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Environment Kindly Coalbed Methane Drilling Fluids

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***Abstract*—Discharged drilling fluids in Coalbed Methane (CBM) have certain negative impacts on the environment and the follow-up operations when they are treated improperly. With the scattering well locations and limited budget, it is suitable to adopt the method of solidifying the fluids, rather than the conventional drilling fluids treatment measures. In the Erdos Block CBM drilling, test results of six pollution indexes including pH, chrominance, total suspended matter (TSM), biochemical oxygen demand (BOD5), chemical oxygen demand (COD), total chromium and hexavalent chrome in drilling fluid waste from 5 current wells exceed the National Sewage Discharge Standard Ⅱ (NSDS Ⅱ), while test results of those items in fuzzy-ball drilling fluids in which the main treating chemical is cement meet this standard. 200m³ of discharged fuzzy-ball drilling fluids from Well EU2-H was solidified into rock in 10 days without using large equipment; the quality of the rock's leach liquor meets the NSDS Ⅱ and the rock strength is high enough to sustain the vehicles in the following operations. Also, the land in which the solidified rocks are buried is recoverable for farming. Conclusion can be drawn that the technology of solidifying fuzzy-ball drilling fluids can control the source of drilling fluid pollution in a cheap and applicable way and the fluids are environment friendly.**

***Index Terms*—Coalbed Methane, drilling fluid waste, Fuzzy ball drilling fluids, solidify**

I. INTRODUCTION

CBM exploration and production in China is experiencing a booming period, with the increasing number of drilled wells and total drilling footages, which result in large volume of drilling fluid waste. The treatment of those fluids is as important as the formation fracturing and farming production recovery in lateral stage, affecting the lives of local inhabitants directly. However, the reality is far from satisfying. In Erdos CBM Block field operation, most drilling crews failed to treat their drilling fluid waste effectively, causing gas emission in the atmosphere and poisonous leach liquor in the soil. It takes a long time to recover the field's ecological system. Compared with conventional oil and gas field development, CBM drilling industry hasn't yet developed a timesaving and low cost drilling fluid waste treatment technology given the short history. Several conventional drilling fluid waste treatment measurements are applied in oil and gas industry include: (1) discharge directly [1]; (2) biological treatment [2]; (3) dispersed treatment [3]; (4) emulsification with microwave radiation [4], etc. In this article, we primarily introduce a method called solidifying treatment, namely solidifying the fluid waste into soil-like materials, which can be buried in the field or reused as construction material by adding certain kinds of solidifying agents to the water base drilling fluid. By applying solidifying treatment, the pollution on soil caused by metallic ion and organic substances from fluid waste can be dramatically reduced. Besides, the field of drilling mud pit can be reinstated for continue operations or farming [5]. With these advantages, solidifying technology [6] is adopted for fuzzy-ball fluid waste treatment in Erdos CBM development.

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II. PROCEDURE FOR PAPER SUBMISSION

CBM well sites are always away from the roads and the field's geographical circumstance is complicated. With limited engineering budget, expense control is a great pressure while solidifying drilling fluid to meet national standard. Moreover, the solidifying process is supposed to complete in a short time so as to facilitate the follow-up operations and local farming.

A. Field pollution assessment

In CNPC's Erdos CBM drilling operation, sodium bentonite is used in the first spud, then polymer in the second spud, and fresh mud or polymer in the third spud. Fuzzy-ball fluid is adopted in the third section in Well EU2 to stabilize the wellbore and to control formation damage [7]. There are treating chemicals including base inorganic salt, sawdust, sealing agent, highly viscous sealing agent, anti-caving asphalt, drill cuttings and weighting materials in the waste in addition to betonies, hydro polyacrylamide, CMC, polyanionic cellulose, natural vegetable gum and secondary cationic polymer. Besides all the materials in the ordinary drilling fluid, fuzzy-ball waste contains treating chemicals like surface acting agent (SAA), natural high molecular polymer (HMP).

Pollution indexes of drilling fluid waste, according to NSDS Ⅱ, include pH, chrominance, TSM, BOD_5, COD, total chromium and hexavalent chrome. Test results of the above indexes of the drilling fluid waste field samples from Well E19-8、E1-3、E2-21、E19-1 and E2-9 are shown in the Table 1.

