The Effect of Rice Husk and Sawdust on the Properties of Oil-Based Mud at Varied Temperatures

Anawe Paul A.L[1*], Efeovbokhan Vincent E[2], Adebayo Thomas A[1], Nwaogwugwu M. M[1]

1. Department of Petroleum Engineering, Covenant University, Km 10 Idi-iroko Road, Canaan Land, Ota
2. Department of Chemical Engineering, Covenant University, Km 10 Idi-iroko Road, Canaan Land, Ota

*E-mail of corresponding author E-mail: paul.anawe@covenantuniversity.edu.ng

Abstract

The effect of rice husk and sawdust additive to oil based mud has been investigated. It was discovered that the pH values obtained were slightly acidic for the rice husk but slightly alkaline for the sawdust based mud samples. It was also observed that while the addition of rice husk to an oil-based mud increases the mud densities from 9.5 for 5g additive to 10.0ppg for 25g additive and increases the apparent viscosities from 55 for 5g additive to 115cP for 25g rice husk additive. As expected the apparent viscosity reduced with increasing temperature (55 to 37.5 from 60^o-100^{o}C for Sample B). The addition of sawdust additive to similar oil based mud causes much lower effect on densities (9.60 for 5g to 9.8ppg for 25g sawdust added) and viscosities. The results show that rice husk can be used as filtration loss additive in oil-based mud slight modifications to attain the desired mud cake thickness. It was also observed that increase in temperature resulted to increase in the filtration rate and decrease in plastic viscosities, apparent viscosities and gel strength of the oil-based mud.

Keywords: Rice husk, sawdust additives, drilling mud

1. Introduction

The drilling fluid is related either directly or indirectly to almost every drilling problem. The first objective in planning a mud programme is the selection of a mud that will minimize the amount of lost time in the drilling operation. Generally, a good drilling fluid is simple and contains a minimum number of additives. This allows easier maintenance and control of its properties (Max & Martin 1974).

Most drilling fluid formulations contain a base liquid and additives which must be dissolved or mechanically dispersed into the liquid to form a homogenous fluid (Makinde et al 2011). One of the reasons for improving drilling performance and management is cost. The contribution of drilling mud in terms of overall cost of drilling may be between 5 to 15% but may cost 100% of drilling problems. The role of drilling fluids include, stabilizing wellbores, keeping off formation fluids, clearing cuttings from the drill bit face and lubricating the bit, controlling bore pressures, temperatures and many more has attracted very close attention and scrutiny by many researchers (Darley & Gray 1988). Generally, water based mud (WBM) systems are the cheapest and preferred mud systems for drilling and hole cleaning (John & Eric 1933). The choice of the drilling mud to employ for a drilling occasion is determined by so many complex factors, which include, well design, well pressures, type of well formation to be encountered, temperature and cost. The final selection of the drilling fluid is based on five basic properties including mud rheology, density, fluid loss, chemical composition and solids content (Geehan & Mckee 1989). A good drilling mud should have high viscosity to carry cuttings to the surface and suspends weighting agents in the mud (Geehan et al 1990). This is carefully balanced to prevent excessive viscosity that may lead to excessive pump pressure and decrease in drilling rate (Geehan et al 1990). A good balance of pressure is required within the well bore to prevent wall of the bore from caving in and the formation fluids from entering into the borehole. High density of the mud helps to maintain the required hydrostatic pressure. The higher the density of the mud compared to the density of the cuttings the easier it is to be suspended in the mud and hence better cleaning of the bore. If the mud weight is too high the rate of drilling is reduced. The fluid loss helps to create a low permeability filter cake to seal between the well bore and the formation. Control of fluid loss prevents the invasion of the formation by filtrate and minimizes the thickness of the filter cake on the wall of the wellbore. Drilling fluids satisfy many needs in their capacity to do the following: suspend cuttings (drilled solids), remove them from the bottom of the hole and the well bore, and release them at the surface, control formation pressure and maintain well-bore stability, seal permeable formations, cool, lubricate, and support the drilling assembly, transmit hydraulic energy to tools and bit, minimize reservoir damage, permit adequate formation evaluation, control corrosion, facilitate cementing and completion, minimize impact on the environment and inhibit gas hydrate formation (Drilling Fluid Processing Handbook 2006, Darley 1965, Darley & Gray 1986)). The most critical function that a drilling fluid performs is to minimize the concentration of cuttings around the drill bit and throughout the well bore. This must be controlled by allowing drilling fluid pass through a screen to remove particles larger than the openings maintained at some relatively low concentration. Drilled solids must be controlled because as drilled solids are added to the drilling fluid, fluid loss decreases but filter cake become thicker and less compressible (American Association of Drilling Engineers 1999). Drilled solids also increases the plastic viscosity of the mud. Sawdust can be regarded as a good additive to drilling mud (Max & Martin 1974). Fluids with low plastic viscosity can remove cuttings better. High plastic viscosity diminishes the effectiveness of yield point for hole cleaning in all vertical holes It increases fluid pressure losses in the circulating system, which decreases drilling performance (American Association of Drilling Engineers 1999). Solids problems can arise due to decreasing particle size even though the concentration of solids in the fluid remains unchanged. As particle size decreases, the resultant increase in solids area and number of particles increases plastic viscosity and can create or exacerbate hole problems (Goins & O'Brien 1960). Loss of circulation occurs when the formation drilled is extremely permeable and a pressure differential is applied toward the formation. The mud loss rate dramatically increases by the excessive overbalance pressures created by the hydrostatic head of the column of mud in the hole. In some cases, decreasing the differential pressure by reducing the fluid density and pumping rate or pressure will stop fluid losses and regain circulation Saudi (Aramco 2006). However, the most effective method for combating lost circulation is to reduce the permeability of the borehole wall by introducing properly sized bridging material, commonly known as loss circulation material (LCM) into the rock pores with a high viscosity pills. Bridging particles contained in the mud will not seal the zone if they are smaller than the formation pores (Aramco 2006). Shale are the most common rock types encountered while drilling for oil and gas and give rise to more problems per meter drilled than any other type of formation (Boll 1992) Shale stability is largely driven by changes in stress and chemical alteration caused by infiltration of mud filtrate containing water (Allen et al 1991). This problem led to increasing research towards oil-base mud in the 1970's as a means of controlling reactive shale. Oil based mud (OBM) not only provides excellent well bore stability but also a good lubrication, temperature stability, a reduced risk of differential sticking and low formation damage potential.

