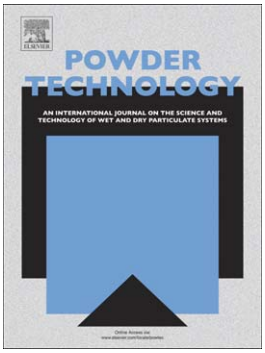

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Analytical solution for the dynamic model of tumbling mills

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Abstract

Optimisation of grinding circuits is invariably dependent on sound process models together with process simulators that can solve the process models accurately. Most of the process models are solved numerically because analytical solutions are not available, which can lead to errors in the results due to the numerical approximation of mathematical equations. Whiten [1], and Valery Jnr & Morrell [2, 3] have developed a dynamic model with numerical simulation for autogenous and semi-autogenous mills, and validated the model with dynamic response of mills in terms of power draw, grinding charge level, slurry level and product size distribution to changes in feed rate, feed size, feed hardness and water addition [2, 3]. In this work, an analytical solution for their dynamic model of tumbling mills has been developed based on the knowledge of solutions to the first-order nonhomogeneous linear differential equations. Two algorithms, Direct Single Time method (DST) and Direct Multiple Time method (DMT), were applied to obtain the analytical solutions respectively. It was found that analytical solutions are more accurate than the traditional finite difference numerical methods. However, the DST analytical method has a drawback of numerical instability due to the accumulation of round-off errors which are amplified by exponential functions, whilst the DMT method can provide stable solutions. To test the DMT analytical method, two cases of SAG mill dynamic operation were studied with both the traditional numerical method and the newly developed analytical method, further proving the robustness and feasibility of the analytical solutions.

Key words: dynamic model, tumbling mills, SAG mill, analytical solution, Direct Single Time method (DST), Direct Multiple Time method (DMT)