Modeling the rheological behaviour of cement pastes

This task aims to develop a constitutive rheological model that will be able to account for the complex rheological behavior of cement pastes over a spectrum of water-to-cement (w/c) ratios and temperature values. We have fully parametrize our Stephanou-Ioannou model [1] against the data of Wang et al. [2], which provides data for the shear stress vs. shear rate for various temperatures between 20 and 80 ºC and water-to-cement (w/c) ratios equal to 0.5, 0,7, 1, 1.2, 1.5, and 2 (measurement time 5 mins after preparation), and of Xu et al. [3], which provides data for the shear viscosity vs. shear rate for a variety of temperatures between 12 and 45 ºC and smaller w/c ratios equal to 0.5, 0,6, 0.75, and 0.8 (the additional results for w/c=1, 1.2, and 1.5 are not considered here since they do depict experimental measurements for smaller shear rates that 180 s^{-1}). The parametrization entails two steps: the first step is to parametrize the model for early times before the onset of the hydration reactions, and then to parametrize the model for later times after the hydration reactions have set in. More details will be made available in a paper we will soon submit for publication. Below, we provide the comparison of the model predictions against the data of Wang et al. [2], and of Xu et al. [3].

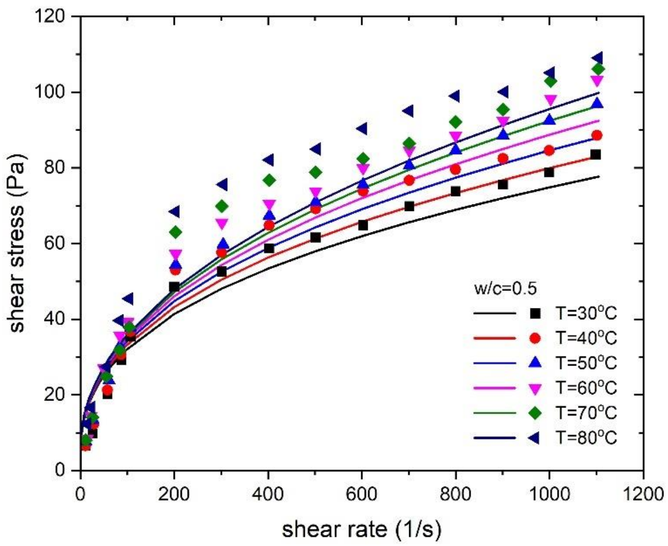

Fig. 1.1: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Wang et al. [2] (symbols) when w/c=0.5 (temperature in ºC) using the Arrhenius-type expression to express the temperature dependency.

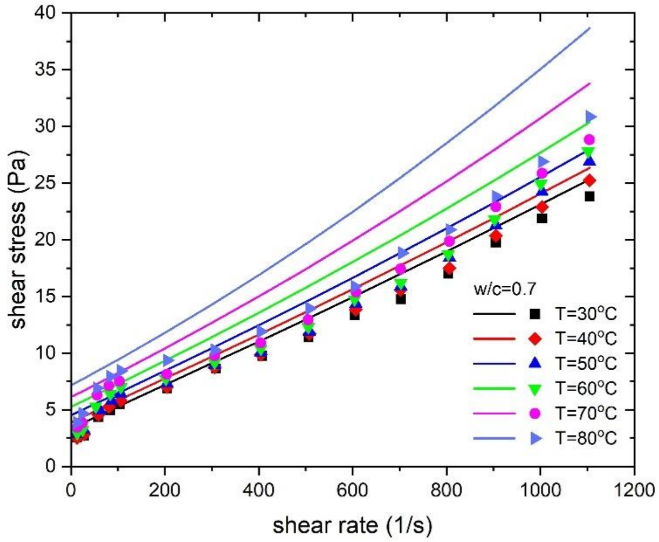

Fig. 1.2: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Wang et al. [2] (symbols) when w/c=0.7 (temperature in °C) using the Arrhenius-type expression to express the temperature dependency.

