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FORMATION OF FORCE AND HEAT NETWORKS IN BINARY PARTICLE SYSTEMS UNDER THERMALLY-ASSSISTED COMPACTION

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ABSTRACT

Understanding the fundamental multi-physics behind the thermally-assisted compaction of granular media that consists of binary particle systems provide the essentials to fabricate particulate assemblies with specific functionalities. The macroscopic material properties of the consolidated product, such as: mechanical strength, thermal and electrical conductivity, are contingent upon the knowledge of the inter-particle relations that determine the microstructure. Unlike the continuum media, granular materials host inhomogeneous distribution of contact networks, which results in uneven distribution of loads in the dense particulate assemblies. Moreover these structural arrangements play critical role in forming preferred paths of heat transport within the micro-structural arrangement. It is the purpose of this study to suggest that insight into the nature of thermally-assisted compaction of granular materials with binary sized particle system.

Keywords: thermo-mechanical coupling, granular material, particle mechanics approach.

INTRODUCTION

We work on a particle mechanics approach that entails the integration of contact mechanics principles with thermal-contact model analytical solutions to account for the effective modeling of heat conduction within the deformed state of granular materials. We consider a packed two dimensional arrangement of spherical particles compressed by heated boundary walls. Starting from pair interactions, we trace the formation of force and heat chains, and investigate the role of mechanical and thermal material properties of binary systems in microstructural arrangement of the confined system. In this regard, normalized contact force distributions and normalized heat distribution serve as important indicators of defining the uneven profiles of force and heat network. Numerical results unveil the cross-property connection between these networks and the macroscopic properties of the compacted system of particles.

RESULTS AND CONCLUSIONS

In an attempt to understand the effect of particle size on the microstructural arrangement of thermally-assisted compaction of granular materials, two different systems of spherical, and conforming particle systems are compared. A square container of 0.4m edge is compacting a bed of stainless steel particles by the downward movement of the top horizontal boundary wall, which is kept at 493K. In Fig.1 a system of 1486 particles, 1195 of them with a radius of

4mm and the rest of 8mm is visualized. Fig. 2 is a system of 1760 particles, where 1225 of them are 4mm in radius and rest is 6mm.

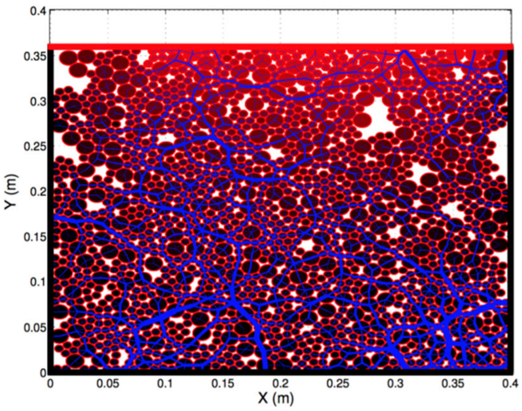

Fig. 1 - Force chains in a system of 1486 particles, ε=0.10 and ΔT= 200K

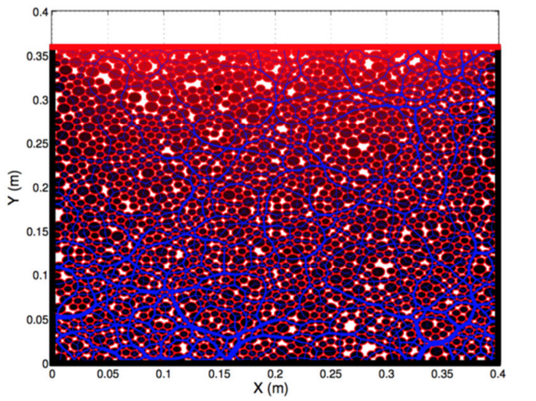

Fig. 2 - Force chains in a system of 1760 particles, ε=0.10 and ΔT= 200K

Force networks seen in Figures 1 and 2 show that systems, which have particles with similar in size, have more uniform distribution of contact forces. In Fig. 3normalized force distributions of the considered cases are compared for three different compaction strain.

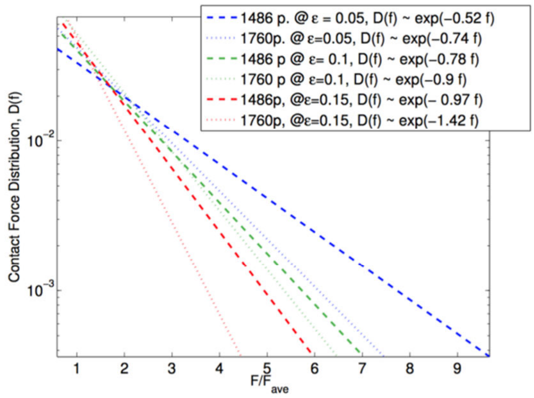

Fig. 3 - Force distribution comparison of two binary systems

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REFERENCES

[1]-K Chen, *et al.*. Granular materials: Packing grains by thermal cycling. Nature, 442(7100):257-257, 2006.

[2]-Watson L Vargas and JJ McCarthy. Thermal expansion effects and heat conduction in granular materials. Physical Review E, 76(4):041301, 2007.

[3]-Trushant S Majmudar and Robert P Behringer. Contact force measurements and stress-induced anisotropy in granular materials. Nature, 435(7045):1079-1082, 2005. Models and Methods. World Scientific, 2013.