플라이애쉬 시멘트 페이스트의 수화열류 감속 단계 분석 및 모델링에 대한 실험적 연구

Deceleration stage and modeling of hydration heat flow for fly ash cement paste

왕자호[1] · 이한승[2*]
Wang, Zihao[1] · Lee, Han-Seung[2*]

Abstract

This study investigated the effect of fly ash content on the isothermal hydration heat of cement pastes. Two different pastes with fly ash content were studied to cure at 35°C. The hydration heat flow deceleration stage of slurry was simulated and compared by Jander Equation and Ginstling-Brounshtein Equation. The results show that Jander Equation and Ginstling-Brounshtein Equation have certain defects in the modeling of the deceleration stage of the heat flow of cement fly ash paste, and the fitted curve can not describe the deceleration stage well.

키 워 드 : 플라이 애쉬, 시멘트 페이스트, 수화, 모델링
Keywords : fly ash, cement paste, hydration, modelling

1. 서 론

Fly ash is widely used as an supplementary cementing material in the modern concrete industry to improve concrete performance and reduce carbon dioxide emissions, and promote environmentally friendly construction. Due to the pozzolanic reaction of fly ash, the C-S-H gel was formed by consuming the $Ca(OH)_2$ produced during the hydration of Portland cement. The hydration kinetics of fly ash-containing cement pastes have been extensively studied, but most of the studies on hydration kinetics only stay at the early hydration heat flow, and only limited work focuses on the modeling of the heat flow deceleration stage. And these studies are all based on the Jander equation to model the deceleration phase, but Provis pointed out the shortcomings of the Jander equation for modeling diffusion-limited dynamics, that is, particle curvature and asymptotic consumption are ignored in the derivation. He then suggested using the Ginstling-Brounshtein equation instead. Therefore, the purpose of this study is to use the Jander equation and the Ginstling-Brounshtein equation to conduct a post-modelling comparison and analysis of the decline phase of the composite binder with different fly ash contents.

2. Experimental methodology

In this paper, type I ordinary portland cement (OPC) with a density of 3.16g/cm^3 and low-calcium fly ash (FA) with a density of 2.35g/cm^3 were used as experimental raw materials. Table 1 shows the mixing ratios of all pastes containing fly ash. Replace 0% and 30% cement with fly ash, respectively. The water-to-binder ratio was fixed at 0.5. The heat flow rate and cumulative heat of hydration of fly ash cement pastes were measured using a TAM Air isothermal calorimeter at 35 °C for 72 h. Before testing, bring the TAM Air unit to the specified temperature. Pour powder into ampoules. Water was then added to the ampoules and the slurry was mixed using a small mixer. Immediately after uniform mixing, the ampoule was sealed and placed in the calorimeter channel to continuously monitor the release of the heat of hydration over time.

1) 한양대학교 스마트시티학과 석사과정
2) 한양대학교 건축학부 교수, 교신저자(ercleehs@hanyang.ac.kr)

Table 1. mix proportion of paste (wt%)

Sort of admixture	W/B (%)	Water (%)	Cement (%)	Fly Ash (%)	Curing Temperature (℃)
FA0	50	50	100	0	35℃
FA30	50	50	70	30	35℃

3. Results and Discussion

The Jander equation is the most commonly used model for descent simulation in recent years. But in the introduction, we also said that the defects of the jander equation have been pointed out, and Provis suggested to use the Ginstling-Brounshtein equation to replace it to model the deceleration stage. Figure 1 and 2 show the results of modeling the deceleration stage of the sample using the two models. It can be seen from the figure that the two diffusion stage-based models have some similarity but only satisfactory data can be obtained in the range. At present, the Ginstling-Brounshtein equation is the preferred description for the hydration deceleration stage, but the fitting effect is not satisfactory from the results. At least it is necessary to use mathematically correct equations to establish the model.

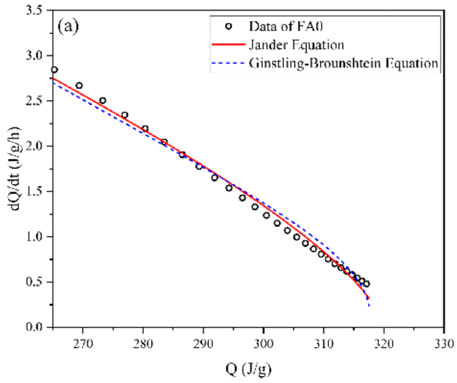

Figure 1. Modelled hydration flow rate for FA0

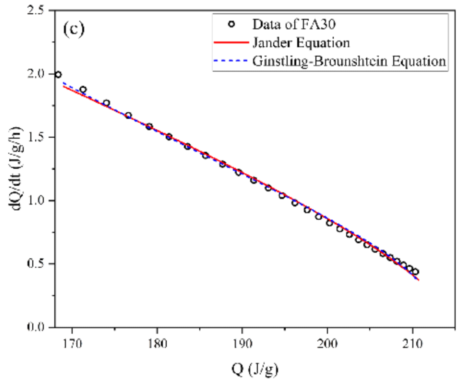

Figure 2. Modelled hydration flow rate for FA30

4. Conclusion

The currently used model cannot accurately simulate the descending segment, a single model may not be sufficient to describe the entire range of post-peak data, so new models may need to be found to model the deceleration stage.

Acknowledgement

본 연구는 국토교통부 건설기술연구사업 (과제번호:21SCIP-B150834-04)의 연구비 지원에 의해 수행되었습니다.

References

1. John L. Provis , (2016), On the use of the Jander equation in cement hydration modelling, RILEM Technical Letters