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An extended dynamical model of a geyser induced by inflow of gas (3) : effects of various friction loss in an underground watercourse

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We have proposed a mathematical model (a static model), a dynamical model and a modified dynamical model of a geyser induced by inflow of gas (a periodic bubbling spring) based on observation of Hirogawara Geyser (Yamagata, Japan)and model experiments of the geyser and have also proposed a combined model combining above 2 models. And numerical simulations of the modified dynamical model or the combined model reappear dynamics of spouting of geysers induced by inflow of gas and it becomes possible that parameters (volume of the underground space, depth of spouting hole and so on) under a geyser are estimated due to comparison between results of simulation and those of observation. Moreover we have verified above models through geological exploration, analysis of hot spring water and radioactive prospecting. Then we added evaporation effect of gas dissolved in hot spring water to the combined model.

Then we expanded the combined model through adding effects of a complicated underground watercourse, that is, effects of watercourses' sudden expansion, sudden contraction, repeat of them and elbow shape to the combined model. As a result, though we could see change of spouting's amplitude, period and so on dependent on degrees of above effects, we could also see that these effects were much smaller than those of other parameters, that is, volume of the underground space, depth of spouting hole and so on. But in the case of such a long watercourse as a geyser's underground watercourse, an effect of friction loss between walls of the watercourse and hot spring water flowing along it is largest among the other effects concerning head loss. Therefore we have to consider above effect of friction loss when we discuss spouting dynamics of a geyser.

In this study, we expand further above expanded model through adding effects of friction loss between walls of the watercourse and hot spring water during spouting to the combined model and estimate effects of it on spouting dynamics through numerical simulation of the further expanded model. Concretely through giving coefficients of friction loss of various wall surface's shapes to the above further expanded model we estimate effects of friction loss on spouting dynamics. By the way, though above modified dynamical model of a geyser induced by inflow of gas also includes effects of friction between walls of the watercourse and hot spring water, it deals with only laminar flow based on Poiseuilleś law. On the other hand, this study deals with not only laminar flow but also turbulent flow.