EGU General Assembly 2020
Online | 4–8 May 2020

Session ERE 4.1 Versatile Subsurface Storage of Future Energy Systems

D996 | EGU2020-4511

Effect of Micro-MgO-based Expanding Agent on Rheological and UCS Properties of Well Cement at Early Age

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OUTLINE

- INTRODUCTION
- EXPERIMENTAL PROGRAM
- RESULTS
- CONCLUSION

INTRODUCTION

Why does cementing is so important to well integrity?

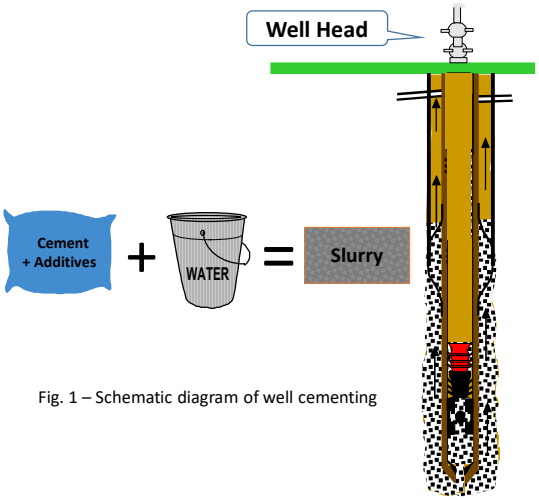


Fig. 1 – Schematic diagram of well cementing

- ❑ **Cement sheath – the unique physical barrier between casing and formation**
- ❑ **Long term wellbore integrity strongly depends on the cement sheath**
- ❑ **Fundamental functions as:**

  Zonal isolation

  Casing protection

  Axial loads support

Major Cementing Problems in Wells (oil & gas)

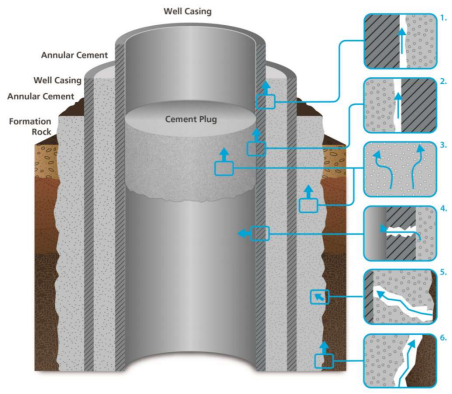


Fig. 2 – Potential leakage pathways in well structure, Celia et al. (2005)

Possible pathways

- Interface between casing and cement
- Interface between casing and cement plug
- Micro channels in cement
- Casing damage
- Cracks in cement sheath
- Interface between cement and formation

Some facts

- 25% wells fail as result of bad cementing
- 80% wells give problem of gas migration in Gulf of Mexico (Naohiko Yahaba, 2010)

Possible Reasons Behind

- ❖ **Efficient mud/ well wall residue removal**
- ❖ **Rheological control & cement slurry placement**
  - mixing process
  - concentration of solid component
- ❖ **Shrinkage issue**
  - chemical shrinkage
  - bulk volume shrinkage
  - thermal shrinkage
  - etc.

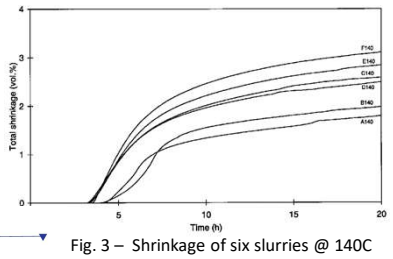


Fig. 3 – Shrinkage of six slurries @ 140C
(Ref: K. R. Backe, etc. 1998)

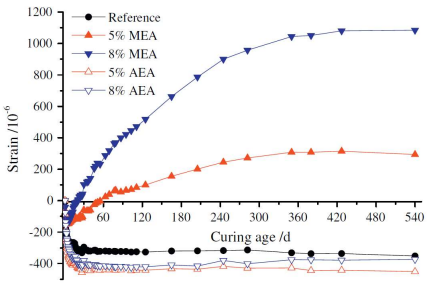


Fig. 4 – Autogenous deformations of Portland cement pastes containing various contents of MEA under non-wet curing condition
(Ref: L. Mo, M. Deng, etc. 1998)

Why use micro-MgO (MMGO) in oil well cementing?

