gel strength is defined by Amani, et al. as a "Gel Strength is the shear stress measured at low shear rate after a mud has set quiescently for a period of time (10-sec. and 10-min. in the standard API procedure, although measurements after 30- min. or 16-hrs may also be made". Based on the previous studies gel strengths of drilling fluid/ mud could be defined as a measure of the shearing stress required to initiate flow after static period of time and finite rate of shear, so gel strength is the ability of the drilling mud to suspend drilling cuttings and other solid additives. They are measured by observing the maximum shear stress value while slowly turning the3-rpm setting after being static for some period of time (lb/100 ft). With sufficient gel strength can help suspend drill cuttings in the hole and allow them to settle out on the surface.

Gel strength measured by Fann 35A type rotational viscometer. Gel strength measured by observing the maximum shear stress value while slowly turning the 3-rpm setting after being static for some period of time. Standard values for gel strength are taken after 10sec, 10 minutes and 30 minutes. Table 4 illustrates the measured gel strength at two different times.

Table 4 Gel strength measurement

Gel strength at 1 min (lb/100ft^2)		Gel strength at 10 min (lb/100ft^2)
First	10.5	23
Second	10.5	23
Average	10.5	23

4.4 FILTRATION AND FILTER CACKE:

Filtration defined by Nasser et al. as a "Fluid loss is the measurement of filtrate passing from the drilling fluids into a porous permeable formation. Low fluid loss is a characteristic of good drilling fluids and the key to borehole integrity. The goal of good drilling fluids is to create a thin filter cake on the side of the borehole. This prevents the excessive loss of fluids into the formation". Based on drilling fluids reference manual[10] two types of filtration are considered, static and dynamic. Static filtration occurs when the fluid is not in motion in the hole.

Table 5 filtration measurements

Time (min)	1	2	4	6	9	10	16	25	30	Volume (cm^3)	Thickness of filter cake (mm)
Volume (drops)	30	48	74	82	95	104	144	183	210	13.5	1.7

5- CONCLUSION:

HP/HT operations seem to be new normal for oil and gas industry. Drilling into the reservoirs with elevated temperature and pressure requires a fluid with stable rheological properties. In this laboratory work, the effect of higher temperature and higher on the rheological characteristics of water –based mud was studied. The following conclusions were made based on the results obtained from the tests:

1- Yield Values decreases with increasing in temperature until reaches 25 lb/100ft2 at 50 0C and started increasing with increases temperature slightly to 34 lb/100ft2 at 120 0C then after reduces to lowest point nearly 18 lb/ft2 at 200 0C.

2- Plastic viscosity drilling mud reduces with increasing temperature and the effect of pressure was neglected especially at lower temperature.

3- Viscosity decreases with increasing temperature until the temperature reach to 150 C the viscosity plateaus at minimum values for all different rotor speeds. The effect of pressure on viscosity is not more predominate as the effect of the temperature.

4- Gel strength measured based on the Fann 35A viscometer at different time such as one min and 10 min gel strength, gel strength rises with increasing the rotation time at the same rmp.

5- Bingham Plastic model gives a perfect mathematical description of water based mud’s rheology especially viscosity at higher temperature and pressure.

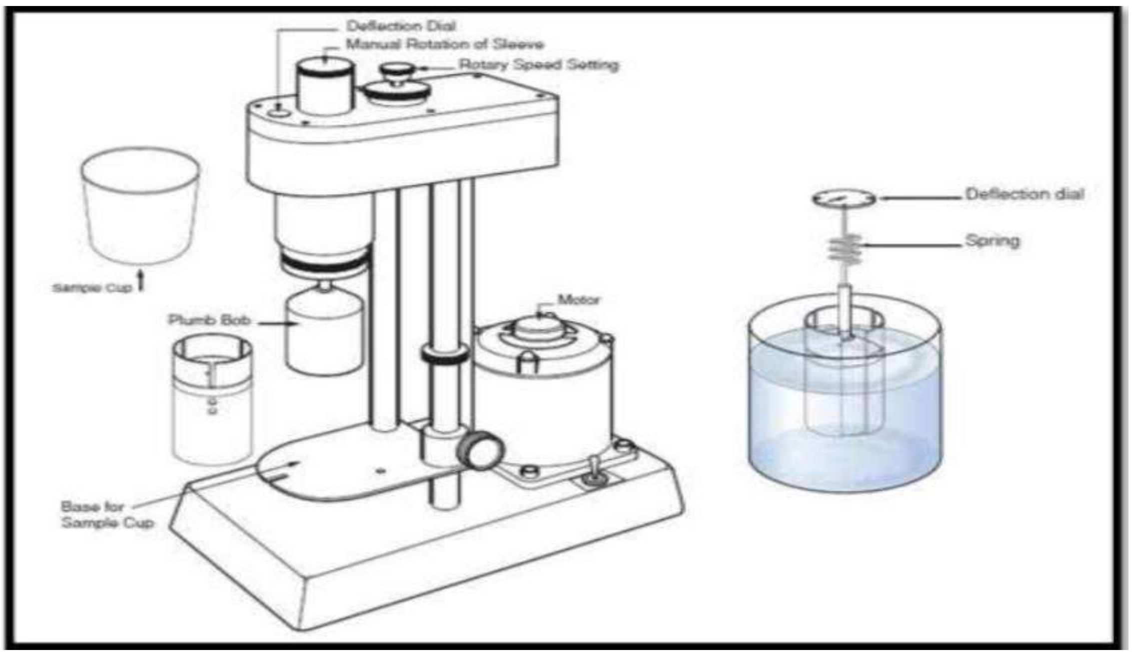


Figure: Fann V-G meter.

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