

*GPEC 2004 Paper Abstract #2:*

**Title: From PET Bottle Flakes to Final Products: Product Quality is Determined by Melt Filtration**

Author(s): Dr. Monika Gneuss

Improvements in the collection systems of PET bottles as well as new legislations present new possibilities for the PET industry. There are a number of products where the substitution of virgin with recycled material makes economic and processing-technical sense, e.g. staple fiber, thermoforming sheet, nonwovens or strapping.

EACH OF THESE PRODUCTS PLACES REQUIREMENTS ON THE PROPERTIES OF THE RECYCLED PET, WHICH ARE CLOSE TO THOSE OF VIRGIN MATERIAL. APART FROM THE INTRINSIC VISCOSITY AND COLOR/TRANSPARENCY, FOREIGN PARTICLES OR CONTAMINATION IN THE MELT AFFECT THE PRODUCT QUALITY.

PET bottle flakes are processed into high quality pellets or are added directly to virgin material during the production of final products. Today, direct recycling, the use of 100 % flakes in the manufacturing of end products without the intermediate repelletizing step, is becoming popular. The melt filtration step plays an important role in all these processes and determines the end quality that can be achieved.

The paper first discusses the technical and economical demands made on a filtration system used in PET bottle flake applications. Then, the fully-automatic Rotary Filtration System is introduced, which is well suited for the processing of bottle flakes. The possibilities it offers for direct recycling are explained. Then, various direct recycling concepts are described. These concepts differ regarding pre-drying, extruder type and demands on the filtration system. The different requirements and solutions regarding the filtration step are explained.

# From PET Bottle Flakes to Final Products: Product Quality is Determined by Melt Filtration

*Dr. Monika Gneuss  
Gneuss, Inc.  
921-A Matthews Mint Hill Road  
Matthews, NC 28105  
Phone 704.841.7251  
Fax 704.841.7254  
monika.gneuss@gneuss.com*

## Abstract

Improvements in the collection systems of PET bottles as well as new legislations present new possibilities for the PET industry. There are a number of products where the substitution of virgin with recycled material makes economic and processing-technical sense, e.g. staple fiber, thermoforming sheet, nonwovens or strapping.

Each of these products places requirements on the properties of the recycled PET, which are close to those of virgin material. Apart from the intrinsic viscosity and color/transparency, foreign particles or contamination in the melt affect the product quality.

PET bottle flakes are processed into high quality pellets or are added directly to virgin material during the production of final products. Today, direct recycling, the use of 100 % flakes in the manufacturing of end products without the intermediate repelletizing step, is becoming popular. The melt filtration step plays an important role in all these processes and determines the end quality that can be achieved.

The paper first discusses the technical and economical demands made on a filtration system used in PET bottle flake applications. Then, the fully-automatic Rotary Filtration System is introduced, which is well suited for the processing of bottle flakes. The possibilities it offers for direct recycling are explained. Then, various direct recycling concepts are described. These concepts differ regarding pre-drying, extruder type and demands on the

filtration system. The different requirements and solutions regarding the filtration step are explained

## Filtration in PET bottle flake applications

Ideally, a filtration system has no influence at all on the production process, is a low investment and does not cause any operational costs. In reality, all filtration systems are pressure consumers and often cause significant process disturbances and therefore costs.

Typical processing-technical demands on a filtration system are

- ◆ continuous and process constant mode of operation,
- ◆ pressure constant mode of operation,
- ◆ low pressure consumption,
- ◆ safe and easy filter change,

while typical economical demands are:

- ◆ low investment costs,
- ◆ low screen costs,
- ◆ short return on investment,
- ◆ little maintenance and operator attention.

With polyester bottle flakes there are even higher demands:

- ◆ As PET is very sensitive a short residence time of the melt in the system is very important in order to avoid degradation.

- ◆ Due to the high contamination rate of bottle flakes a high screen capacity is necessary.
- ◆ The filtration system must be able to handle sudden contamination surges.

All in all, the goal is to achieve a consistent and high quality regarding IV, color, transparency and mechanical strength.

### **Fully-automatic filtration system RSF*genius***

One system, that fulfills all these processing-technical demands on a filtration system for PET bottle flake applications, is the fully-automatic filtration system RSF*genius*.

