

STUDY REFERRING TO MANUFACTURING TECHNOLOGIES OF THE SURVIVAL KIT CASES MADE OF PLASTIC MATERIALS

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Summary: The present study describes the principle of two modern technologies that can be used for manufacturing of survival kits cases made of plastic materials. The case of the survival kit can be made by injection molding using either Gas-Assisted Injection Molding or Foamed Thermoplastics Injection Molding. Generally, gas-assisted injection molding generates important savings of material and energy, improvement of surface quality, reduction of weight and increase of mechanical strength. The injection molding of foamed thermoplastics is used for production of lightweight parts (with density varying from 0,6 to 0,9·10³ kg/m³), large-dimension parts for packaging, furniture, different housings, etc. Also, the foaming of plastic materials are applicable at injection molding of very thick products, with favourable effect for their surface quality and appearance due to the elimination of melt flow marks.

1. INTRODUCTION

Natural or artificial disasters and catastrophes are major changes occurring on earth or in atmosphere. Nowadays, the impact on human lives of these more and more frequent unfortunate events, imposes the imperative necessity of design and production of the survival kits destined for the distressed population.

Basically, the survival kit has three compartments - Fig.1 - containing tools, equipments, devices, pre-prepared nutritive supplies, medicines, all together being an aid for people from the distressed areas [7].

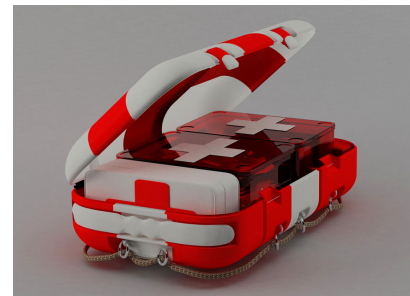
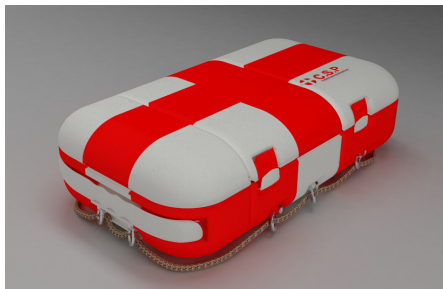


Fig. 1. Disaster survival kit

The medicines are into the first compartment, the nutritive supplies are into the second one and the third compartment receives the tools, equipments and devices.

The survival kit must comply with certain safety and resistance requirements - for instance, in order to be delivered by parachuting - so it is shock resistant, lightweight, water-floatable, high temperature resistant, etc.

The present study describes the principles of two modern technologies suitable for manufacturing of the survival kit cases made of plastic materials :

- gas-assisted injection molding
- foamed thermoplastic injection molding

These technologies are suitable for the manufacturing of lightweight, water-floatable, high shock and temperature resistant survival kit cases.

2. GAS INJECTION TECHNIQUE – GIT

The quality requirements for injection molded parts can not always be satisfied using the conventional injection processing. It is difficult to injection mold thick-wall parts without visible flow marks on their surface and no internal (remanent) stress.

In order to achieve these requirements, a new technological development was introduced lately:

- GIT - Gas Injection Technique, also known as Gas-Assisted Injection Molding (GAIM)

This is an injection molding technique with internal gas pressure also mentioned in the specialty literature as

- GID - Gasinnendruck-Technik
- IAG - Injection Assistee par le Gaz [1,2,3].

Gas-assisted injection molding could be understood as a bi-injection where the second polymer is replaced by gas (nitrogen).

The main advantages of nitrogen are :

- not oxidizing the polymer at high temperature
- non-pollutant
- cheap

The result of GIT is a product with thin and hollow walls, as intended for the survival kit case (Fig. 2) [7].

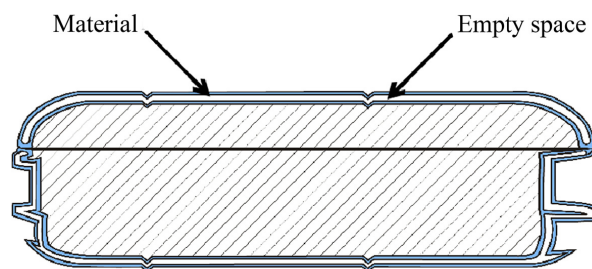


Fig.2. Case made using incomplete injection molding and internal gas pressure

The gas injection molding can be done on a conventional injection molding machine in two ways:

- complete injection
- incomplete injection

All types of thermoplastic polymers can be used in this type of injection technology.

