111(A) - 8

Paper submitted to Regional Symposium on Chemical Engineering 1997
October 6-8, 1997, Johor, Malaysia

THE EFFECTS OF MUD CONTAMINATION TO WELLBORE STABILITY

(8)

Surej.K.S*
Ariffin.S†
Zularisam**
Petroleum Production Operation Research Group
Faculty of Chemical and Natural Resources Engineering
University Technology Malaysia

Abstract

The paper describe a series of laboratory works for wellbore instability due to mud contamination by different mud system. Three favorite mud system, Water Base mud, Oil Base Mud and Inverted Emulsion Mud has been used for the research. The perforated wellbore model invaded with these mud systems and the stability test conducted to suggest the best mud system which gives best stability. The perforation pattern also studied in the research. In general, it is found that the Oil Base Mud system give the best stability followed by Inverted Emulsion Mud and Water Base Mud system regardless of the perforation pattern. The perforation pattern analysis shows that the spiral pattern exhibits the most stable pattern followed by inplane and inline.

Introduction

Mud is an important item which is use as drilling fluid during drilling and completion of a oil/gas well to maintain the hydrostatic pressure. Maintaining the hydrostatic pressure is primarily important to avoid problems such as formation collapse which leads to casing collapse, sand production and etc. Other factors such as shale swelling, fluid loss also occurred due to modification of the physical and chemical characteristic of the mud.

Laboratory Works

As early experiment, laboratory work has been done in order to determine the basic mechanical properties such as porosity, permeability, compressive and tensile strength of sandstone sample which will be used for design the wellbore model later. The basic mechanical properties were determined correspondence to the American Standard Testing Method (ASTM- Suggested Method by Brown).

Sandstone sample were cored for 2 inches diameter and cut for 5" length for compressive strength. Whereas for the tensile strength test 2" diameter cores were cut for 1" length. Then the specimen were tested for porosity and permeability before the compression test under a Servo Controller machine and for the tensile the Brazilian testing method were used.

Wellbore model then design form sandstone mass obtain from field. The sandstone were cored in dimension of 2" and then trimmed to 6" length. Later 1" borehole cored at the

---

* Research Officer/MSc student in University Technology Malaysia
† PhD & Assoc Prof. in University Technology Malaysia
** Research Student

center of the core. To represent casing, 0.5" OD steel pipe was then cut to correct length. The core then has been put in the oven to remove the moisture. The weight then recorded before the cores were saturated with glycerol to represent as oil formation. As the cores has been fully saturated again the weight been recorded. Then the saturated core will be contaminated with 3 type of mud system which has been widely used in the field at the moment. The mud systems used in the research are Water Base Mud (WBM), Oil Base Mud (OBM) and Inverted Emulsion Mud(IEM).

In order to place the casing (steel pipe) in the center of the borehole, G Class Cement as been squeezed in the annulus as bonding agent between casing and formation. The system then left over for 24 hours to allow the cement to set. Then sandstone model then

perforated (shot density 8 SPF) in accordance to the perforation pattern i.e.spiral, inplane and inline hand drill right through the cement into the sandstone wellbore model.

The stability test then been conducted for the wellbore model using Servo Controller Compression Machine. Load has been applied at a constant rate (0.7 $MN/m^2/s$) until the wellbore model fails. A plot of axial load against deformation was produced to indicate the onset of the failure of the wellbore model.

Results and Discussion

The results show that the porosity value is the range of 0.07% to 0.18%. Found that the permeability range from 0.1mD to 0.8 mD. The average value for the compressive strength, Co is 32 MN/m2 and average value for tensile strength, To is 1.85 MN/m2.

In general, the results show that the perforated wellbore may fail depending on the mud system and perforation pattern. The wellbore without any mud contamination appear more stable compare to contaminated wellbore. The complete summary of the contaminated wellbore failure for can been seen in Figure 1.