Like all filtration systems developed by Gneuss, this system is based on the patented Rotary-Technology. The main characteristic is the disk, which is rotating between two filter blocks. The special filter media are located on the filter disk in a ring pattern. The filtration system is sealed by very hard and flat contact surfaces, without sealing elements. This makes the system operate practically wear-free. Depending on the size of the system, it is laid out for pressures of up to 7,000 psi. The rotation of the disk makes an automatic exchange of dirty screens possible without any influence on the production process.

Illustration 1 shows a photo of an RSF*genius* 150 und illustration 2 the technical layout.

The rotation of the filter disk is actuated by a pressure and/or time controller. The filter disk is indexed - by means of a hydraulic drive - in small increments, replacing a partial area of the screen at a time. This means that constant pressure processing ( $\pm 30$  psi) is provided. The active filtration area as well as the contamination level is always consistent.

The fully-automatic mode of operation is realized by an integrated screen cleaning system. The screens are cleaned by a patented, back-flush piston system just before the contaminated screen is re-introduced into the melt channel. Filtered melt is diverted inside the outlet block from the main melt flow and it is transported to the back-flush piston. After every indexing step, this piston presses the diverted melt by high-pressure impulses through a small

opening across the contaminated screen. The material quantity necessary for this process is freely adjustable and ranges in PET bottle flake applications between 0.03 % and 0.5 % of the throughput rate. The speed for the melt to be pressed through the screen is also freely adjustable to assure an optimum screen cleaning.

The filter disk, and therefore also the melt, is completely encapsulated by the two filter blocks. Neither the melt nor any of the parts that get into contact with it get into contact with the atmosphere. Thanks to the short construction of the system and the rheologically optimized flow channel, the residence time of the melt in the filtration system is very short (< 1 minute). Therefore this system is well suitable for thermally-sensitive materials like PET.

Screens can be inserted into the cavities by opening a small cover giving access to the cavities. The screen change process does not disturb the production process. The number of automatic screen re-uses is only limited by the alternating loading and determined by screen fineness and melt viscosity.

### **Possibilities for direct recycling offered by fully-automatic filtration**

The application of the RSF*genius* and its performance features are especially beneficial in the processing of PET bottle flakes into high quality end products. In order for the price advantage of bottle flakes to be used, the recycling process must be as cost efficient as possible. The key to achieving this is the melt filtration system.

The use of bottle flakes in conventional lines means more screen changes and therefore more process disturbances and more operator work. Thanks to the fully-automatic and process-constant mode of operation of the RSF*genius*, bottle flakes can be used without compromising process stability.

The RSF*genius* reacts quickly to process changes caused by varying contamination levels and sizes in the melt. Therefore, efficient filtration without process disturbances is provided. Due to the fully-automatic mode of operation larger quantities of contaminated material can be processed with ease. Contamination surges can be handled without any problem as filtration area can be exchanged very

quickly - by fast indexing of the filter disk - without any influence on the process or any operator work.

The unique advantages can be summarized as follows:

- ◆ As the screens are automatically exchanged, the active filtration area and therefore the rheology can be optimized to the throughput rate. The filter area capacity amounts to max. 1.7 m<sup>2</sup>/h or 18.3 ft<sup>2</sup>/h.
- ◆ Used screens can be exchanged without any disturbances of the production process.
- ◆ When choosing the filtration fineness it is not necessary to compromise between quality and screen life time. Constant filtration quality down to 25 microns is possible.
- ◆ The filter operates process consistent, i.e. no viscosity, pressure or throughput variations are created.
- ◆ No problems with contamination surges.
- ◆ Screen life time > 10 days (100 – 300 automatic screen re-uses)
- ◆ With the encapsulation as well as the short construction of the system and the rheologically optimized melt channels (residence time of the melt < 1 minute) the thermal sensitivity of PET is accommodated. During a screen change no crack products (black specs) are introduced, therefore a continuous production of quality products is possible.
- ◆ The filter – even during screen changes - does not cause any pressure variations or any variations in the downstream process. Therefore it is optimally suited for the direct manufacture of high quality end products. With the right filtration fineness it is even possible to stabilize the downstream process, e.g. by extending the spin pack life time in fiber applications.

