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Institut fur Stromungslehre und Warmeubertragung
Department of Particulate Flow Modelling

Materials to Simulations to Applications

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Abstract

Numerous industries process particles. In this work, we focused on how to efficiently picture the behaviour of particles by means of numerical simulations, laboratory experiments, and Artificial Neural Networks (ANNs).

Particle-particle contact laws and particles size distributions determine the macroscopic simulation results in Discrete Element Method (DEM). Commonly, contact laws depend on semi-empirical parameters which are difficult to obtain by direct microscopic measurements.

To clarify this aspect, we present the related elements of the DEM theory. The ANN theory is also introduced to demonstrate ANN effectiveness towards generalization.

Later, we describe the series of small scale DEM simulations with different sets of particle-based simulation parameters and particle distributions, which we performed. The macroscopic results of these simulations were used to train dedicated feed-forward ANNs by backward propagation reinforcement. Concurrently, the bulk behaviours of raw particles were characterized by means of macroscopic laboratory experiments. These particles were those commonly used by metallurgical industries (i.e., coke, iron ore, sinter, and limestone).

At this point, the relationship between macroscopic results and microscopic DEM simulation parameters could be investigated.

We subsequently utilized this artificial neural network to predict the macroscopic ensemble behaviour in relation to additional sets of particle-based simulation parameters and particle distributions. By this method, a comprehensive database was established, relating particle-based simulation parameters to macroscopic ensemble output. If compared to an experiment of a specific granular material, this database identifies valid sets of DEM parameters which lead to the same macroscopic results as observed in the experiments. Finally, we applied this method of DEM parameter identification to two industrial scale processes of steel production.

Part I

Introduction

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Chapter 1

Motivation and insufficiency of the State of the Art

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Chapter 2

Aim

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Part II

State of the Art

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Chapter 3

Discrete Element Method

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3.1 Literature Values

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Chapter 4

Computational Fluid Dynamics

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Chapter 5

Artificial Neural Network

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Part III

Identification of DEM parameters

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Chapter 6

Numerical Simulation

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6.1 Angle of Repose

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6.2 Shear Cell

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Chapter 7

Artificial Neural Network Training

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Chapter 8

Experimental Characterization

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8.1 Particle Distribution

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8.2 Angle of Repose (p-p) - Small Scale

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8.3 Angle of Repose (p-p) - Large Scale

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8.4 Schulze Ring Shear Cell tester (p-p)

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8.5 Jenike Shear Cell tester

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Part IV

Results and Discussion

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Chapter 9

Validation

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Chapter 10

Influence of variations of input parameters

the influence of variations (distributions) of input parameters

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Chapter 11

Influence of poly-dispersity

the influence of variations (distributions) of poly-dispersity

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Part V

Applications

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Chapter 12

Sinter Plant

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Chapter 13

Blast Furnace

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Part VI

Conclusion

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