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Non-convex Shape Effects on the Dense Random Packing Properties of Assembled Rods

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Abstract

The packing of rod-like particles, which is common in physical and mathematical studies, has arisen in a variety of industrial applications. Elongation effect on the packing properties of rod-like particle has been well investigated. Besides that, rod-like particles can be easily deformed into a large amount of non-convex shapes by simply bending or assembling several particles, in which effects of non-convex deformations should also be concerned. In this work, the packing behaviors of particulate systems composed of various non-convex deformations of rod-like particles are numerically simulated via the analytical model and the relaxation algorithm. The packing configurations are further optimized using the Monte Carlo method to eliminate the local ordered structures. 8 shapes of non-convex particles including 2-dimensional and 3-dimensional particles are employed in the packing systems. Independent of aspect ratio, the dense random packing densities of identical assembled rods are up to 20% higher than those of spherocylinders and are less dependent from the specific particle shape. However, the coordination numbers of various non-convex particle packings are quite different. With a parameter of convex ratio defined, a packing composed of more non-convex particles will have a higher coordination number. This indicates that for more non-convex particle packings, there are more constraints and entanglements among neighboring particles, resulting in a more stable configuration. The nearest-neighbor contact to a centered particle in 3DX-shaped particle packings is quite different from those of other shapes, which can be identified from the location of the first peak in the radial distribution function. It is also the cause to the distinct disparities of estimated excluded volumes of non-convex particles simulated in this work.

Keywords: random packing; packing density; shape effect; non-convex particle

1. Introduction

In recent decades, the problem of shape effects on the dense random packing properties of non-spherical particles has attracted much attention [1-8]. Among various particle shapes in physical and mathematical studies, rod-like particles are very common [9-14]. Packings of such particles have also arisen in a variety of industrial applications. For the factors that attribute to packing properties, elongation effect is one of the most important. Previous works indicated that the dense random packing density generally decreased with the increase of elongation. However, for elongated particles, a dense random packing is comparably difficult to generate due to the