ACCELERATED DRYING OF PLASTICS WITH NEW HUNGARIAN PATENTED TECHNOLOGY

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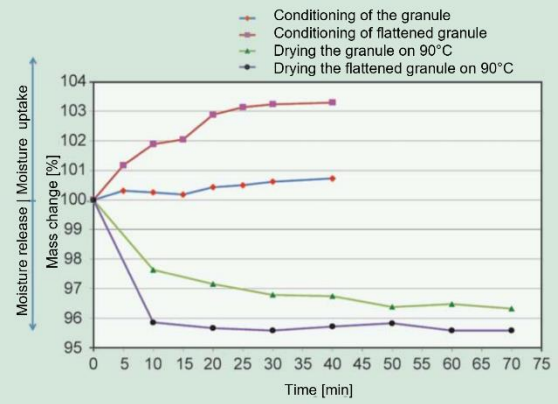
The distributed plastic granules on the market are usually lenticular or cylindrical shape, what in most cases must be dried before processing, since they take up moisture from the environment. The not adequate drying effects the structure and characteristics of the material, therefore the processibility and the quality of end-product.

1. INTRODUCTION

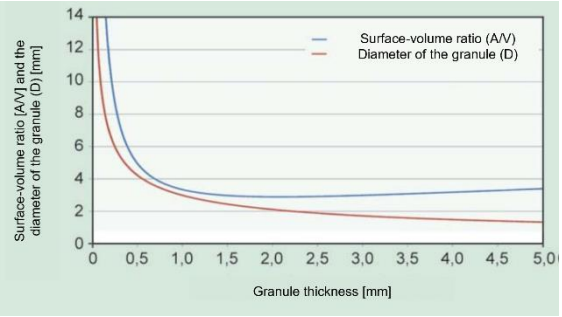
The unjustifiably long and high temperature drying (over drying) can result in the degradation of the polymer chains or additives. In case of low temperature or short duration drying (under drying) the leftover moisture in the material can also cause degradation, reduced product quality, and difficulties in processing. These factors together with the drying temperature and drying time bring serious uncertainty into the production process. The manufacturers of plastic drying equipment are continuously developing their products to achieve faster, more effective, and more controlled drying process [1]. It can be stated that the drying equipment on the market only effects the drying conditions (drying temperature, drying time, the pressure and dew point of the drying air, etc.) and the shape of the granules viewed as constant.

During an experiment we examined how the conditioning time changes as function of the wall thickness of the product. We experienced that with reduced wall thickness the moisture uptake increased by orders of magnitude. The results of the first measurements are shown on figure 1, it displays the conditioning and drying curves of the PA6 granules and the flattened granulate grains.



1. Figure: Conditioning and drying curves of the PA6 granulate grain and the granule flattened to 0,7 mm

Figure 1 shows well that the granules flattened to disk shape give down and take up moisture faster under identical conditions. The explanation for this is that the raw material can take up or give down the moisture easier if the diffusion pathway is reduced by pressing and if the evaporating surface as well as the surface volume ratio is increased. It can be seen on figure 1 that less than 10 minutes is enough to completely dry out the flattened PA6 sample.



2. Figure: Effect of the pressing and stretching on the surface-volume ratio and diameter of an average, cylindrical granulate grain

Figure 2 displays the surface-volume ratio and diameter of an average cylindrical granulate grain with 2 mm diameter and 2 mm length in function of its length (thickness). It shows that the smallest surface-volume ratio is at the original size. Reducing the length (thickness) of the granulate grain, under 1 mm the surface-volume ratio intensively increases. The curve also shows that even if the granule were pressed and long thread formed, the surface-volume ratio would increase.

2. SHORT ANALYSIS OF THE DRYING PROCESS

During the analysis of the drying process recommended to examine the drying of the granulate link, the movement of many granulate grains, and the material flow separately.

The drying process of the individual granulate grain can be split into two sections:

a) Diffusion: The moisture content of the granule grain is continuously striving for balance with the environment. If relative humidity of the environment decreases, then the moisture diffuses from the inside of the granule to its surface. This is a rather time-consuming material transport, which other than the environmental conditions, depends primarily on the diffusion pathway, so the size and shape of the granulate grain. The simplest drying equipment heats up the drying air, others dry out the drying air (its moisture content is described by the dew point of the air), while some equipment forms vacuum in the tank of the dryer [2-4].

b) Evaporation: The moisture diffused to the surface of the granule needs to be evaporated, the air used for drying takes away the moisture. The evaporation depends on the size of the granulate grain surface, the condition of the drying air (temperature, pressure, humidity etc.), the volume flow, and space filling of the granulate grains.

Material flow in the drying system

The movement of the granulate grains in the tank of the dryer is not homogeneous, consequently the duration of the stay changes depending on the pathway of the granulate grain. For example, the Moretto company has developed tank structures which can make the material flow and duration of stay more consistent therefore decreasing the drying time too [5].

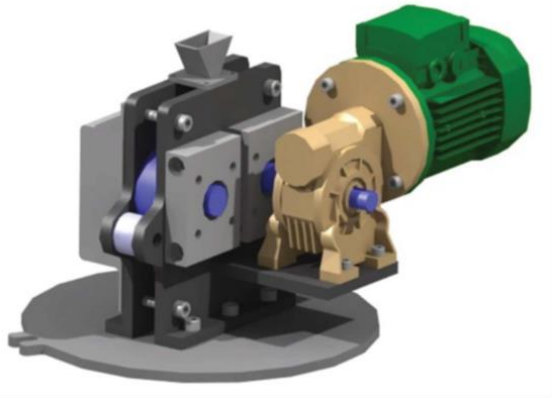
Other problem is that the dried-out material takes up the moisture again if it contacts the air, so it needs to be placed in the processing machine as soon as possible.