OBM has been invaluable in the economic development of many oil and gas reserves. The only real challenge though, is the disposal of OBM cultings which can have a lasting environment impact (Bloys et al 1994).

A key method of maintaining shale stability using OBM is to ensure that the ionic concentration of the salts in the internal (aqueous) phase of the mud is sufficiently high, so that the chemical potential of the water in the mud is equal to or lower than that of the formation water in the shale (Fletcher 1993). When both solutions have the same chemical potential, water will not move, leaving the shale unchanged. If the water in the internal phase of the mud has lower chemical potential than the fluid in the formation, water will travel from the shale to the mud, drying out the rock. Unless dehydration is excessive, this drying out usually leaves the wellbore in good condition (Mody & Hale 1993. Chenevert 1970). A number of relatively new types of mud systems have been introduced. For example one route is to substitute the oil phase in OBM with synthetic chemicals. In this way the excellent characteristics of OBM may be reproduced.

2. Methodology

2.1 Materials Used: Aged Ofada rice husk, white soft wood sawdust, diesel oil purchased from a filling station all in Ota, Ogun State, Nigeria

2.2 Apparatus:

Items of equipment used include: mud balance, Hamilton Beach Mixer, Vann rotary viscometer, High Temperature/ Pressure Filter Press, Weighing balance, pH meter, Heating Mantle

2.3 Preparation of Mud

A total of 14 mud samples were prepared. One mud sample was completely blank (no rice husk or wood dust), five of the mud samples were prepared using only rice husk, another set of five prepared with sawdust of 0.5mm particle size and the last three mud samples were prepared using a mixture of both rice husk and sawdust. In the preparation of the blank oil-based mud, a ratio of 3:7 of diesel oil to water was used, with 10g of bentonite, 150.97g barite and 5g of salt (NaCl). The density, rheological and filtration properties were then carried out at different temperatures on the various blank oil-based muds (no rice husk or wood dust). Rice husk that has been previously dried in an oven was then added to the various blank oil-based muds at predetermined weights and the density, rheological and filtration properties tests were again carried out as before. Furthermore, aged sawdust made up of mixture of three most popular west Nigerian woods: Mahogany, Ipe and African blackwood at 0.5mm particle size, which has been previously dried was taken and added to the blank muds at varied weight ratios. The various test properties-density, rheological and filtrations were performed. The last set of the oil based muds were prepared using a combination of the rice husk and sawdust at varied weight ratios added to the blank muds. The various weight ratios of rice husk and sawdust is as shown on table 2.1 below.

2.4 Rheological Properties (Mud Viscosity and Gel Strength)

The rotary viscometer was used. Here, the splash guard was first placed onto the bob shaft with short tube end up towards the bearings. It was pushed up. The appropriate bob was screwed on with the tapered end up towards the splash guard. The sleeve was placed onto the rotor over the bob. The mud sample was placed in a sample cup and the rotor sleeve immersed to the fill line on the sleeve by raising the platform. The lock nut was tightened on the platform. The power switch unit was then turned on. The speed selector knob was rotated to the stir setting and the sample was mixed for a few seconds. The knob was rotated to the 600 RPM setting, when the dial reached a steady reading, the 600 RPM reading was recorded. The speed selector knob was again rotated to the 300 RPM setting, when the dial reached a steady reading, the 300 RPM reading was recorded.

The speed selector knob was rotated back to the stir setting and the sample was re-stirred for a few seconds. The speed selector knob was rotated to the gel setting and immediately the power was shut off. 10 seconds after the sleeve stops rotating, the power was turned on while looking at the dial. The maximum dial deflection before the gel breaks at the 10-second gel strength was recorded. For the 10-minute gel strength, the fluid was re-stirred and the maximum dial deflection after 10 minutes was recorded. The procedure was done at different temperatures of 60°C, 70°C, 80°C, 90°C and 100°C for each of the respective mud samples.

2.5 Mud Filtration Properties

The Standard filter press was used. The dry parts were first assembled in the correct order: base cap, rubber gasket, screen, a sheet of filter paper, rubber gasket and cell. The cell was secured to the base cap and then filled with the mud sample to ½" of the top. The entire unit was then set in place in the press frame. The top cap was placed on the cell and the unit secured in place with T-screw. A dry graduated measuring cylinder was placed under the filtrate tube for filtrate collection. With the aid of the regulator T-screw the valve was rapidly opened to the filter cell at 100 psi pressure for 30 minutes. The volume of the filtrate in the graduated measuring cylinder was then recorded as the filtrate loss in 30 minutes. The filter cell was then removed and filter cake thickness determined. This procedure was then repeated for all the mud samples.

3. Discussion of Results:

3.1 Effect of Additives on the Density and pH Values of Mud Samples

In Table 3.1, as the weight content of the rice husk was increased from 5g to 25g (samples B to F), there was a significant increase in the mud densities compared to the density of sample A. Similar pattern was observed for the saw dust as its weight increased from 5g to 25g (sample G to K), there was a corresponding increase in the mud weights or densities relative to the density of sample A. However, the densities of rice husk formulated mud were generally higher than those formulated using sawdust under the same prevailing conditions. The pH values of the mud samples became slightly acidic with the addition of 5g to 25g of rice husk (samples B to F).While with the addition of same quantity of sawdust, the pH values became slightly alkaline.