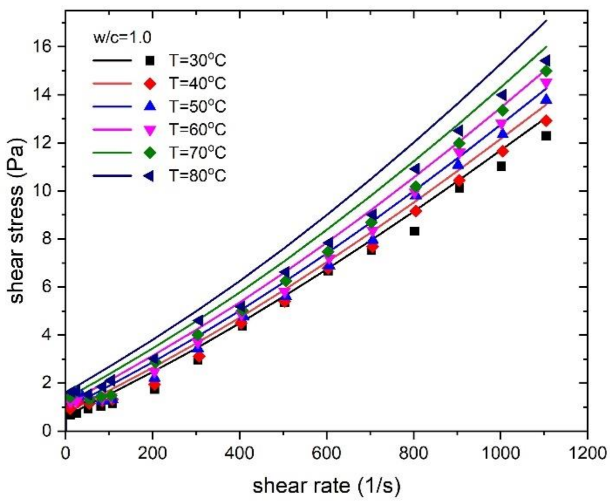

Fig. 1.3: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Wang et al. [2] (symbols) when w/c=1.0 (temperature in °C) using the Arrhenius-type expression to express the temperature dependency.

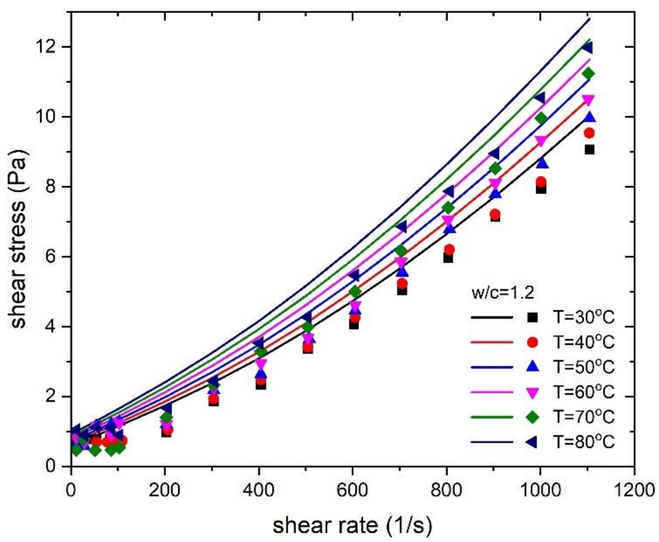

Fig. 1.4: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Wang et al. [2] (symbols) when w/c=1.2 (temperature in °C) using the Arrhenius-type expression to express the temperature dependency.

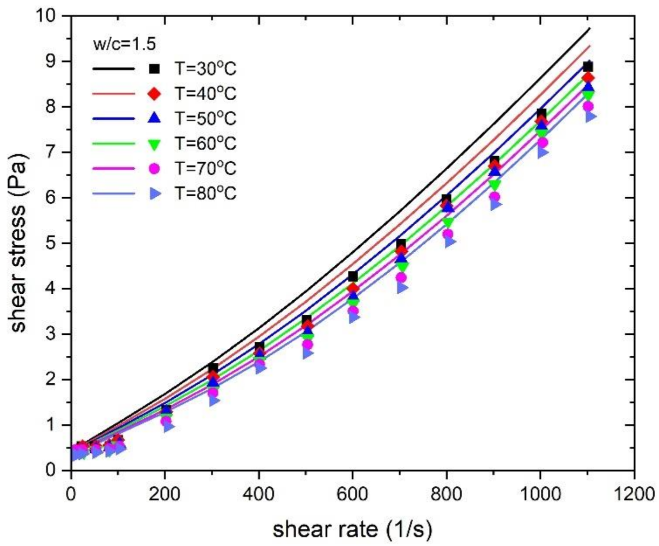

Fig. 1.5: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Wang et al. [2] (symbols) when w/c=1.5 (temperature in °C) using the Arrhenius-type expression to express the temperature dependency.