- ◆ Thanks to the guaranteed process consistency during screen changes (i.e. reduction of production losses), minimized backflushing losses, minimized variations in product thickness (i.e. material savings) and high number of fully-automatic screen re-uses of the RSF*genius*, it makes the cost-efficient direct recycling of PET bottle flakes into high quality end products like sheet or fiber possible.

### **Concepts for direct recycling of PET bottle flakes**

In the last few years, several processing variants for PET bottle flakes have won recognition. They differ regarding the quality of the final product as well as regarding the economic efficiency.

With variants 1 and 2 (see illustration 3) a single screw extruder is used, which supplies the pressure for the filter and the die. The variants differ in the way the pre-drying is done and they are suited for the production of pellets.

The demands on the filtration system:

- ◆ Minimal operation effort and expenses
- ◆ Constant filtration quality
- ◆ No creation of viscosity variations
- ◆ No problems with contamination surges
- ◆ Small melt loss caused by back-flushing
- ◆ Long screen life time

are met, as explained, by the fully-automatic filtration system RSF*genius*.

With variants 3 and 4 (see illustration 4) a melt pump is installed after the filter. Therefore these variants are also suited for the production of film/sheet, staple fiber, BCF-yarn, nonwovens, mono filaments and strapping.

In direct recycling there are additional demands on the filtration step:

- ◆ No creation of pressure variations
- ◆ No creation of throughput variations

These demands are also met by the RSF*genius*.

With variants 5 and 6 (see illustration 5) twin screw extruders are used. These have the advantage of a very short residence time. With a short residence time values like the viscosity, color, opaqueness and mechanical strength can be preserved. The variants differ in the way the pre-drying is done, resp. the abandonment of pre-drying, and the kind of vacuum ports. With both variants a screen changer is integrated at the end of the extruder to protect the melt pump. The pump provides a constant melt flow and the pressure for the fully-automatic filtration system RSF*genius*.

The demands on the safety-net filter at the end of the extruder are the following:

- ◆ Shortest residence time of the melt
- ◆ Screen change during operation with short quality loss
- ◆ Long screen life time (with 400-500  $\mu\text{m}$ )

These demands are fulfilled by the discontinuous screen changer HSS*sprimus* (see illustration 6).

The extruder-integrated design and the rheologically optimized melt channel guarantee a minimal residence time of the melt.

The demands on the filtration system are the same as with variants 3 and 4.

When twin screw extruders are used, more components are used overall. In order not to nullify the advantage of the short residence time, it is important to minimize the residence time from the extruder end to the die. Therefore, Gneuss offers complete solutions extruder/screen changer/pump/filtration system with optimized melt channels and integrated adapter flanges for twin screw lines (see illustration 7).

Variants 7 and 8 (see illustration 8) differ from variants 5 and 6 in the quality of the PET bottle flakes. If very dirty flakes with contamination  $> 500 \mu\text{m}$  is used a discontinuous screen changer causes frequent production disturbances. Therefore, in this case, a fully-automatic filtration system is required as the safety-net filter.

## Summary

In the last few years, several processing variants for manufacturing high quality end products from PET bottle flakes have won recognition. In all concepts, filtration systems play a key role. The process-constant and fully-automatic RSF*genius* meets all demands that are made on a filtration system in PET bottle flake applications. With their filtration systems, as well as integrated screen changer/melt pump/filtration system combinations, Gneuss can offer an ideal solution for all direct recycling concepts.

