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Influence of the compression length on the ultimate stress in the process of mechanical agglomeration of dry ice

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Abstract

This paper presents the results of research on improving the efficiency of the mechanical agglomeration through optimising the distance to which the ram approaches the die face in the final position. The focus of this study is the influence of the compression length on the value of the ultimate stress in the process of mechanical agglomeration of crystallized carbon dioxide. The first part of the paper proposes a model describing the influence of the geometric parameters of the residual amount of material which must remain in the cylinder on the value of axial force during subsequent compression phase of the process. The research part of the paper presents the empirical research results to verify the proposed model. The results of the work will be used to determine the influence of the described geometrical parameters of the dry ice residue on the axial force value. The derived mathematical model will be used for defining the design requirements as the starting point for the design and building of dry ice compression and granulation machines.

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Keywords: mechanical agglomeration; compression; dry ice; carbon dioxide;

1. Introduction

Use of by-products generated in various industrial activities is getting an increasing attention. These materials include carbon dioxide extracted from post-industrial waste for subsequent reuse. Often the quantities of carbon dioxide recovered in this way exceed the on-site reuse capacity of the factory. For this reason the carbon dioxide is liquefied by compression for easy storage. In this form it can be supplied to the customers.

The transition from liquid to solid phase is an adiabatic process. Solidified carbon dioxide (dry ice) is stable at a temperature of minus 78.5°C and at the ambient outdoor temperatures sublimates to the environment [1,2]. These properties made it a suitable material for various refrigeration applications.

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However, intensive sublimation is an obstacle in effective use of its thermal properties. The sublimation rate can be reduced by reducing the surface exposure through mechanical agglomeration of dry ice particles. The process of mechanical agglomeration is effected with specially designed machines [2,3].

Ram pressing method is most commonly used. Figure 1 presents a schematic of a typical work assembly of such machines.

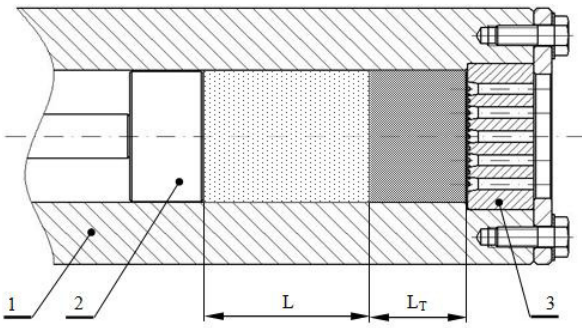

Fig. 1. Crank press system of dry ice compression/extrusion machine, 1 – compression cylinder, 2 – ram, 3 – extrusion die with multiple extrusion channels, L – new feed length, L_T – pre-feed length.

The crank press system consists of the compression cylinder (1) and the ram moving inside it (2). While moving on the section *L* the ram reduces the space occupied by the dry ice particles. Densification is caused by the converging shape of the die channels (3). The density of the material being densified increases up to the moment when the resistance during compression becomes equal to the resistance of extrusion through the die openings (channels). Thus the dry ice is compressed to a density of about 1.6 g/cm^3 in the process inducing stress level of minimum 14 MPa [4].

This paper describes the effect of the amount of material remaining in the compression cylinder on the process of compression. This amount is the residue from the preceding cycle of the production process. In the paper it is called pre-feed amount and its length is designated L_T.

2. Description of the test procedure

The influence of the pre-feed length (L_T) was determined with a specially developed test method. Measurements were recorded for the following pre-defined L_T values (Table 1).

Table 1. Values of L_T

No.	1	2	3	4	5
L_T [mm]	0	5	10	20	30

The tests were carried out with the Insight strength tester from MTS, equipped with a 50 kN strain gauge sensor. The measured parameters were the force and the cross-piece travel distance and the measurement results were recorded at a constant frequency of 10 Hz. A constant production speed of 6 mm/sec. was maintained during the tests. Three measurements were recorded for each L_T value.