3.2 Effect of Additives on the Viscosities of Mud Samples

The effect of additives on the viscosity of the oil based mud relative to the blank sample are as displayed – rice husk (Figs3.2 – 3.4), sawdust (Figs3.5 – 3.7), combination of rice husk and sawdust (Figs3.8 – 3.10) and without any additives or blank (Figs3.1). Generally, viscosities for all the samples tend to decrease as temperature was increased. The effect of rice husk additive produced higher viscosity effect than all the other additives. It was observed that the higher the quantity of rice husk added the higher the viscosity of the mud samples. For instance, for sample F in which 4.7% addition of rice husk was made, the viscosity variations were 250, 230, 220, 210, 200, and 190 cP measured at different temperatures of 60, 70, 80, 90, and 100 ^oC respectively and 600 rpm viscometer speed. In contrast, 4.7% sawdust addition to mud sample K, marked decrease in viscosities measured under the same conditions were observed: 78, 73, 65, 60, and 55 cP at temperatures of 60, 70, 80, 90, and 100 ^oC and 600 rpm viscometer speed. A combination of the rice husk and sawdust gave viscosity values of 97, 86, 80, 76, and 71 cP (in between that of the rice husk and sawdust) under the same set of conditions. It becomes obvious from the foregoing that rice husk as an additive to drilling mud would act as viscosifying agent while the sawdust could be used as a viscosity reducing agent. The gel strengths of sample B to F moderated with rice husk were generally higher than the mud samples G to K moderated with sawdust at 0.9 to 4.7 % addition respectively. For all the samples the gel strength generally decreased as the temperature was increased from 60 to 100 ^oC. The gel strengths at 10 seconds were also generally higher than the gel strength at 10 minutes for all the mud samples. As temperature of the mud samples increases from 60°C to 100°C, the viscosities and of the mud samples decrease. Also the plastic viscosity of the mud samples reduced as temperature was increased from 60°C to 100°C. The filtration tests for the mud samples were carried out at 100 psi. In table 3.2, the filtrate loss for each of samples B to F was generally lower compared to the blank sample A. In contrast, the filtrate loss for samples G to K was more compared to samples B to F. It was observed that as the filtrate loss increased for all the mud samples as temperature was increased. The mud cake obtained from sample B to N was the same as that of sample A. The texture of the mud cake was soft and porous.

4. Conclusions

Based on the lab experiments and data analysis carried out in this research work, the following conclusions are drawn as follows:

Rice husk added to the mud increased its densities, plastic viscosities and apparent viscosities. Hence the rice husk can be used as a viscosifier and a weighing agent.

Saw dusk added to the mud produced lower effect of densities and viscosities compared to the rice husk.

The results show that rice husk can be used a filtration loss additive in oil-based mud but it will need some modifications to attain the desired mud cake thickness.

The mud cake measured was 0.05cm which is little because the additives could not stick to the oil-based mud.

An increase in temperature resulted to increase in filtration rate of the oil-based mud.

Addition of rice husk reduced the pH value tending towards acidic mud.

Increase temperature results in decrease in plastic viscosities, apparent viscosities and gel strength of an oil-based mud.

Generally the use of naturally occurring additives such as sawdust, rice husk and many others should be encouraged, further researched and included in drilling fluids production by mud engineers. They have the capability to replace some of the synthetic mud additives being currently used. The benefits derivable are enormous and attractive which; include compatibility with the environment, lower overall investment cost, clean environment from the use of environmental waste materials, readily biodegradable and less toxic to human operators.

Limitations:

The research was carried out in a typical laboratory setting and thus was difficult to completely simulate down-hole conditions of the investigated properties.

References

Allen D, Auzerais F, Dussan E, Goocle P, Ramakrishn T.S, Schnartz L, Wilkinson D, Ferdham E, Hammond P and Williams R, (1991) Invasion Revisited; Oil Field Review 3(3) 10 – 23.

American Association of Drilling Engineers (1999), Techniques and Technology for Improving Solids Control Management. Shale Shakers and Drilling Fluid Systems. Gulf Publishing Company (5^{th} Edition), Houston, Texas USA

Bloys B, Davis N, Smolen B, Bailey, L Frasser, L and Holder M (1994) Designing and Managing Drilling Fluids Schlumberger mud Solids Monitor (MSM) and Fluid Monitoring Package (FMP).

Boll G.M, Wong S.W, Savidson C.J and Woodland D.C (1992) Bolehole Stability in Shales; SPE European Petroleum Conference Cannes, France p16-18.

Chenevert M.E (1970) Shale Control With Balanced Activity Oil-Continuous Oil-Continuous Muds, Journal of Petroleum Technology 22, 1309 – 1319.

Darley, H. C. H. (1965) Designing Fast Drilling Fluids J. Petrol. Technol., pp. 465–470.

Darley H.C.H and Gray G.R (1988), Composition and Properties of Drilling and Completion Fluids Gulf Publishing Company (5th Edition), Houston, Texas USA.

Darley, H. C. H., and Gray, G. R., (1986) Composition and Properties of Oil Well Drilling Fluids, 5th ed., Gulf Pub. Co., Houston.

Drilling Fluid Processing Handbook (2006),

Fletcher P, (1993) Chemical Thermodynamics of Earth Scientists; Longman Scientific and Technical Harlow Essex, England.

Geehan T, Helland B, Thorbjornsen K, Maddine C, Mclntire B, Shepherd B, Page W (1990), Reducing the Oil fields Environmental Footprint. Oil Field's Review 2, No. 4, 53-63.

Geehan T and Mckee A (1989), Drilling Mud: Monitoring and Managing it. Oil Field's Review 1, No. 2, 41-52

Goins and O'Brien (1960), Blow Out Control and What You Need to Know About It. Series from Oil & Gas Journal, 1960.

John G and Eric V.O (1933) Hole Cleaning Quick Guide & Best Practices Manual, Shell Exploration and Production Company P.O Box 61933 New Orleans, LA, 70161.

Makinde F.A., Adejumo A.D., Ako C.T. & Efeovbokhan V.E. (2011) Modelling The Effects Of Temperature And Aging Time On The Rheological Properties Of Drilling Fluids Petroleum & Coal 53 (3) 167-182, 13.

Max R. A and Martin V. S (1974) Drilling Fluids Technology

Mody F.K and Hale A.H (1993) A Borehole Stability model to Couple Mechanics and Chemistry of Drilling Fluid-Shale interactions; IADC/EPE Drilling Conference, Amsterdam.

Saudi Aramco (2006), Drilling & Workover Engineering, Drilling Manual: Introduction to the Drilling Manual.

