

Appendix

Appendix A: Risk Assessment from NTNU

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| NTNU  HMS | Kartlegging av risikofylt aktivitet | Utarbeidet av HMS-avd. | Nummer HMSRV2601 | Dato 3/22/2011 |  |
|--|-------------------------------------|---------------------------|---------------------|-------------------|---|

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|---|---|-------------------|----------------------------|--|---------------------|---|
| Enhet: | Institutt for materialteknologi | Dato: | 10.02.2020 | | | |
| Linjeleder: | Tor Grande | | | | | |
| Deltakere ved kartleggingen (m/ funksjon): (Ans. veileder, student, evt. medveileddere, evt. andre m. kompetanse) | Kjersti Kleveland, Anne Marie M. Moe, Bjørn almi, Rongling Yuan | | | | | |
| Kort beskrivelse av hovedaktivitet/hovedprosess: | Bacheloroppgave student Rongling Yuan. Avanserte keramer for fremtiden. | | | | | |
| Er oppgaven en rent teoretisk? (JA/NEI) | NEI | | | | | |
| "JA" betyr at veileder innstår for at oppgaven ikke innholder noen aktiviteter som krever risikovurdering. I dette tilfellet er det ikke nødvendig å fyll ut resten av skjemaet | | | | | | |
| Skal du motta prøver fra industri? (JA/NEI) | JA | | | | | |
| "JA" betyr separat risikovurdering av prøvene individuelt | | | | | | |
| Er det trygt å utføre arbeidet utenfor normal arbeidstid (8-17)? (JA/NEI) | JA | | | | | |
| Signaturer: | Ansvarlig veileder: | Kjersti Kleveland | Student: | | | |
| | | | Rongling Yuan | | | |
| ID nr. | Aktivitet/prosess | Ansvarlig | Eksisterende dokumentasjon | Eksisterende sikringstiltak | Lov, forskrift o.l. | Kommentar |
| 1 | Konduktivitets måling | Rongling Yuan | | Støvmask, engangshansker og vernebriller | n/a | Engangshansker, lab frakk, støvmask, vernebriller og innesko er påkrevd. |
| 2 | pH-måling | Rongling Yuan | | Støvmask, engangshansker og vernebriller | n/a | Engangshansker, lab frakk, støvmask, vernebriller og innesko er påkrevd. |
| 3 | Viskositetsmåling | Rongling Yuan | | Støvmask, engangshansker og vernebriller | n/a | Engangshansker, støvmask, vernebriller, innesko og lab frakk er påkrevd. |
| 4 | Forberede gipsformer | Rongling Yuan | | Engangshansker og vernebriller | n/a | Engangshansker, støvmask, vernebriller, innesko og avtrekkshetter er påkrevd. |
| 5 | Slip Casting | Rongling Yuan | | Hansker, vernebriller | n/a | Hansker og vernebriller er påkrevd. |

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| NTNU  HMS /KS | Risikovurdering | Utarbeidet av HMS-avd. | Nummer HMSRV2603 | Dato 2/4/2011 |  |
|--|-----------------|---------------------------|---------------------|------------------|---|