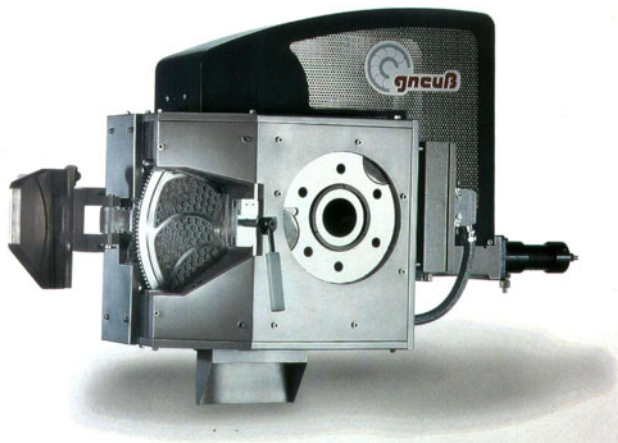
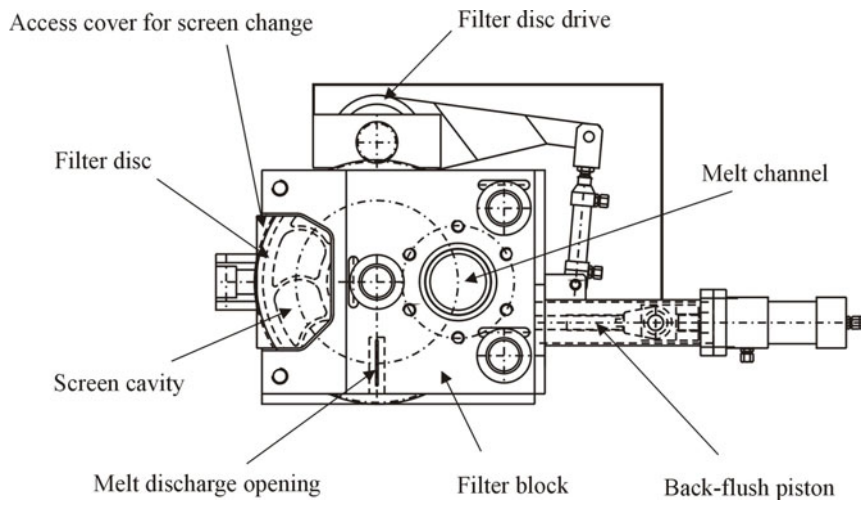
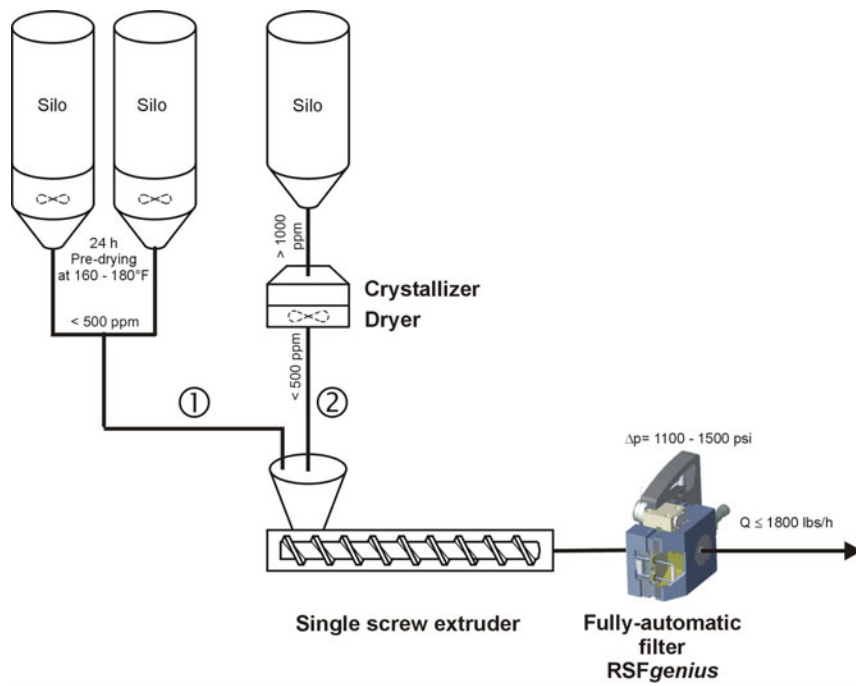