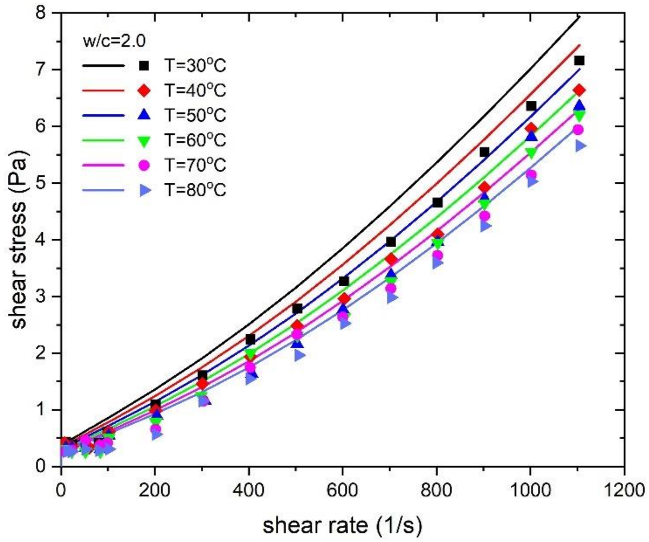

Fig. 1.6: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Wang et al. [2] (symbols) when w/c=2.0 (temperature in °C) using the Arrhenius-type expression to express the temperature dependency.

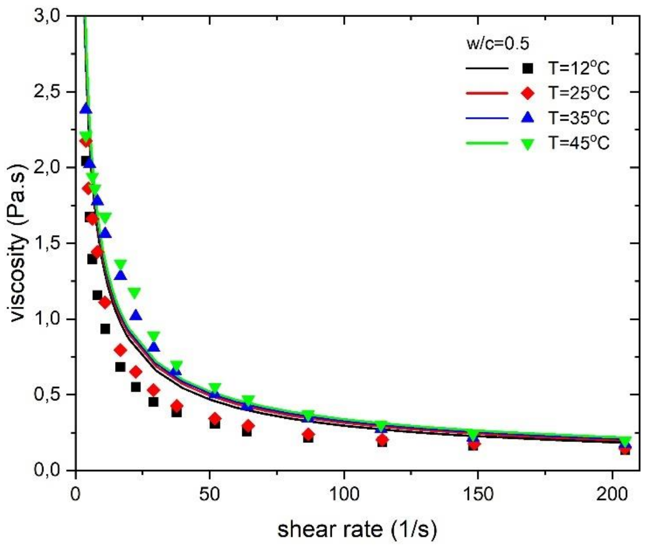

Fig. 1.7: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Xu et al. [3] (symbols) when w/c=0.5 (temperature in °C) using the Arrhenius-type expression to express the temperature dependency.

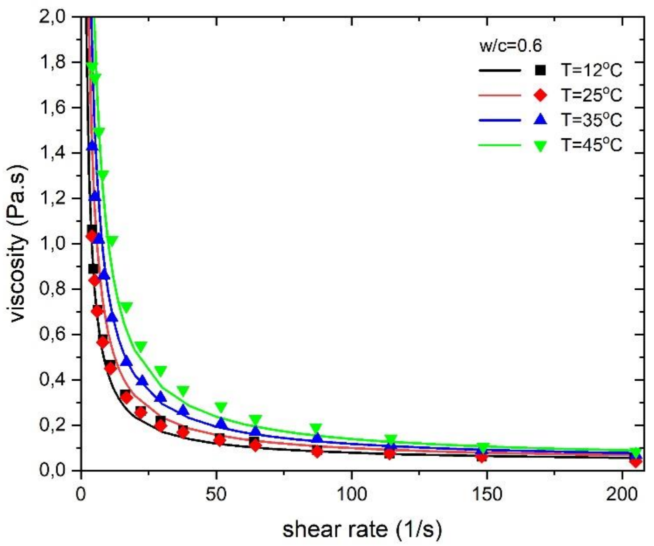

Fig. 1.8: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Xu et al. [3] (symbols) when w/c=0.6 (temperature in °C) using the Arrhenius-type expression to express the temperature dependency.