From economical point of view, it should be taken into consideration that even in ideal case, when the most modern drying equipment is used the energy usage is around 20-80 kWh/1000kg depending on the material type [1]. But with inadequate settings the energy requirement could be multiple of this.

3. STRUCTURE OF THE PRESSING EQUIPMENT TO MODIFY GRANULATE GRAIN SHAPE

The granulate grains required for our early experiments were pressed by a simple lever press. The most important parameter was the thickness of granulate grains, which was

changed between 0,2…1,5 mm., A cylindrical pressing machine was designed and manufactured to produce bigger amount of grains and for industrial trials, its model can be seen on figure 3.

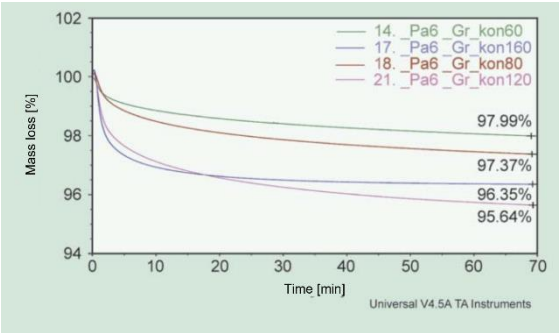


3. Figure: Model of the prototype of granule pressing equipment

4. REVIEWING THE RESULTS OF THE ACCELERATED DRYING

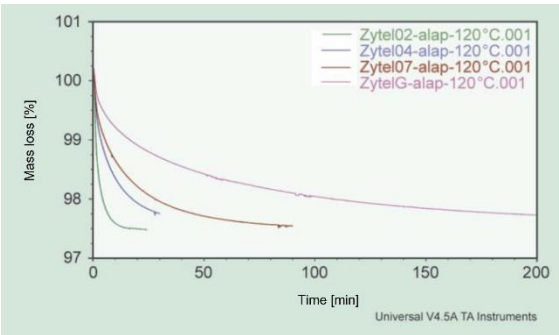
4.1. RESULTS OF THE TGA TESTS

We examined the drying of the conditioned PA (Zytel 73G50HSLA) granule with the content of 50m% glass fibre and the also conditioned specimen pressed from the original granule. For the measurements TAQ50 thermometer was used. During the measurement the mass change of the samples, i.e. the mass loss was measured under isothermal conditions. The mass loss was displayed as a percentage in function of time. Figure 4 shows the TGA curves of the original granule, which were determined at 60, 80, 120, and 160°C. Well displayed that by increasing temperature the mass loss i.e. the moisture loss happens more faster. As expected, at higher temperature shorter drying time is enough. The curves defined on 120 and 160°C intersect each other. The explanation for this is that the conditioned samples were wiped dry before the experiment, but some moisture could have stayed on their surface. Important to note that drying on high temperature can cause degradation so in practice this material is usually dried under 120°C [6].



4. Figure: Mass loss of the granulate grains determined at 60, 80, 120, and 160°C

On figure 5 the results determined on 120°C are shown in function of the thickness of the samples. The thickness of the flattened samples was 0.2, 0.4, and 0.7 mm, while the diameter of the granulate grain was approximately 2 mm. The measuring results are proof that decreasing the thickness greatly accelerates the drying process, so with this method the drying time can be reduced to the fraction of the original.



5. Figure: Mass loss in function of granulate grain thickness determined on 120°C

4.2. DETERMINING THE LENGTH OF GLASS FIBRE

The question is if flattening the granulate grain effects the material properties, or it causes quality deterioration. We examined the length of the glass fibre in the samples preheated to 100°C and in the coldly flattened samples. The results are summarised in table 1, which shows that it is necessary to preheat the required granule in case of a material with glass fibre, since it helps to avoid the brokage of glass fibre.

During warm shaping, 10% of size reduction can be experienced compared to the original.

1. Table: The average of the glass fibre length and the size dispersion in each sample

	Length of glass fibre		
	in the original granule	**in the cold flattened sample**	**in the warm flattened sample**
Average	0,800 mm	0,335 mm	0,713 mm
Scatter	0,134 mm	0,076 mm	0,114 mm
Scatter in percent	16,77%	22,55%	16,01%

4.3. RESULTS OF THE TENSILE TEST

From the granule, warm and cold pressed samples injection moulded specimen was made, and tensile test was performed on them, the results are summarised in table 2.

The results in table 2 display well that the mechanical properties of the material with 50m% glass fibre content and the samples pressed with preheating are almost identical. A 7% difference can be measured in tensile strength. At lower glass fibre content or unfilled polymer this property reduction can be negligible.

2. Table: Result of the tensile tests

	Elongation at break [%]	**Tensile strength [MPa]**	**Modulus [MPa]**
Results – original granule	5,01	215	4871
Scatter – original granule	0,22	3,33	90,02
Results – flattened grain	5,19	200	4645
Scatter – flattened grain	0,24	4,30	91,35

5. CONCLUSION

By flattening the granulate grains the drying time can be reduced significantly. The early experiences were proven by the measuring results, we were able to build a prototype which made it possible to manufacture larger amount of samples for the injection moulding tests. Our goal is to make, test and distribute an equipment in the near future, which can decrease the drying time to few 10 minutes under industrial conditions. Using the system, the drying difficulties of the mass plastics (for example PET) and the high-performance technical materials can be avoided.

The patenting of the technology is at advanced stage.

The measurements were performed at the College of Kecskemét, Faculty of Material Technology and at Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Polymer Engineering with the support of Cavity Eye Hungary Kft. and HDH Engineering Kft.

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