Potential expansion property compensates shrinkage

Abundance resource (magnesite is one of the abundant minerals on earth)

Adjustable property of MgO material

- production condition (temperature, curing time)
- graine size/ specific area
- inherent chemical expansion property when touching water (the hydration product of MgO, $Mg(OH)_2$ has around 200% volume increase than its original form)

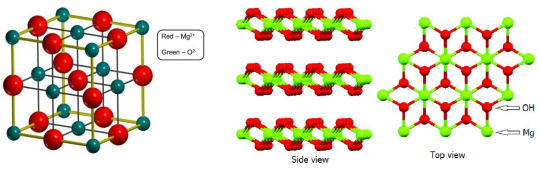


Fig. 5 - MgO and $Mg(OH)_2$ schematic structure
(Ref 1: https://www.slideserve.com/aulii/method-3-simple-distillation
Ref 2: Shirley Nakagaki, etc. 2016)

Light Burned MgO
Calcining Temp. 815 - 925 ℃
Particle size: 50 – 120 micron
Features: reactive

Hard Burned MgO
Calcining Temp. 925-1500 ℃
Particle size: 120-1000micron
Features: less reactive

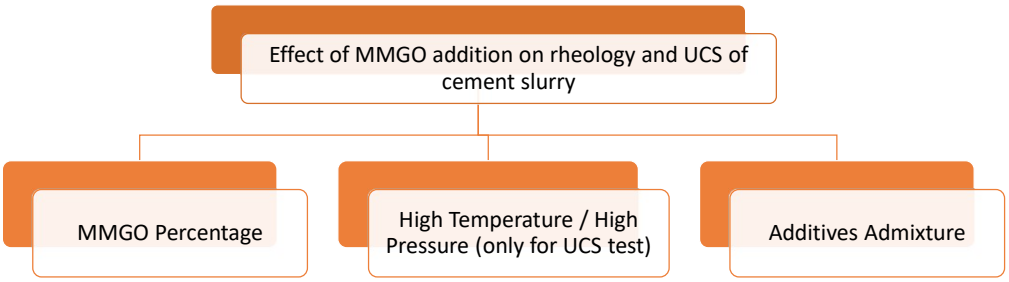
Dead Burned MgO
Calcining Temp. >1500 ℃
Particle size: >1000 micron
Features: least active

Figures Source: http://www.hcysmzp.com/product/552.html
https://magnesiasolutions.com/products/magnesium-oxide-dead-burned-mgo/

Introduction(contd.)

Objective

To get some insights of potential impact of MMGO addition on rheological and mechanical property of class G cement slurries.



EXPERIMENTAL PROGRAM

❖ Experimental Plan

Slurry Notation	Temp. °C	Pressure psi	Additives	MMGO % BWOC	Test Type
Base Mix (Class G)	90	atm	NA	NA	PV, YP, GS
	145	3k	NA	NA	UCS
Extended Mix (Class G + micro-Silica + MMGO + Additives)	90	atm	Included	0, 1%, 2%, 3%	PV, YP, GS
	145	3k	Included	0, 1%, 2%, 3%	UCS

❖ Slurry Preparation

- ❑ Reference standard: API Specification 10-B
- ❑ Mixing method: wet mixing (additives are mixed in water and later cement-silica mixture is mixed)

Fig. 6 - Blender

Fig. 7 - Atm. Consistometer

Experimental Program (contd.)