Table 2.1: Weight Variation of Rice Husk and Sawdust additives in Oil Based Mud Samples

Mud Samples	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Rice husk (g)	0	5	10	15	20	25	0	0	0	0	0	5	10	10
Sawdust (g)	0	0	0	0	0	0	5	10	15	20	25	10	10	5

Table 3.1: Densities and pH of Formulated Mud Samples

Samples	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
Density	9.30	9.50	9.90	10.00	10.20	10.00	9.60	9.60	9.70	9.80	9.80	9.60	9.80	9.60
pH	7.92	6.71	6.72	6.21	6.04	6.11	9.47	7.61	7.65	7.86	7.86	8.68	8.34	8.35

Table 3.1: Yield Point, Plastic and Apparent Viscosities of Selected Mud Samples

Temperature (^oC)	Sample	60°C	70°C	80°C	90°C	100°C
Plastic Viscosity (cp)		26	20	21	19	8
Yield Point (lb/100ft^3)	A	42	65	42	34	46
Apparent Viscosity (cp)		47	52.5	42	36	31
Plastic Viscosity (cp)		20	19	18	14	10
Yield Point (lb/100ft3)	B	70	69	62	59	55
Apparent Viscosity (cp)		55	53.5	49	43.5	37.5
Plastic Viscosity (cp)		55	60	59	55	55
Yield Point (lb/100ft3)	F	120	100	92	90	80
Apparent Viscosity (cp)		115	110	105	100	95
Plastic Viscosity (cp)		11	11	13	13	11
Yield Point (lb/100ft3)	G	76	60	49	37	33
Apparent Viscosity (cp)		49	41	37.5	31.5	27
Plastic Viscosity (cp)		13	7	13	11	18
Yield Point (lb/100ft3)	L	67	71	50	40	23
Apparent Viscosity (cp)		46.7	42.5	38	31	29.5

Table 3.2: Filtration Properties of Selected Mud Samples

Filtrate @ T°C	Sample	Water Volume (ml)	Oil Volume (ml)	Total Volume (ml)	Cake Thickness (cm)
60		55	155	210	0.05
70		68	160	228	0.05
80	A	73	173	246	0.05
90		77	180	253	0.05
100		83	191	274	0.05
60		48	89	137	0.05
70		51	93	144	0.05
80	E	54.2	96.8	151	0.05
90		56	100	156	0.05
100		61	110	171	0.05
60		48.5	129	177.5	0.05
70		55.3	140.2	195.5	0.05
80	H	58	146	204	0.05
90		63	153.2	216.2	0.05
100		72	164	236	0.05
60		40	102	142	0.05
70		48.2	116	164.2	0.05
80	J	53.6	127	180.6	0.05
90		60	134	194	0.05
100		69	143	212	0.05
60		54	124	178	0.05
70		59.8	133	192.8	0.05
80	L	67.4	142	209.4	0.05
90		70	150	220	0.05
100		76	158	234	0.05

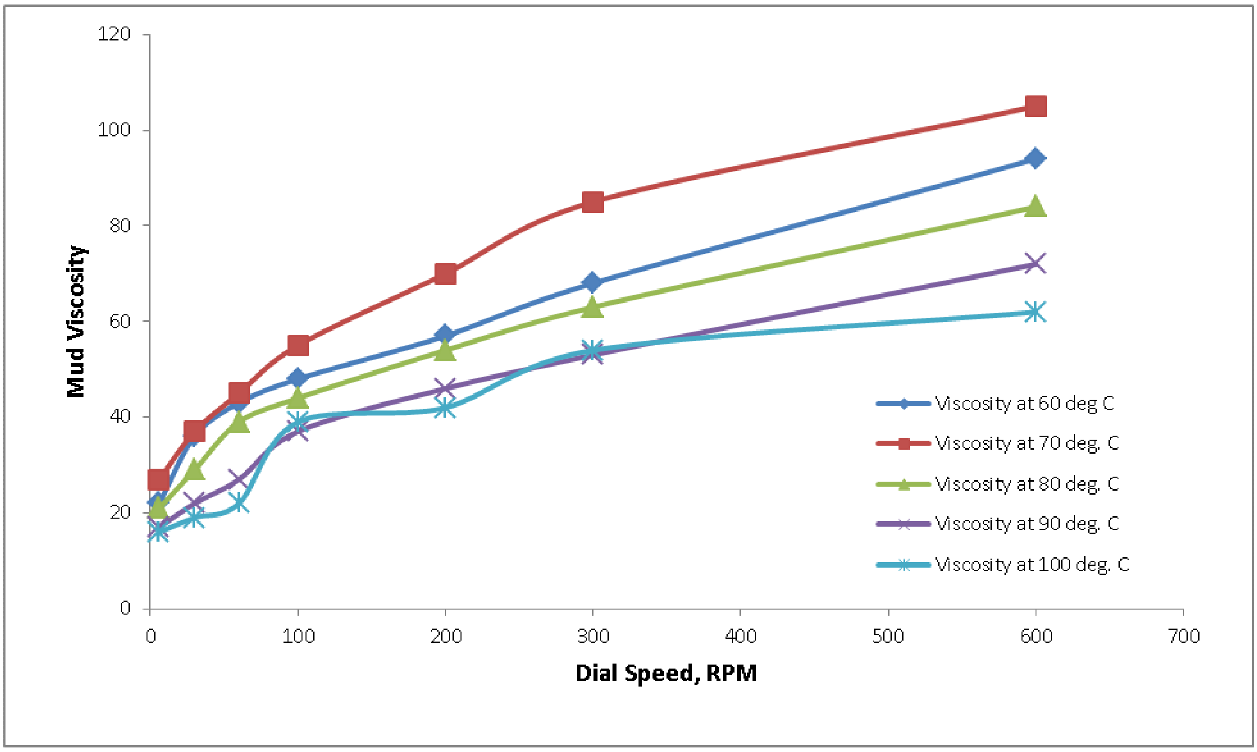

Figure 3.1: Viscosity Variation with Temperature of Oil Based Mud (Sample A)

