774. Tribological adhesion of particles in acoustic field

Vladas Vekteris[1], Vytautas Striška[2], Vadim Mokšin[3],
Darius Ozarovskis[4], Rolandas Zaremba[5]
Vilnius Gediminas Technical University, Department of Machine Engineering, Lithuania
E-mail: [1]*vekteris@vgtu.lt*, [2]*vytautas.striska@vgtu.lt*, [3]*vadim@vgtu.lt*,
[4]*darius.o@vilpra.lt*, [5]*roliuxas@gmail.com*

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Abstract. This paper investigates interaction between two particles in acoustic field. It is shown that additional oscillating movements of particles occur as a result of plain acoustic wave action. This sufficiently increases the probability of collisions between particles. Micro-displacements in the collision zone help to remove various pollutants, oxidation products and adsorbed gas molecules from surfaces of particles. Strong adhesive bonds are formed in the contact area between the particles.

Keywords: acoustic field, particles, adhesion, aggregation.

Introduction

Surfaces of solid particles dispersed in the atmosphere are fouled by oxidation products and have high moisture content [1]. Chemical bonds (short-range forces) between surfaces of particles reach their peak value under the action of these pollutants [2]. If two particles come into contact with each other only Van Der Waals interaction become sufficient for adhesion, because chemical bonds reach peak value and total thickness of fouling layer is bigger than action interval of mentioned surface forces. However, if the interaction of particles takes place in the presence of acoustic field, additional tangential force occurs. This force can break the fouling layer thereby removing pollutants and increasing the contact area between the particles. It is considered that small displacements occur on the separation surfaces of particles under the action of tangential forces. This results in several-fold increase in adhesion and higher degree of aggregation of particles.

When two particles approach one another, Van Der Waals attraction forces start to act between them. These forces occur due to fluctuations in the charge distribution of atoms and molecules of particles. These charges form continuously moving dipoles. As a first solid body approximation, it can be considered that Van Der Waals force acting between atoms or molecules has additive character. Therefore total force can be calculated by summing pairs of atoms of the both surfaces. With this assumption, Casimir [3] first derived the formula for adhesion force acting on interface of two mirror polished surfaces: $F_A = \hbar c \pi^2 A / 240 z_0^4$, where: $\hbar = h / 2\pi$, h is the Planck's constant, c is the speed of light, z_0 is the separation between surfaces, $A >> z_0^2$ is the area.

It is established [4] that Van Der Waals adhesion force acts between all the materials which are brought together at the nanometric distance. If the separation between surfaces is less than 1 nm, various chemical bonds are formed between surfaces depending on chemical composition of surfaces.

Fuller and Tabor [5] proposed the "adhesive parameter": $\theta = E z^{3/2} \beta^{1/2} / \beta \Delta\gamma$, where E is the effective Young modulus, z is the separation of average lines of two bodies, β is the curvature radius of asperities, $\Delta\gamma$ is the variation of surface energy. Quantity $\beta\Delta\gamma$ is related to the adhesion force and quantity $E z^{3/2} \beta^{1/2}$ – to the surface force between asperities which appears when surfaces are torn apart.

If Fuller-Tabor parameter is small the adhesion plays a central role, if large – asperities dominate, adhesion becomes weak.