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Development novel approaches for modeling dense granular flows

Doctoral dissertation

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Abstract

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Granular flows, are characterized by a high solid volume fraction of the solid phase. An example of such a flow is the fluidization. Fluidization is a phenomenon where, under the influence of a flowing gas, the solid particles undergo constant motion, and behave like a fluid. The phenomena finds diverse applications, and gained popularity in recent years. It finds it application in industries such as chemicals, pharmaceuticals, food, energy. Especially in the latter example, the technology has numerous applications due to its many advantages over traditional boiler designs. All this, is mainly due to the growing computational resources that allow the use of advanced computer models, to predict the behavior of the solid phase. Due to the large number of particles characterizing granular flows, modeling them is not a trivial task. The large volume solid volume fraction affects a very large number of complex interactions between particles. To reduce the financial outlay accompanying attempts to improve existing technologies, it is necessary to use accurate numerical models to map the phenomena occurring. Despite the computational techniques that are already available, there is still room to try to improve them, or draw advantages from them, to combine them into a new approach.

The dissertation presents two different approaches. One is the use of machine learning techniques to improve collision detection. It is based on combining the Hybrid Euler-Lagrange model with the Discrete Element Method model, through the use of a simplified model. The simplified model will be integrated into simulations using the Hybrid model, through User Defined Functions. When a collision is detected, it will be triggered, thereby replacing the existing approach based on Kinetic Theory of Granular Flow. The results of the calculations will be compared with experimental measurements, carried out on a testing-rig replicating the conditions of the simulations carried out. The second proposed approach uses neural networks to predict field values in a numerical model of a circulating fluidized bed boiler. The approach is part of a prediction and prescriptive system developed, to allow intelligent control of the boiler, located at the Lagisza power plant in Będzin.