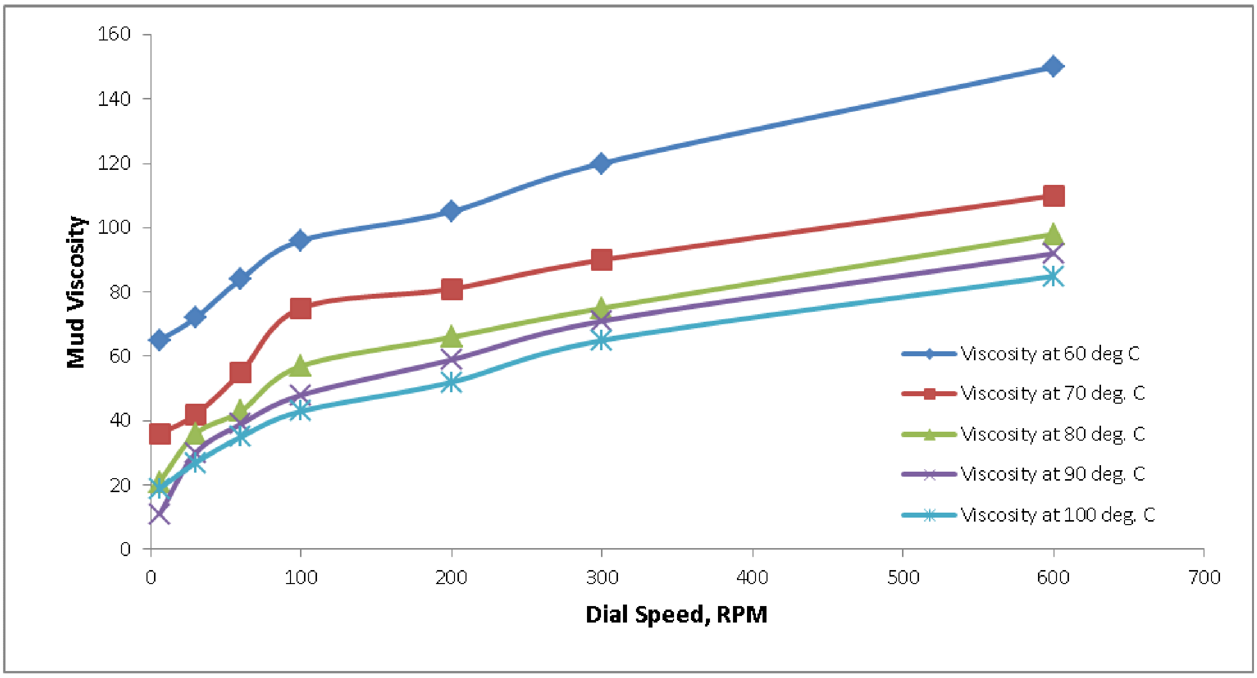

Figure 3.2: Viscosity Variation with Temperature of Rice Husk Formulated Oil Based Mud (Sample C)

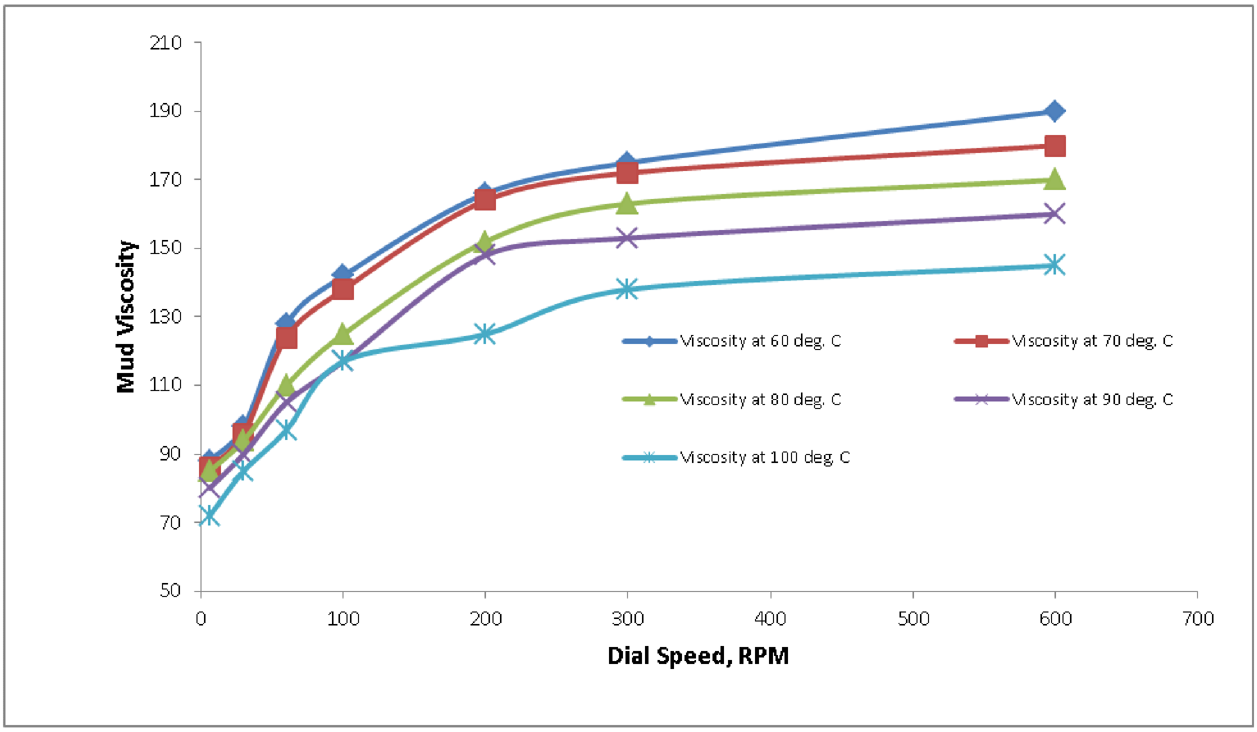

Figure 3.3: Viscosity Variation with Temperature of Rice Husk Formulated Oil Based Mud (Sample E)