Effects of Mud System

Figure 1, shows that the uncontaminated wellbore model give better strength compare to contaminated wellbore. Therefore can be said that invasion of mud system into sandstone (formation) will reduce the strength and wellbore stability

The wellbore stability is decreasing as the mud system been changed from Oil Base Mud to Inverted Emulsion Mud to Water Base Mud. This phenomenon can be related to the factor of degree of mud invasion into sandstone As the more mud filtrate invade the sandstone, the stability of the model will be decreased. This phenomenon are in agreement with Krueger and Vogel, they found that the formation damage is proportional to amount of mud filtrate.

Figure 2 shows the relationship between mud filtrate and mud system. Found that the WBM exhibit the least mud filtrate compare to OBM and IEM. This results are in the agreement with Krueger and Vogel. As the results the WBM suppose to gives the most stable wellbore but the stability test shows that the WBM system wellbore gives the most unstable wellbore.

This is due to the mud filtrate from WBM consist of chemical and water mixture. The mud filtrate will reacts will clay in porous medium of sandstone which is as cementing agent of the sandstone grains. Therefore the clay swells and degree of cementing will be reduced. As the results this will reduce the stability.

From the experiment (Figure 2) found that the Inverted Emulsion Mud (IEM) has more filtrate loss compare to Oil Base Mud (OBM). Thus, the stability of the former mud system has lower wellbore stability than later. Moreover the particle size of IEM is smaller than OBM. As the result, this will be unable to mud particles from plugging in the porous area of the sandstone and allow more mud filtrate to invade the porous sandstone and vice versa for OBM. Since sandstone usually demonstrate water-wet characteristic, therefore the mud filtrate for OBM find the difficulties to penetrate the porous area of the sandstone.

Effects of Perforation pattern

Figure 3 shows the relationship between the perforation pattern and the wellbore instability for different mud system. It is found that the spiral pattern exhibit the most stable perforation pattern followed by inplane and inline regardless of the mud system. The phenomenon is due the arrangement of the perforation tunnels. Since the spiral pattern arranged in a plane inclined to the applied stress and this will have higher rock mass strength compare to inplane and inline pattern. Whereas for the inline pattern the perforation tunnels were put in one vertical line which is parallel to the applied load/stress. In the case of inplane pattern which were considered as intermediate stable pattern, the tunnels were arranged in one horizontal line perpendicular to the applied load/stress, which resulted higher rock mass strength than inline pattern but lower compare to spiral pattern.

Conclusion

As the conclusion, can be concluded that the wellbore instability decreases as the formation is invaded with mud regardless of the mud system. The wellbore instability decreases as the mud system been changed from water base mud (WBM) to inverted emulsion mud (IEM) and oil base mud (OBM). The spiral pattern is the most reliable pattern which exhibit the most stable wellbore followed by inplane and inline pattern regardless of the mud system and degree of invasion. The perforation pattern doesn't influences the mud contamination degree in the formation since the contamination occurred during drilling.

Acknowledgment

1. Ministry of Science and Technology Malaysia - for IRPA Grant (Funding)
2. Research and Development Unit of Universiti Teknologi Malaysia
3. Faculty of Chemical and Natural Resources Engineering
4. Petronas Research and Scientific Services.

REFERENCES

1. Ariffin.S, Surej.K.S, " Hole inclination Angle Design Consideration for Wellbore Stability and Sand Production", COSTAM, 1995

2. Jaeger,J.C & Cook," Fundamental of Rock Mechanics", 3rd Edition, Chapman & Hall London, 1979.

3. Ariffin.S " A Study of Perforation Stability by Physical and Numerical Modeling PhD Thesis, 1990.

4. Nowak,T.J,Krucger,R.F.," The effects of mud filtrate and mud particle upon the permeabilities of cores", API Drilling and Production Practices, 1951,p164.,

5 Krueger,R.F.,Vogel,L.C.,," Damage to sandstone cores by particles from drilling muds.", API Drilling and Production Practices, 1954, p158.