Table 1: Pollution indexes of drilling fluid waste samples from 5 wells

Well No.		E19-8	E 1-3	E2-21	E19-1	E2-9
pH	Standard	6~9	6~9	6~9	6~9	6~9
	Test result	10	9	9	8	10
	Status	Exceeding the standard	up to the standard	up to the standard	up to the standard	up to the standard
chrominance	Standard	80	80	80	80	80
	Test result	3500	1000	3000	500	5500
	Status	beyond the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard
TSM mg/L	Standard	300	300	300	300	300
	Test result	13488	17179	12235	6457	19282
	Status	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard
BOD_5 mg/L	Standard	60	60	60	60	60
	Test result	22.2	22	28	23.4	29.9
	Status	up to the standard	up to the standard	up to the standard	up to the standard	up to the standard
COD mg/L	Standard	150	150	150	150	150
	Test result	4364	3612	2408	1354	2859
	Status	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard
total chromium mg/L	Standard	1.5	1.5	1.5	1.5	1.5
	Test result	0.8	2.9	1.4	1.6	7.9
	Status	up to the standard	Exceeding the standard	up to the standard	Exceeding the standard	Exceeding the standard
hexavalent chrome mg/L	Standard	0.5	0.5	0.5	0.5	0.5
	Test result	2.5	3.1	5.6	2.8	5.6
	Status	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard

We can see from the above Table that of these indexes: chrominance, TSM, COD, total chromium and hexavalent chrome, exceed national standard. Average test result is 20 times greater than the standard, 68.5 times as the most. High COD will aggravate water eutrophication, undermining water's self-purification ability and affecting plants' growth. Salt, base and halite will harden earth, making it difficult or unable to grow plants. High-valent metallic ion in soil will not only affect plants' growth and microbe's reproduction, but also be absorbed and enriched by plants and then transferred to animals and humans. Chemical additives and their degradable waste will have impacts on aquatic life and birds.

Fuzzy-ball drilling mud was used in CBM Well EU2-H to enhance formation's bearing strength, stabilize wellbore, stop leakage and reduce damage to reservoir [8]. At the same time, the fluid waste was supposed to meet the NSDSⅡ. So pollution index tests of the mud's four chemical treating agents as well as the mud itself were conducted in lab and fields are shown in the Table 2.

Table 2: Pollution indexes of fuzzy-ball drilling mud and its main chemical treating agents

Sample	Content	pH	Chrominance degree	TSM mg/L	BOD_5 mg/L	COD mg/L	Total chromium mg/L	Hexavalent chrome mg/L
NSDSⅡ		6~9	80	300	60	150	1.5	0.5
Nucleation agent	0.1%	7	5	0	587.8	332.6	0.16557	0
	0.2%	7	5	0	1689.9	725.4	0.33114	0
	0.4%	7	5	0	659.0	994.8	0.57341	0.0056
Film forming agent	0.4%	7	5	0	130.2	1231	0.12565	0
	0.7%	7	5	0	75.5	3607	0.15347	0
	1.0%	7	5	0	68.7	3769	0.18129	0
Fuzzy agent	0.5%	9.0	5	0	95.4	218.2	0.03547	0
	1.0%	9.0	5	0	112.2	258.9	0.10546	0
	1.5%	10	5	0	78.4	916.5	0.17545	0
Layer generating agent	0.5%	8	5	0	125.8	3078	0.05432	0.01468
	1.0%	9	5	0	751.7	3463	0.06688	0.02124
	2.0%	9	5	0	938.7	3463	0.07944	0.0278
Lab fuzzy-ball mud	1#	10	5	0	885.7	2119	0.03525	0.00226
	2#	10	5	0	1143.7	3796	0.03547	0.00206
	3#	11	5	0	1433.2	4011	0.05387	0.00306
Fuzzy-ball mud waste	1#	9	180	740	19.5	351	1.1	2.2
	2#	8	100	680	21	482	1.8	1.9
	3#	8	156	700	16	378	1.7	1.2

From the table, seven characteristics of the pollution indexes can be drawn:

pH. The chemical treating agents' pH value meet NSDSⅡ, while lab mud's doesn't because it is not controlled in lab. Actually, pH value ranging 3 to 11 is adjustable.

Chrominance. The pure white mud's chrominance degree is 5, which is up to standard. While the high chrominance of field mud waste is the result of the composition combination of fuzzy-ball mud and other discarded materials.

TSM. Lab mud contains no TSM in contrast with the field mud. The source is weighting materials, drill cuttings and betonies mud in the first spud and second spud.