| Enhet: | Institutt for materialteknologi | Dato: | 10.02.2020 | | | | | | |
|--|---|---|----------------------------------|-------------------------|---------------------|-------------------------|-------------------|--------------------------|--|
| Linjeleder: | Tor Grande | | | | | | | | |
| Deltakere ved risikovurderingen (m/ funksjon): (Ans. veileder, student, evt. medveileddere, evt. andre m. kompetanse) | Kjersti Kleveland, Anne Marie M. Moe, Rongling Yuan | | | | | | | | |
| Risikovurderingen gjelder hovedaktivitet: | Bacheloroppgave student Rongling Yuan. Avanserte keramer for fremtiden. | | | | | | | | |
| Signaturer: | Ansvarlig veileder: | Kjersti Kleveland | Student: | | | | | | |
| | | | Rongling Yuan | | | | | | |
| ID nr. | Aktivitet/prosess fra kartleggingsskjemaet | Mulig uønsket hendelse | Vurdering av sannsynlighet (1-5) | Vurdering av konsekvens | | | | Risiko-verdi (menneskel) | Kommentarer/ status Forslag til tiltak |
| | | | | Menneske (A-E) | Ytre miljø (A-E) | Øk./ materiell (A-E) | Om-dømme (A-E) | | |
| 1 | Konduktivitets måling | Puste de løse SiC pulver | 1 | A | A | A | A | A1 | Støvmaske og vernebriller må brukes for å forhindre at pulver kommer inn i nesen og øyne. |
| 2 | pH-måling | Puste de løse SiC pulver | 1 | A | A | A | A | A1 | Støvmaske og vernebriller må bakes for å forhindre at pulver kommer inn i nesen og øyne. |
| | | Hudirritasjon pga berøring av bufferløsning | 1 | A | A | A | A | A1 | Bruk vernebrille med sidevern, egne vernehansker. Legg inn rekreasjonsfaser til regenerasjon av huden. Bruk av forebyggende hudbeskyttelse (hudkrem/salver) anbefales. |

| | | | | | | | | | |
|----------|----------------------|---|---|---|---|---|---|-----------|--|
| 3 | Viskositetsmåling | Puste de løse SiC pulver og hudirritasjon pga berering av dispergeringsmidler | 1 | A | A | A | A | A1 | Bruk vernebrille med sidevern. Bruk egnede vernehansker. Kjemikalihansker testet i henhold til EU 374 er egnet, også pustemaske er nødvendig. |
| 4 | Forberede gipsformer | Puste inn de løse gips pulver og hudirritasjon av pulvren | 1 | A | A | A | A | A1 | Bruk vernebrille og støvmaske. |
| 5 | Slip Casting | Puste inn de løse gips pulver og hudirritasjon av pulvren | 1 | A | A | A | A | A1 | Bruk alltid vernebriller og en støvmaske. |
| #REF! | #REF! | Hvis man bruker varmelamper eller varmeovn, det er risiko for forbrenning | 4 | B | A | A | A | B4 | Hvis man bruker varmelamper/varmeovn til å tørke mølde/deler, vil lampene være varme, så må man være forsiktig når man rundt varmelamper/varmeovn. |

Appendix B: Popular science article

How does viscosity affect the stability of silicon carbide slip?

Written by Rongling Yuan.

Introduction of silicon carbide

Silicon carbide ceramics have high mechanical strength, high temperature resistance, wear resistance, corrosion resistance, small thermal expansion coefficient, high thermal conductivity, etc., and are often used in the manufacture of combustion chambers, high temperature exhaust devices, temperature resistant patches, aircraft engine components, chemical reaction vessel tubes



Figure 1: Silicon carbide [1]

and other mechanical components under severe conditions. Silicon carbide is a widely used advanced engineering material and the products have a broad market and application areas to be developed in the fields of energy, metallurgy, machinery, building materials and chemicals.

Silicon carbide ceramics are becoming more and more extensive. For satisfying the needs of industrial production, slip casting is used to produce silicon carbide products required by the market. This casting technique requires the preparation of silicon carbide slip with high solids content with low viscosity to achieve good slip stability [1].

Slip casting process

Casting Methods is more practical. It has many advantages such as simple equipment, uniform distribution of green body, fewer defects and more suitable to produce complex parts. Slip casting as shown in Figure 2 is the common method used to shape silicon carbide ceramic products. The suitable amount additives (such as wetting agents, dispersing agent or deflocculant) to dissolve the raw silicon carbide powder in the solution with a stable condition and prepared a slip. The slip is poured into the plaster mold which has the character of absorbing moisture from slip. After the water is absorbed by plaster mold, a uniform slip layer with a certain thickness is formed. During the dehydration and draining process without heat, a green body with a certain hardness is formed at this time and drained the slip out. The green body goes through the partial drying and separated from plaster mold. The heat is applied after the green body is shaped and goes through a sintering process. To improve the silicon carbide slip with good stability, it is necessary to have research on the viscosity of silicon carbide slip [2].