2.1. Incomplete injection

The principle of incomplete injection is represented in Fig.3

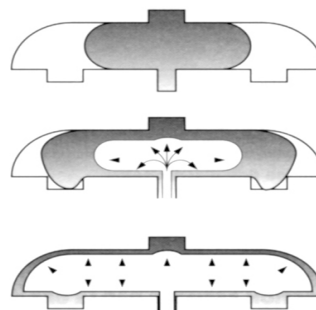


Fig.3. The principle of incomplete injection

This type of injection implies the following stages [4]:

- the mold cavity is partially filled by the plastic melt;

- the gas is introduced into the plastic melt, using either a special machine nozzle fitted in the plasticizing cylinder of the injection molding machine (Fig.4) or a mold nozzle as a special valve of the injection mold (Fig.5). The gas forces the plastic melt to expand to the mold cavity walls;

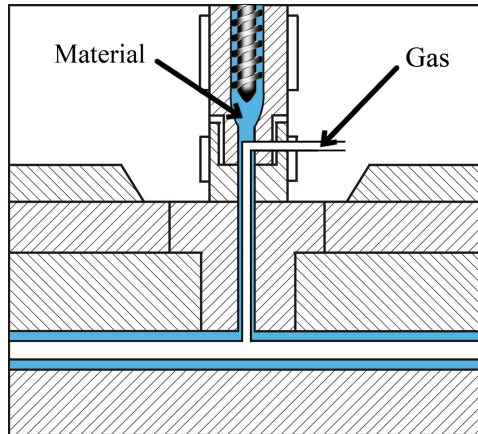


Fig.4. Principle of incomplete injection with coaxial intrusion of gas through the plasticizing cylinder nozzle, applied to molding of survival kit cases.

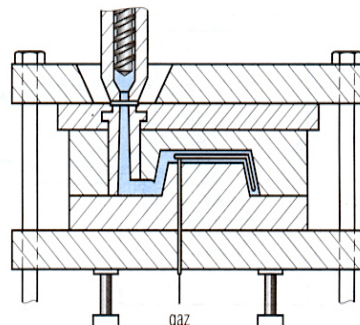


Fig.5. The principle of incomplete injection with direct in-mold gas intrusion.

- the holding pressure required is realized by gas;
- the cooling is realized under gas pressure;
- the decompression stage, meaning the gas recovery, is realized after elapsing the holding pressure time;
- the stripping and ejection of product from mold.

The gas under pressure passes through the polymer melt taking the path of least resistance. Preferentially, the gas travels through the ribs or the thicker areas of molded part. The melt pushed in this manner, run on along the flow path, filling the mold cavity only partially filled with melt.

A foaming effect occurs during the gas-assisted injection molding. The foaming tendency is higher as the walls of the molded product are thicker. Also the higher is the gas pressure, the greater will be the foaming effect since more gas is dissolved into melt at increasing gas pressure. For this reason, it is recommended to fill the mold cavity at low pressure first, then increase the gas pressure in order to compensate melt shrinkage. Also, the surface of the molded product is foaming in a higher extent if the gas pressure is stopped suddenly instead of being gradually decreased.

2.2. Complete injection

The mold cavity is filled with melt first, then the gas is injected into the polymer, still fluid of the molded product. The principle of this method is schematically represented in Fig.6.

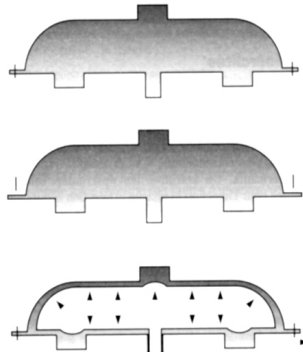


Fig.6. The principle of complete injection

The procedure of the gas injection technique has several advantages and possibilities regarding the geometry and dimensions of molded products. By using this technique can be obtained:

- cost cuts since smaller quantity of plastic is used;
- energy savings since time of injection cycle is shorter;
- reduction or elimination of surface trimming or finishing operations of molded products;
- improving the surface quality of parts;
- increasing the mechanical properties of parts;
- cost cuts derived from more simple design and making of injection molds;
- molded parts are lightweight, with a partial empty core;
- the injected gas jet into the melt permits the maintenance of a homogenous pressure in mold at a lower value than the level required by the classical injection molding. As a consequence, the clamping forces required are reduced accordingly;
- molded parts with more simple reinforcement ribs, increased rigidity and minimal flow marks on surface (Fig.7).