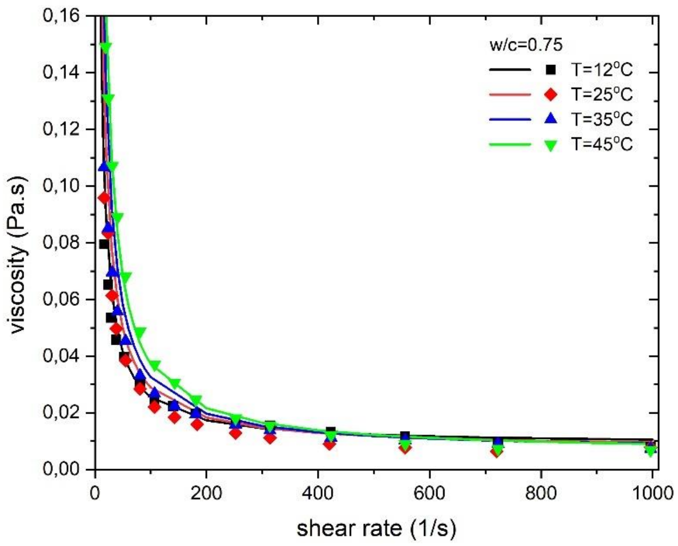

Fig. 1.9: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Xu et al. [3] (symbols) when w/c=0.75 (temperature in °C) using the Arrhenius-type expression to express the temperature dependency.

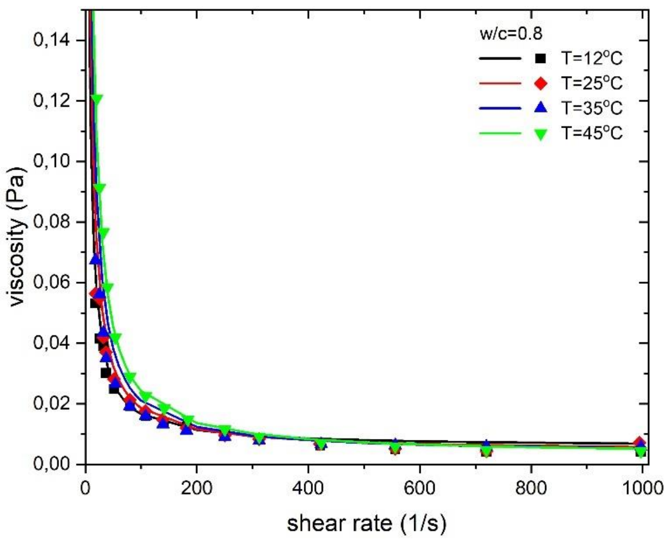

Fig. 1.10: Model predictions (continuous lines) of shear stress vs shear rate and comparison with the rheological data of Xu et al. [3] (symbols) when w/c=0.8 (temperature in ºC) using the Arrhenius-type expression to express the temperature dependency.