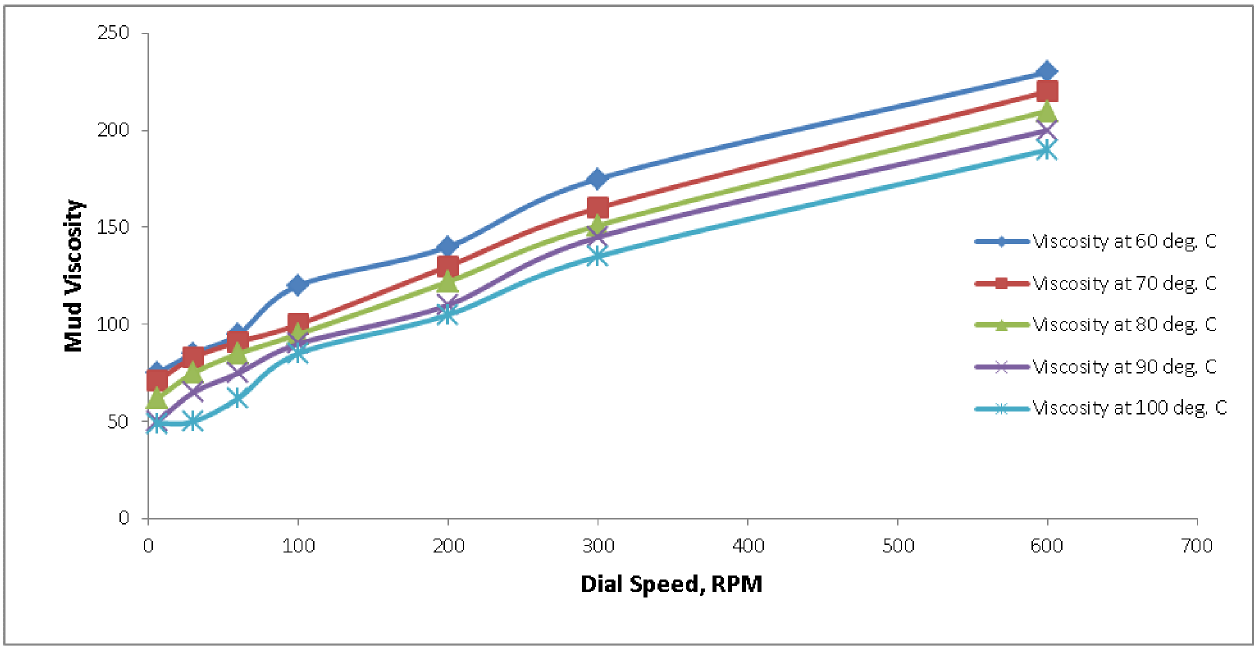

Figure 3.4: Viscosity Variation with Temperature of Rice Husk Formulated Oil Based Mud (Sample F)

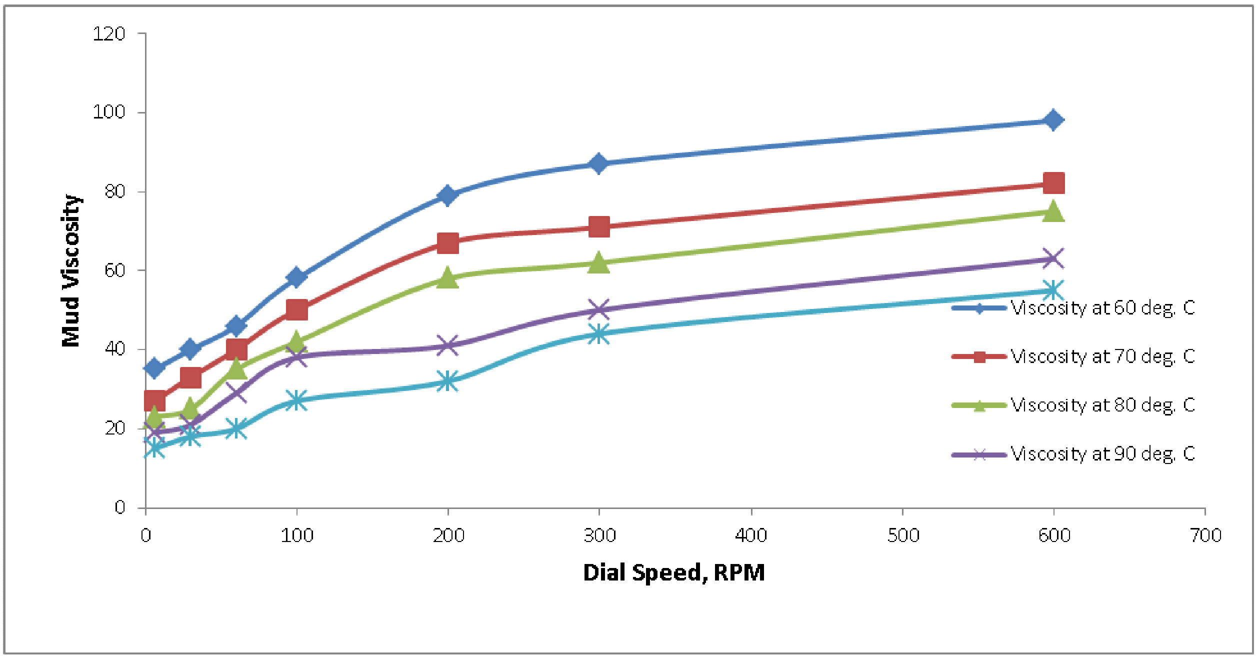

Figure 3.5: Viscosity Variation with Temperature of Sawdust Formulated Oil Based Mud (Sample G)