Illustration 1: RSF*genius* 150

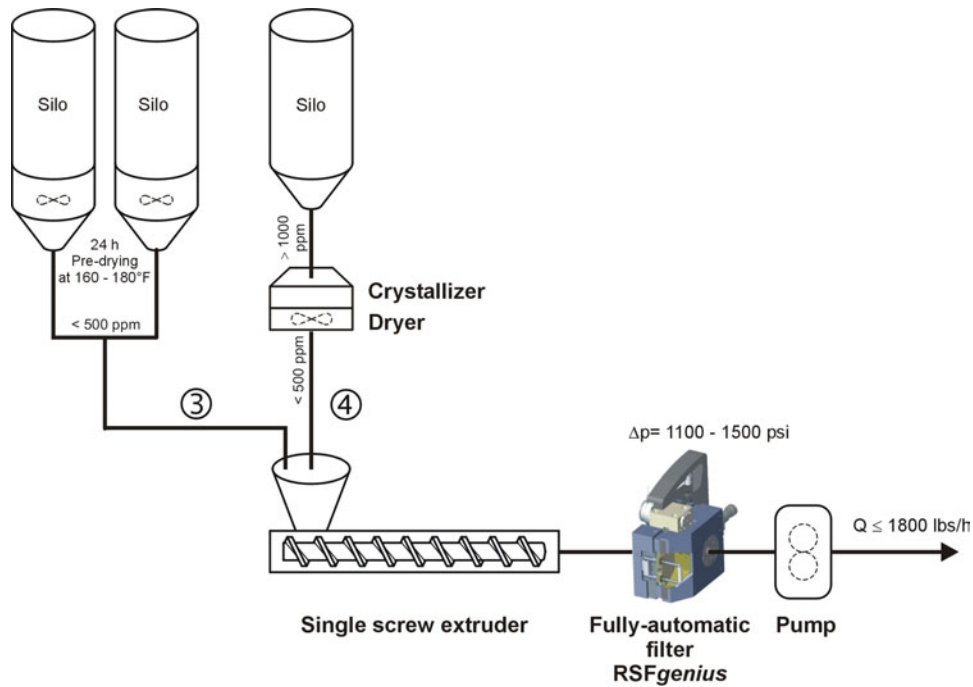


patented

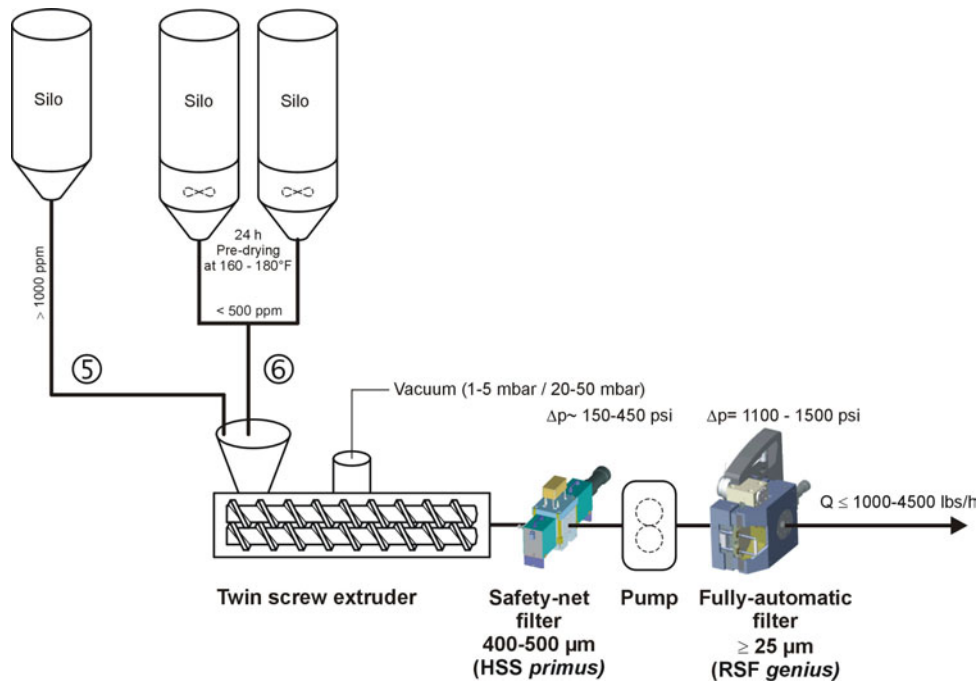
**Illustration 2: Layout of the RSFgenius**



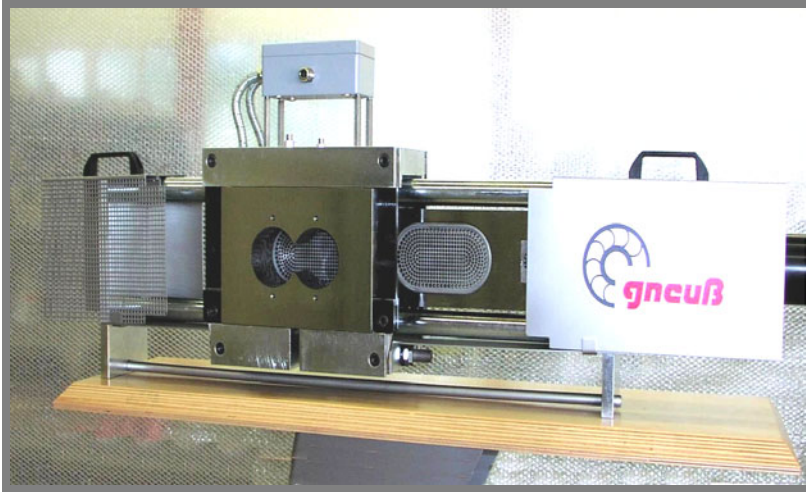
**Illustration 3: Bottle flake processing with single screw extruder without pump**