BOD_5.the change of BOD_5 value is in positive correlation with the layer-generating agent content. However, with the increasing content of nucleation and film forming agents, BOD_5 value rises before hitting a turning point and then decreases. Therefore, the volume of mud waste should be strictly limited.

COD. Chemical oxygen demand (COD) is used to determine the amount of organic substances in wastewater. That the test results in all materials exceed NSDSⅡ complies with the initial intention that degradable organic substances will mitigate mud wastes' impacts on the environment, which is also the original purpose of developing macromolecule, based fuzzy-ball mud.

Total chromium. All chemical treating agents and mud contain low content of chromium except nucleation agent, proving successful chromium control in fuzzy-ball mud.

Hexavalent chrome. Film forming agent and fuzzy agent is clear of hexavalent chrome and layer generated agent contains little of it. Only in high-density nucleation agent can hexavalent chrome be detected, which is rare in field jobs. So this index is also up to standard.

From data listed above, it is clear that fuzzy-ball drilling mud can eliminate original contamination causes to protect the environment.

B. Lab formula for solidifying fuzzy-ball drilling fluid waste

One of the primary purposes of solidifying fluid waste is to facilitate continues operations. For CBM drilling, fracturing is often essential for a particular formation, thus raising specific requirement for rock strength. 4 classes of solidifying agents have been developed to achieve the strength: (1) lime and sodium silicate; (2) gypsum and sodium silicate; (3) lime and calcium oxide; (4) lime and mineral slag

from blast furnace; there are over 100 formulas but only 3 kinds of solidifying methods: solidifying directly, solidifying after viscosity breaking and solidifying after flocculating.

For each method, the rock of different solidifying agent has different strength. Especially, the rock strength of lime & sodium silicate agent solidified directly is strong enough to sustain the vehicles in continue operation and easy to be recovered for farming without viscosity breaker and flocculating agent, thus reducing cost and pollutant. These advantages make it our ideal choice for field operation.

C. Toxicity assessment of leach liquor from solidified rocks

In order to find out the most effective treatment measurement to minimize the impacts on field environment, groundwater and surface water, the pollution assessment of leach liquor from solidified rocks on several main pollution parameters including pH, chrominance, (TSM), BOD5, COD, total chromium and hexavalent chrome were made with different solidifying methods.

Table 3：Pollution indexes assessment of leach liquor

Formula	Leach liquor Sample	Pollutant	pH	Chrominance degree	TSM mg/L	BOD_5 mg/L	COD mg/L	Total chromium mg/L	Hexavalent chrome mg/L
	NSDS II	Upper content limit	6～9	80	300	60	150	1.5	0.5
1#	From rocks solidified directly	Test result	8	5	85	52.3	88.7	0.32	0.03
2#		test result	8	5	97	52.3	84.2	0.05	0.02
3#		test result	7	5	86	33.0	76.7	0.09	0.05
4#		test result	7	5	87	19.6	6.0	0.1	0.06
1#	From rocks solidified after viscosity breaking	test result	9	5	75	39.7	3.0	0.07	0.03
2#		test result	8	5	99	30.7	1.5	0.05	0.13
3#		test result	8	5	23	42.2	16.5	0.03	0.06
4#		test result	8	5	10	45.8	9.0	0.02	0.03
1#	From rocks solidified after flocculating	test result	9	5	58	8.3	117.4	0.1	0.03
2#		test result	9	5	21	2.3	79.2	0.03	0.05
3#		test result	9	5	15	15.0	7.5	0.03	0.02
4#		test result	9	5	12	41.5	1.5	0.02	0.05

All indexes of leach liquor meet NSDSⅡ , proving its environmental-protection advantages, which also facilitate land recovery for farming.

III. FIELD APPLICATION

Normally, the average 100 ~ 300 m³mud waste of each of 14 Erdos CBM well fields including well J19-1 andJ19-2 was firstly processed with precipitation separation, then discharging the water layer and burying settled solids directly. A few drilling crews would bury the naturally solidified waste as required by the oil company or local government. Generally speaking, fast, cost-saving and environment-friendly mud waste treatment technology, which is also suitable for the Block's production, hasn't been developed.