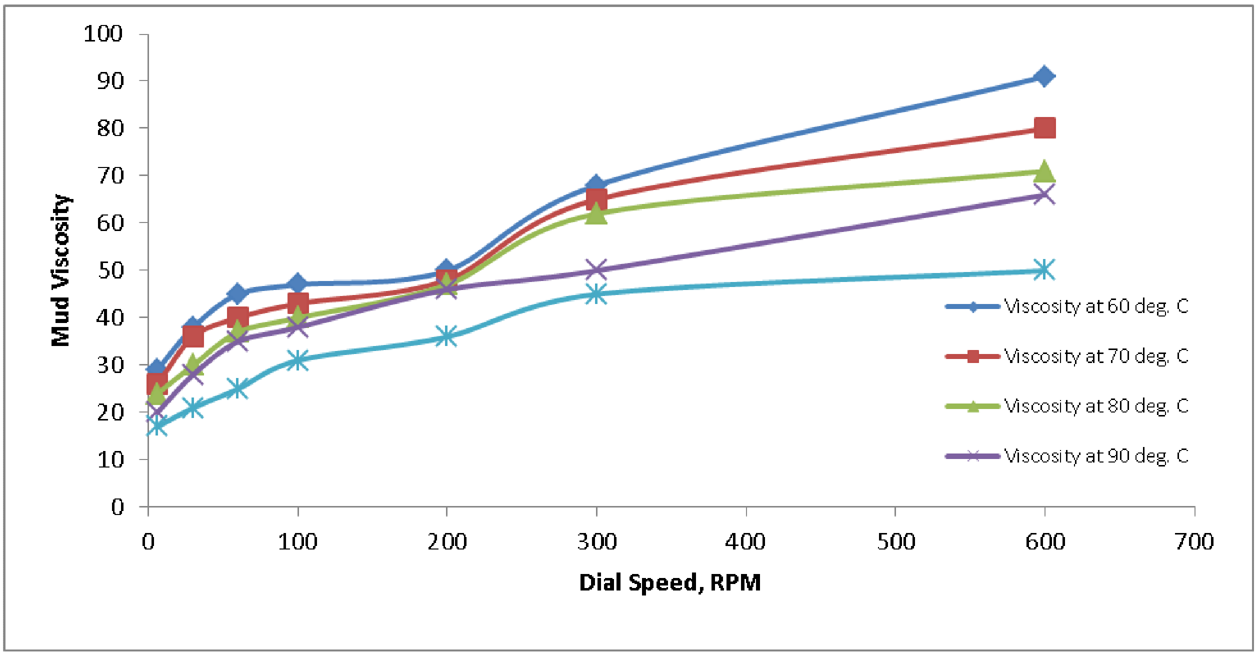

Figure 3.6: Viscosity Variation with Temperature of Sawdust Formulated Oil Based Mud (Sample I)

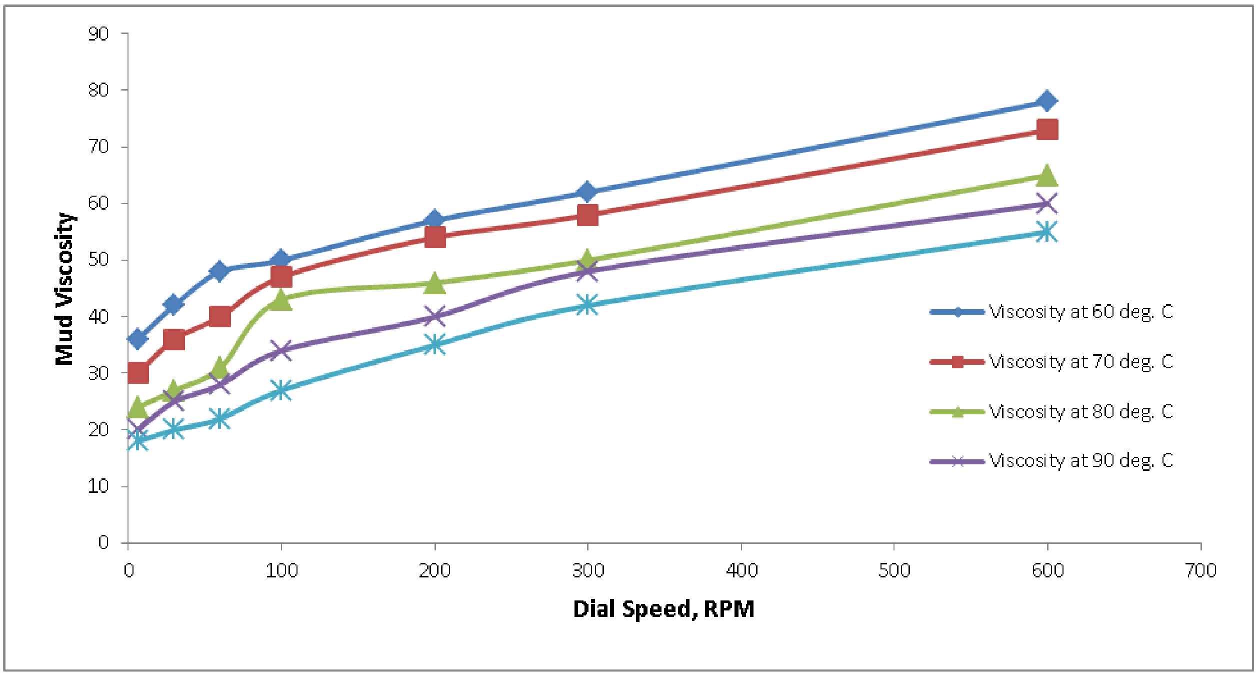

Figure 3.7: Viscosity Variation with Temperature of Sawdust Formulated Oil Based Mud (Sample K)

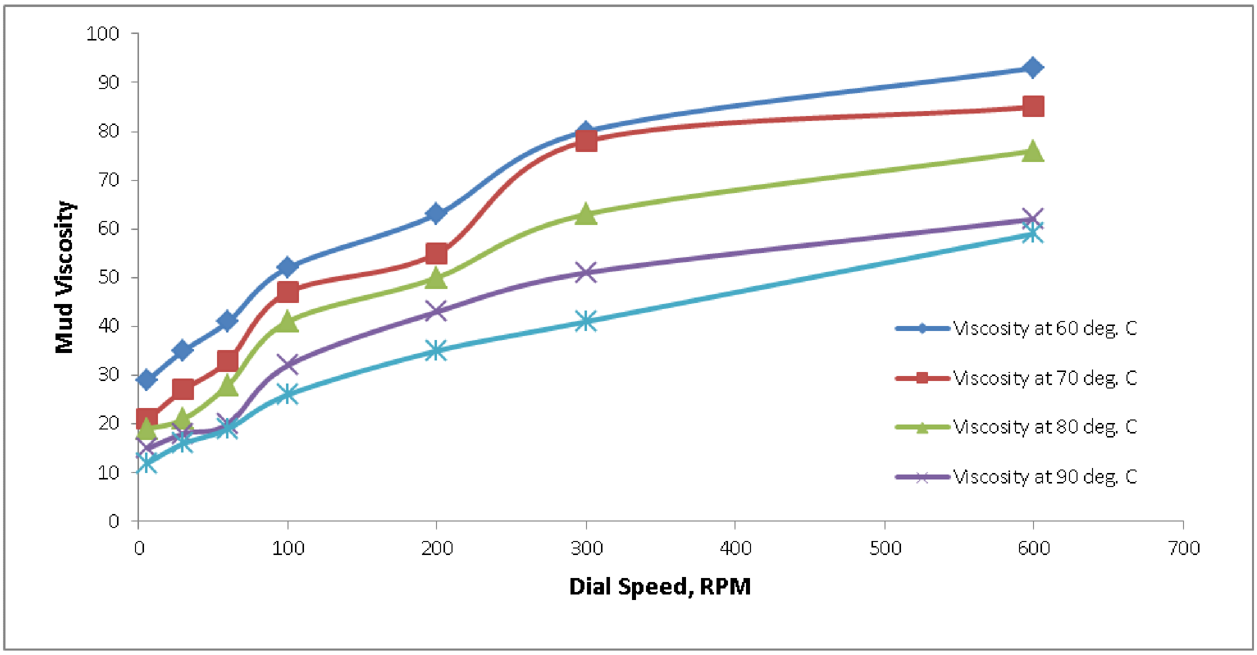

Figure 3.8: Viscosity Variation with Temperature of Rice Husk and Sawdust Formulated Oil Based Mud (Sample L)