6. Bradley,W.B., " Failure of Inclined Borehole", J.Energy Res.Tech.Trans AIME 101 (1979)

7. Cheatham.J.BJr.," Wellbore Stability",SPE of AIME, (June 1984)

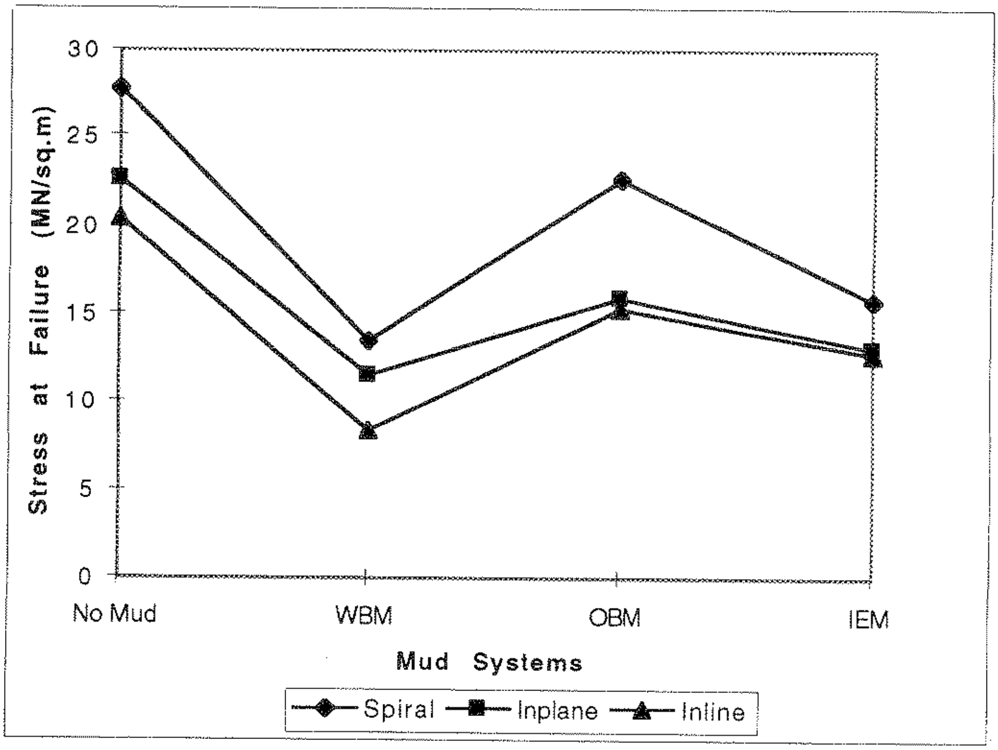

Figure 1 - Effects of mud contamination to wellbore instability