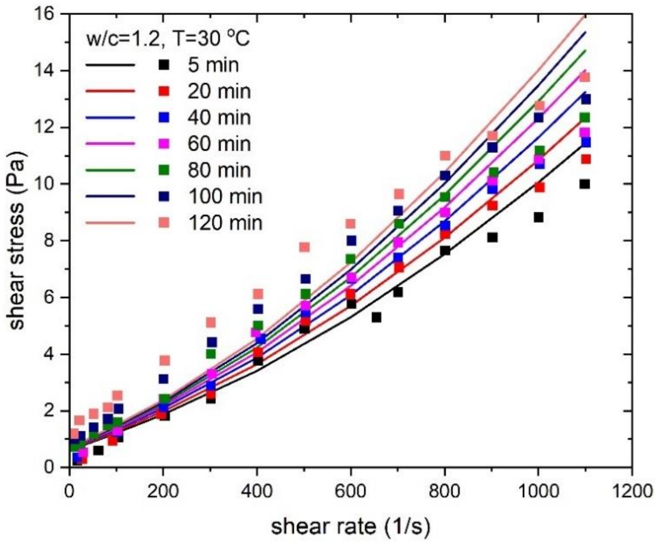

Fig. 1.11: Comparison with the rheological data of shear stress versus shear rate of Wang et al. [2] for w/c 1.2 and temperature 30 ºC using the Arrhenius-type expression to express the temperature dependency.

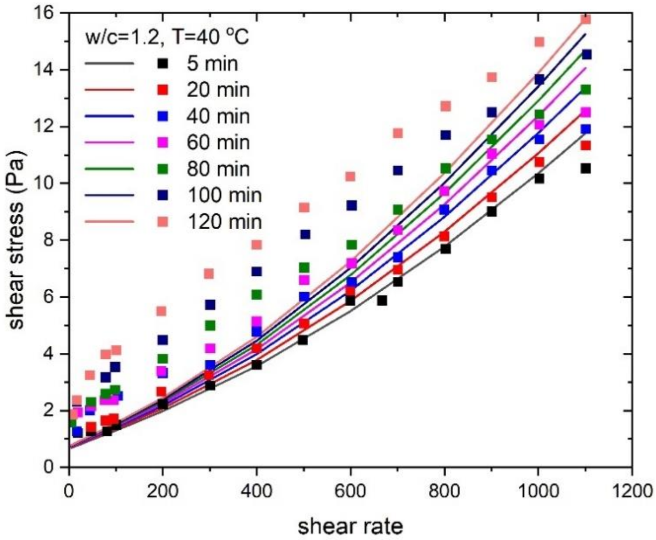

Fig. 1.12: Same as Fig. 1.11, but for a temperature of 40 ºC.

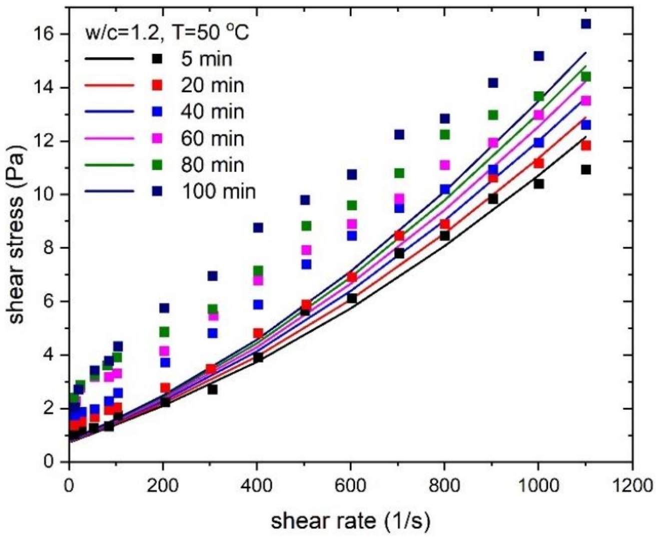

Fig. 1.13: Same as Fig. 1.11, but for a temperature of 50 ºC.