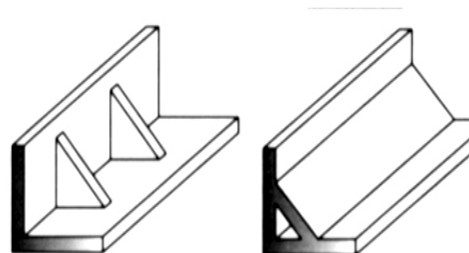


Fig.7. Simplification of reinforcement ribs, increasing of rigidity

Some major advantages of GIT are that :

- the conventional injection machines can be easily equipped to be properly used with this technology - one single nitrogen generator can supply gas to several injection molding machines.

Concluding, since the principles of GIT were known for a long time, this was applied on a larger scale only in the '90 decade. However, at present the potential of GIT is still fulfilled only in a small extent since there are still significant improvement possibilities referring to mold making, technical development of injection machines and management of technological process.

3. FOAMED THERMOPLASTICS INJECTION MOLDING

3.1. Basic principle

Generally, there are three main steps:

- introduction of gas into the thermoplastic melt
- foaming (also known as, blowing or expansion) of plastic material made by gas
- solidification in mold of foamed thermoplastics

The result is a lightweight product (Fig.8).

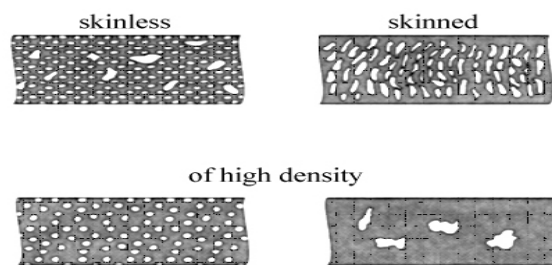


Fig.8. Structures of expanded parts

This technology is used for:

- production of lightweight parts (with low density), large-dimension parts for packaging applications (e.g., survival kit case), furniture, different housings, etc.

The density of these products varies from 0,6 to $0,9 \cdot 10^3 \text{ kg/m}^3$.

- expansion of plastic materials in order to eliminate the flow marks on surface of very thick parts and improvement of product appearance. The density of these products is $\approx 0,95 \cdot 10^3 \text{ kg/m}^3$ [5].

3.2. Foaming methods

There are two kinds of foaming methods: the chemical method and the physical method.

- The chemical method

Into the polymer grain is incorporated a heat-decomposable chemical agent (foaming or blowing agent). At the end of plastification or during the injection stage, at reaching a certain temperature, the foaming agent is decomposed releasing gas.

As foaming agents are used sodium dicarbonate and azodicarbonamide.

After compression, the gas remains into the polymer till the melt reaches the mold. The gas is released leaving a molded product with an alveolar, celled structure.

- The physical method

The foaming agent, mixed with polymer, is changing its physical state due to heat during plastification or injection stage. As physical foaming agents are used nitrogen and n-pentane.

3.3 Types of foamable polymers

All thermoplastic polymers can be expanded with more or less difficulty :

- general purpose polystyrene (PS),
- high impact polystyrene (PAS),
- polypropylene (PP) and fiber glass reinforced polypropylene (PP+GF),
- polyethylene (PE),
- plastified polyvinyl chloride (PVC),
- acrylo butyl styrenes (ABS),
- polycarbonates (PC),
- thermoplastic polyesters,

- polyamides (PA).

A composite material with polyamidic organic matrix is used for production of survival kit cases in order to increase their resistance against high temperature and shock.

3.4. Design of injection machines

The machines employed are similar to the injection machines used for molding of compact parts.

The clamping system is the sole difference to be considered at production of expanded parts.

Inside the mold, there is an additional pressure of $1,5 \div 2,5 \cdot 10^6$ Pa, generated by the gas released by foaming process. As a result, the clamping force requirements are higher, so usually, machines with larger platens are used. During injection, as the temperature rises, the gas is released very quickly. Consequently, the melt must be introduced extremely fast into the mold.

4. CONCLUSIONS

The present study describes the basics of two modern technologies suitable for manufacturing of survival kit cases made of plastic materials: gas-assisted injection molding and foamed thermoplastics injection molding. Both technologies are suitable for low-cost production of lightweight parts with good surface appearance.

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