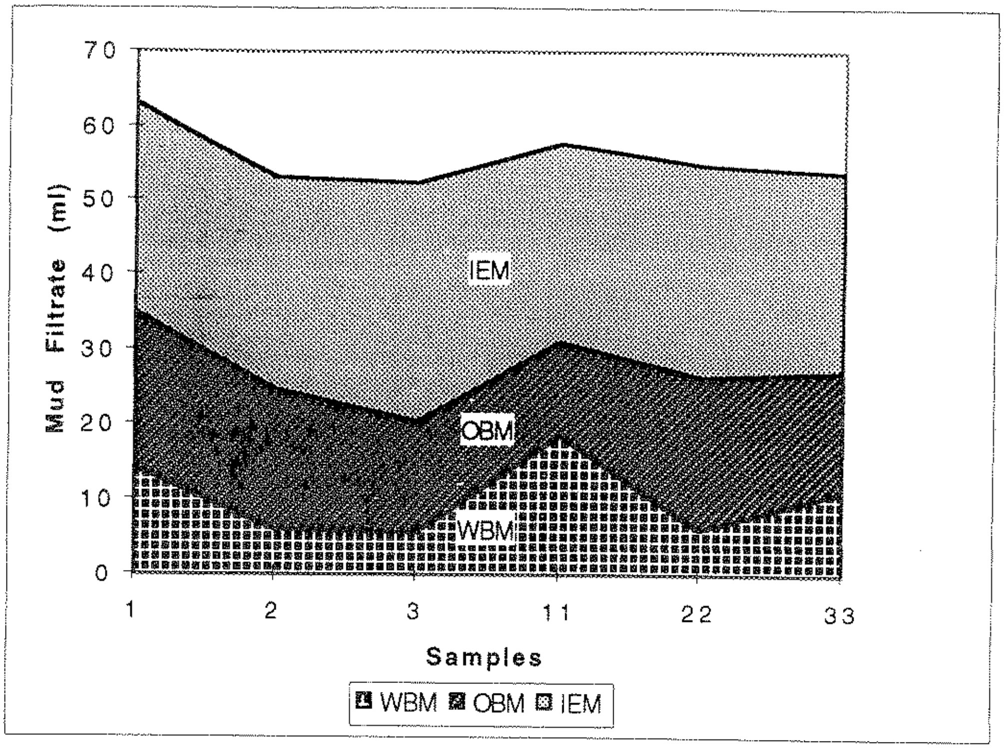

Figure 2 - Mud Filtrate for different mud system into wellbore

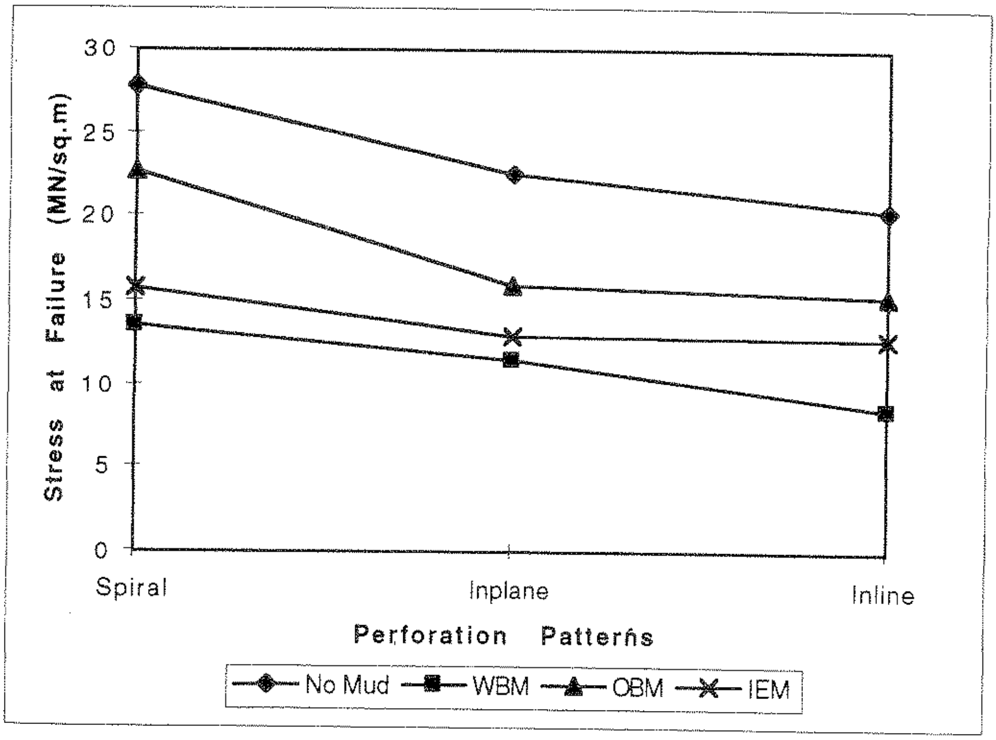

Figure 3 - Effects of perforation patterns to wellbore instability