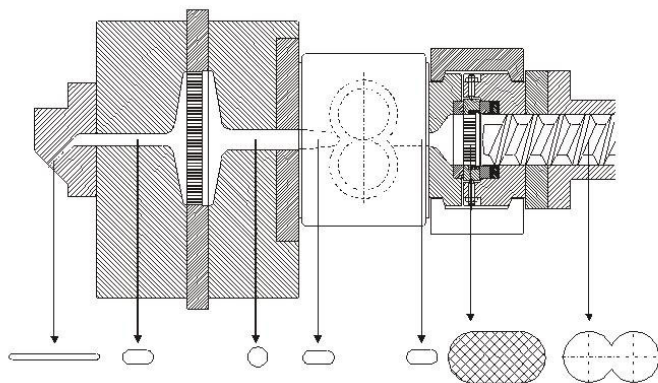
**Illustration 4: Bottle flake processing with single screw extruder and pump**



**Illustration 5: Bottle flake processing with twin screw extruder (clean flakes)**

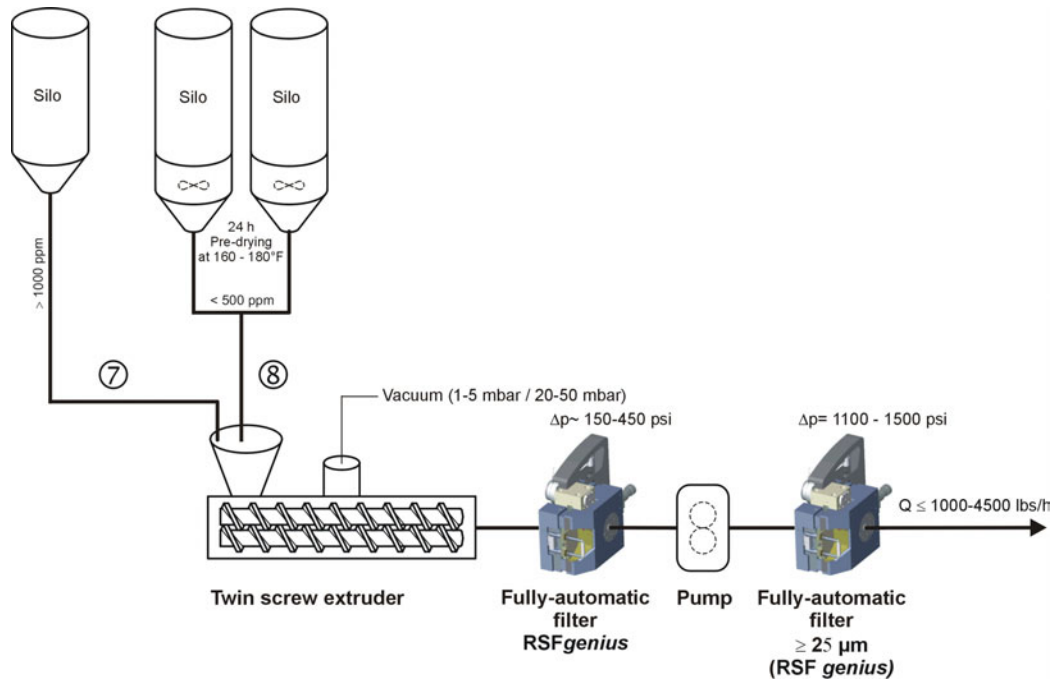


**Illustration 6: Discontinuous screen changer HSSprimus**



**Illustration 7: Integrated extruder/screen changer/pump/filtration system combination**





**Illustration 8: Bottle flake processing with twin screw extruder (very dirty flakes)**