A. Field solidifying procedure for fuzzy-ball drilling fluid waste

We'd like to test the solidifying technology by applying our lab research findings in mud waste from well EU-2H. Like other CBM well fields, some challenges were met in well EU-2H: the confined space isn't suitable for large agitator; the bumpy road can't sustain large-size vehicles; bad climate such as snow or rain in winter often delays operations; varying placement time needs varying doses of solidifying agents for mud waste. To solve those problems, treatment formula and operation procedures are optimized. Wooden molds with the size 500× 400×200mm were made. Also, small sample tests were conducted in field. They are shown in Figure 1-3.

The above figures vividly show the molds, which can be made and dismantled easily, and the solidified rocks, which can be transported by hands and buried on sites. It is effective solidification in confined well field.

Fig.1: Drilling mud waste pool before solidifying treatment

B. Assessment of solidifying effect of fuzzy-ball drilling fluid waste

After completion of field solidifying operation, the pollution indexes test of leach liquor from four-rock sample was conducted. Table 4 shows the test results.

Table 4: Leach liquor pollution assessment

Well No.		E19-8	E 1-3	E2-21	E19-1	E2-9
pH	Standard	6～9	6～9	6～9	6～9	6～9
	Test result	10	9	9	8	10
	Status	Exceeding the standard	up to the standard	up to the standard	up to the standard	up to the standard
chrominance	Standard	80	80	80	80	80
	Test result	3500	1000	3000	500	5500
	Status	beyond the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard
TSM mg/L	Standard	300	300	300	300	300
	Test result	13488	17179	12235	6457	19282
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	Test result	22.2	22	28	23.4	29.9
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COD mg/L	Standard	150	150	150	150	150
	Test result	4364	3612	2408	1354	2859
	Status	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard
total chromium mg/L	Standard	1.5	1.5	1.5	1.5	1.5
	Test result	0.8	2.9	1.4	1.6	7.9
	Status	up to the standard	Exceeding the standard	up to the standard	Exceeding the standard	Exceeding the standard
hexavalent chrome mg/L	Standard	0.5	0.5	0.5	0.5	0.5
	Test result	2.5	3.1	5.6	2.8	5.6
	Status	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard	Exceeding the standard

Fig.2: Field landscape after earth burying

Fig.3: Gas recovery machine and plants after solidifying treatment

From the above Table and Figure, we can make the assertion that the initial de-pollution expectation was met, for all indexes of the leach liquor satisfy the NSDS Ⅱ. Furthermore, the reinstated well field landscape not only prevents soil erosion and pollution, but also provides adequate space for large equipment used in the lateral fracturing and production operation.

IV. CONCLUSIONS

(1) We put forwards the idea that pollution control should begin from the drilling mud waste's own quality. Both theory and field application prove they available, practical and economical.

(2) The unique solidifying technology, which can be applied according to local conditions, meets the challenge that lots of CBM well sites have no easy access for large vehicles.

(3) Both the strength and pollution indexes of its leach liquor meet national standard, meaning this solidifying technology is the right strategy with environmental advantage.

The solidifying fuzzy-ball drilling mud waste technology, which deals with pollution from the very beginning, has profound social influence and bright future for further development.

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REFERENCES

[1] B. F. Wally, L. A. Reitsema, and G. W. Nance, Treatment of Drilling Fluid Wastes In An Environmentally Acceptable Manner[C]. Paper presented at the SPE/IADC 1955 Drilling Conference, New Orleans, Louisiana, March 6-8, 1985.

[2] Perie. F. H, Seris. J. L, and Martignon. A. P, Biological Treatment of Drilling Waste[C]. SPE 29695. (1995)

[3] G. Ferrari, F. Cecconi, and L. Xiao, Drilling Wastes Treatment and Management Practices for Reducing Impact on HSE: ENI/Agip Experiences[C]. SPE 64635.(2000)

[4] Camila Vega and Mayolett Delgado, Treatment of Waste-water/oil Emulsions Using Microwave Radiation[C]. SPE 74167. (2002)

[5] Wang Xuechuan,Hu Yanxin, and Zheng Shujie, Application Status of Waste Drilling Fluid Treatment Technology At Home and Abroad [J]. Journal of Shaanxi University of Science & Technology .28（6）：169-174.(2010)

[6] SPE106799

[7] 郑力会,孔令琛,曹园等．绒囊工作液防漏堵漏机理[J]．科学通报,2010,55（1）：1-9

[8] 201204-孙法佩 张杰-中国煤层气-煤层气 215_9mm 井眼水平井绒囊钻井液技术