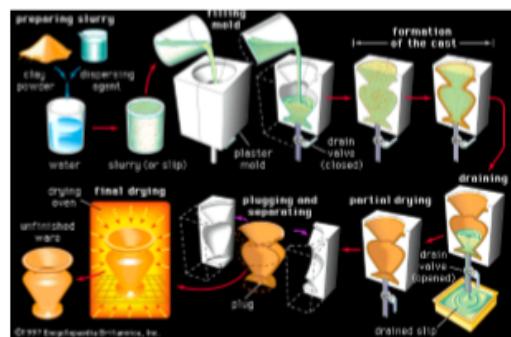


Figure 2: Slip casting process [2].

Viscosity research on silicon carbide slip

To research the viscosity of silicon carbide ceramic slip, the properties of silicon carbide slip need to know. Rheological properties changing the flow and deformation behavior of slip, dispersion mechanism of dispersant preventing particles approaching, and the effects of the slip properties on the green body which adjust the pH value in the slip can adjust the electric charge on the particles surface, so the electric charge increases, the electric double layer repulsion increases, and a stable slip state is achieved. Basic theory of controlling stabilized ceramic slip is obtained. Then, some experiments must be done to analyze the factors which affect the viscosity of silicon carbide slip, such as amount of dispersant and solid content. The four different ratios of solid content, water and dispersant were prepared and measured with spindle nr. 63 of Brookfield viscometer. Slip A contains 80 wt% solid content with 0.03 g AMP-dispersant, slip B contains 80 wt% solid content with 0.12 g AMP-dispersant, slip C contains 87 wt% solid content with 0.03 g AMP-dispersant, and slip D contains 87 wt% solid content with 0.12 g AMP-dispersant. After viscosity measurement, the results as shown in Figure 3.

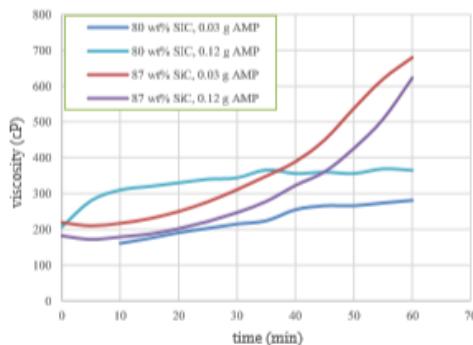


Figure 3: The viscosity as a function of time.

During the viscosity measurement, observed that the slip was precipitated over time. The longer the time, the more obvious the precipitation phenomenon, and the thicker the precipitation layer at the bottom of the slip. Slip A and B measurements were first completed, slip C and D were measured one week after. Observed that the

slip A and B were precipitated, after the hard hand stirring, the original slip state was restored. But the sediment layer of slip C and D, were solidified into a hard block with ca. 1 cm thick at the bottom of the bottle. The precipitation phenomenon in the slip could lead to the upper layer of slip got thinner over time, and if the depth of spindle also in the upper layer, so a decreased viscosity as a result. Similarly, the bottom layer of the slip became more and more viscous by particle settling, and the spindle depth is in the slip's lower layer, which also caused the viscosity increased or over the test range. The Figure 3 shows that the stability of the slip A and B has further improved with the 80 wt% solid content, there is not much change in the viscosity value over the entire range of dispersant from 0.03-0.12 g because of the flocculated layer formed during the time. the slip A and B with same 80 wt% solid content, the stability of the slip with 0.03 g of dispersant was the best. But in the same 87wt% solid content, slip C and D, with 0.12g of dispersant had the best stability.

Sources

- [1] Wang Yun Long & Zhang Meng, "Silicon Carbide Fine Powder," Baidu, 08 2018. [Online]. Available: <https://baike.baidu.com/item/%E7%A2%B3%E5%8C%96%E7%A1%85%E5%BE%AE%E7%82%89/10511571?fr=aladdin>.
- [2] "Form Process of Slip Casting," BRITANNICA, Inc, 07 2015. [Online]. Available: <https://www.britannica.com/technology/slip-casting>.