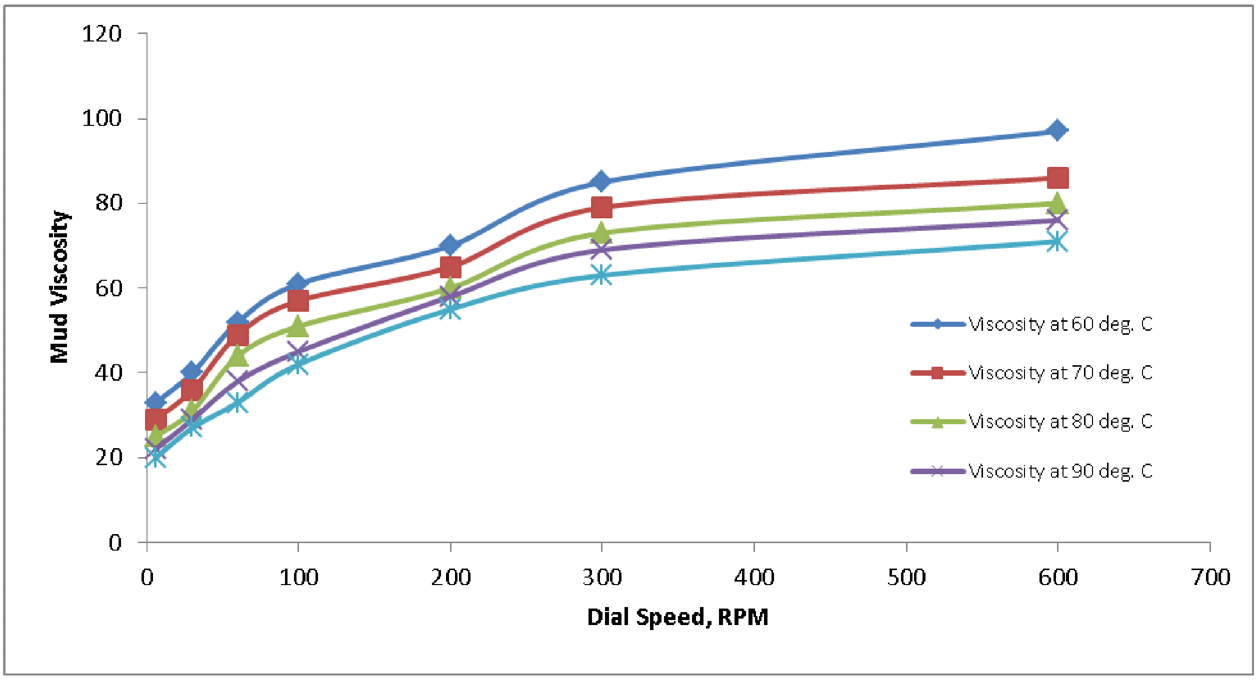

Figure 3.9: Viscosity Variation with Temperature of Rice Husk and Sawdust Formulated Oil Based Mud (Sample M)

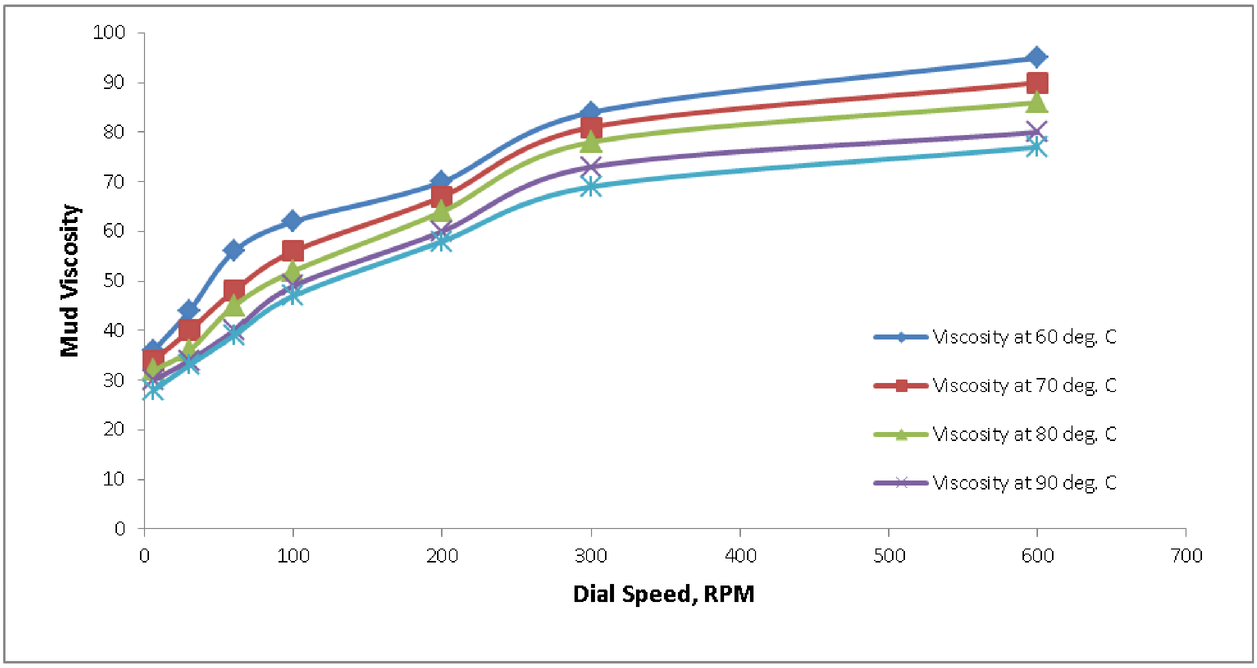

Figure 3.10: Viscosity Variation with Temperature of Rice Husk and Sawdust Formulated Oil Based Mud (Sample N)