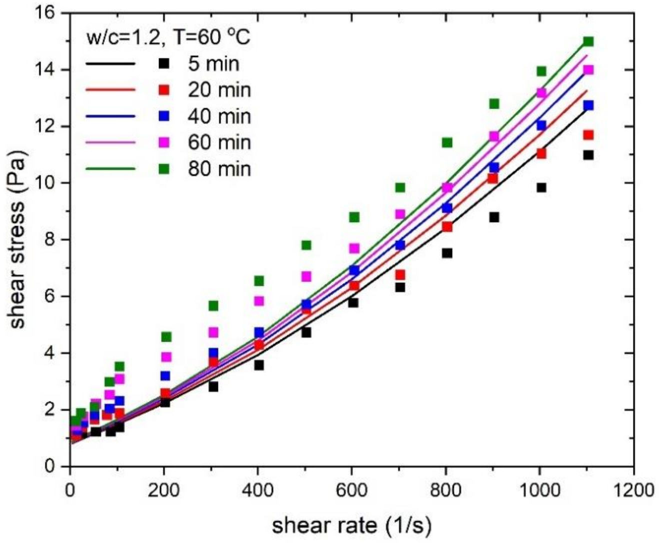

Fig. 1.14 Same as Fig. 1.11, but for a temperature of 60 ºC.

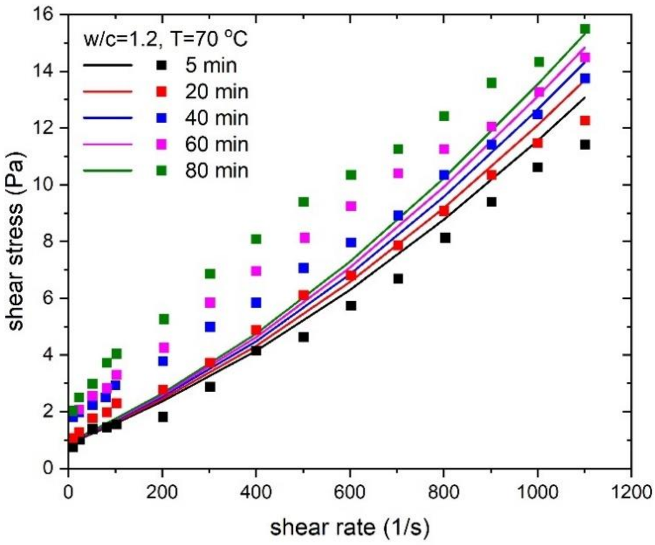

Fig. 1.15: Same as Fig. 1.11, but for a temperature of 70 ºC.

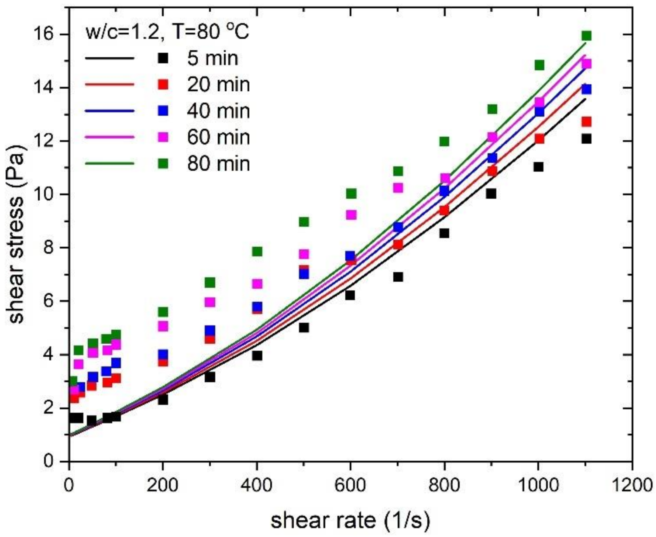

Fig. 1.16: Same as Fig. 1.11, but for a temperature of 80 °C.

References

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[2] M. Wang *et al.*, “Influence of extreme high-temperature environment and hydration time on the rheology of cement slurry,” Constr. Build. Mater., **295**, 123684, (2021),

[3] Z. Xu, Y. Miao, H. Wu, X. Yuan, and C. Liu, “Estimation of Viscosity and Yield Stress of Cement Grouts at True Ground Temperatures Based on the Flow Spread Test,” Mater. 2020, Vol. 13, Page 2939, **13**, 2939, (2020),