An innovative method using an evolutionary technique to design single-channel dies used in the extrusion of crystallised CO2 to reduce electricity and raw material consumption

The method developed supports the design of single-channel dies for extruding crushed materials in reciprocating pelletisation. The innovation of the solution comes from the use of a genetic algorithm, categorised as an artificial intelligence algorithm. This allows the comparison of simulation test results obtained for selected values of the geometrical parameters of the die channel. On that basis, the algorithm, using a probabilistic selection rule, changes the value of the individual geometric parameters in order to achieve the set objective function. The decision-making parameters used in the indicated method are the reduction in the limit value of the force required to carry out the extrusion process while maintaining the product density value within a fixed value range.

Demonstration tests gave credibility to the effects of the developed design method, where the Cold Jet PE80 granulator managed to reduce electricity consumption by 17% and raw material consumption by 5%. The shape of the die channels and their geometric parameters have been filed with the Patent Office of the Republic of Poland (applications Nos. W.131208 and W.131209).

In order to develop a numerical model of the material, tests were carried out to determine a mathematical function describing the change in the value of the mechanical parameters as a function of its density. This was made possible by the development of four test rigs, which were covered by patent applications P.442070, P.442071, P.437840 and P.437839.

The end result was the design of the single-channel dies, which are adapted for installation in the PE80 pelletiser by Cold Jet. Three types of dies were developed for 3 ranges of final pellet density. Converging convex and concave-convex dies were used for the demonstration studies. The results of the study proved that the use of the proposed new die design method reduces electricity consumption by 17% and raw material consumption by 5%. On the basis of which, utility model application Nos. W.131208 and W.131209 were prepared.

In the case of the other dies, they allow pellet production in the range of 1,300-1,500 kg/m3. Dry ice pellets are only offered on the market for densities of around 1,550 kg/m3. Therefore, a proposal is made to produce pellets with different values of it can be considered a product innovation.

The technology, together with patent applications and R&D, was developed as part of a project entitled 'Development of an innovative method using an evolutionary technique to design shaping dies used in the extrusion of crystallised CO2 to reduce electricity and raw material consumption' (contract No.: **LIDER/3/0006/L-11/19/NCBR/2020**), funded by the **National Centre for Research and Development** under the LIDER programme.