❖ Rheological Properties Measurement

- ❑ Device - atmospheric rotational viscometer
- ❑ Measured parameters - plastic viscosity, yield-point, gel strength

❖ UCS Measurement

- ❑ Device – UCA and Compression Unit
- ❑ Measured parameters – uniaxial compression strength (UCS)

Fig. 8 - Atm. Viscometer

Fig. 9 - HPHT Curing Chamber

Fig. 10 - UCA (ultrasonic cement analyzer)

Fig. 11 - Compression Machine

RESULTS

❖ PV & YP vs MMGO Concentration

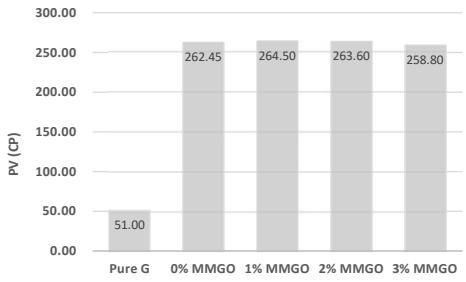


Fig. 12 - Variation of plastic viscosity with MMGO addition change

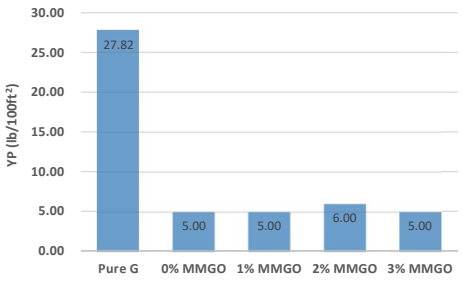


Fig. 13 - Variation of yield point with MMGO addition change

Results (contd.)

Gel Strengths vs MMGO Concentration

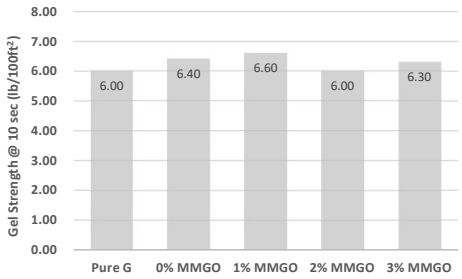


Fig. 14 - Variation of gel strength at 10 sec with MMGO addition change

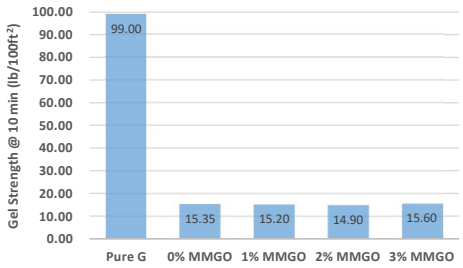


Fig. 15 - Variation of gel strength at 10 min with MMGO addition change

Results (contd.)

UCS vs MMGO Concentration

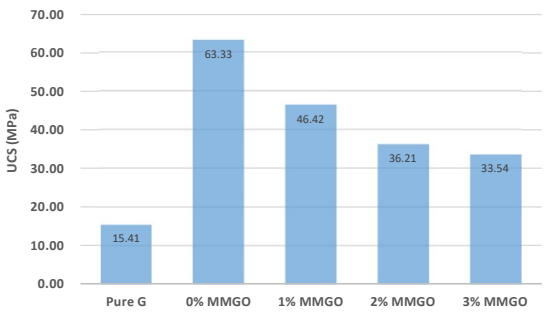


Fig. 16 - Variation of UCS with MMGO addition change

CONCLUSIONS

- MMGO as an additive has a potential for field application in well cementing.
- For extended mixture, MMGO concentration doesn't influence the rheology property of cement slurry very much. So, up to 3% addition, MMGO will not impair the slurry rheology property which is important to make it happen as the efficient turbulent flow regime of displacing cement slurry with previous working fluids (e.g. drilling fluid) and realize the effective placement of slurry at spot.
- For Class G cement, mixed with other additives, the UCS of set cement at early age under HPHT conditions decreases gradually with the increment of concentration of MMGO.
- With the addition of MMGO up to 3% BWOC will not cause the sound issue of set cement (self-cracking) under HPHT curing conditions.

Acknowledgements

Thanks to Halliburton for Material Support

Stay healthy and safe!

Thank You!