RECYCLING OF ADHESIVE TAPE WASTE WITH THE PLAST AGGLOMERATOR SYSTEM

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Abstract
During the production and processing of adhesive tape, waste is generated. Valuable virgin material can be saved by recycling waste instead of dumping. Production waste can be re-introduced into the process of producing new tapes.

1. Tape Growth and Production Trend in Europe until 2002
Between 1978 and 1986 there was a high growth of tape production with 10 % per annum in Europe, Middle East and Africa. From 1986 to 1996 the growth slowed down to 3 %.
1996 to 1999 a growth of 400 to 500 million M.sqm was reached.
In 2000 the world economy was doing well, the growth reached approx. 8 %.
From 2001 to 2002 the growth slowed down to 1 % because of the world-wide recession and the weakness of the USD vs. the Euro.

Graph 1 shows the growth of the PSA (Pressure Sensitive Adhesive) tapes over a 24 years period.
Graph 2 gives an indication of the split of the European production by countries.

Italy with 3.9 B.sqm is the main producing country in Europe and in the world. The 2002 growth in Europe came mainly from Italy.

Graph 3 shows the European production by main application.

Packaging with 74 % produced in Europe is the main enduse followed by masking with 10 % production in Europe.
2. **Size Reduction of Rubber Bales for the Production of Adhesives**

For the production of adhesives, natural and synthetic rubber is used. Depending on the type of rubber, a standard size rubber bale is cut down to granule size in a special guillotine knife mill within seconds. Feeding the rubber granules to a mixer or dissolver vessel will shorten the mixing or dissolving time. The production capacity will be increased up to four times.

**One step granulating system**

Depending on the type of rubber, one step granulating systems with the rubber knife mill type PS-C can be used to granulate the standard bale sizes down to granule particle sizes smaller than 15 mm.

![Diagram of the one step granulating system](image)

1. Belt conveyor
2. Metal detector
3. Guillotine knife mill
4. Pneumatic aspiration
5. Dust collector

In such a one step granulating system, the rubber bales are fed manually or by means of a conveyor belt via a bale feed chute into the rubber knife mill. The rubber bales are directly cut to end particle size with a special guillotine rotor. The particle size is determined by the screen mesh size installed in the rubber knife mill. A pneumatic aspiration system sucks a certain quantity of air through the mill to cool the machine as well as to transport the granulated rubber out of the mill. The rubber granules are separated in a cyclone from the air and can be sacked and immediately stored or directly transported to the next processing step such as i.e. mixer or solvent tank.
Two Step Granulating System

Two-step granulating systems are recommended when rubber bales from relatively insensitive types of rubber are to be size reduced to particle sizes smaller than 4 mm.

A conveyor belt feeds the rubber bales into a precutting mill with a special guillotine type rotor. This rotor precuts the bales into pieces smaller than 40 mm. Another conveyor belt transports the rubber pieces from the first mill into a second mill. This mill also uses a guillotine type rotor which cuts the product to the desired end size. The pneumatic aspiration system sucks the material out of the knife mill and transports it to the cyclone separator.

In case of very heat sensitive rubber types, dusting agents can be added during the granulating process to prevent the sticking of the material. Depending on the particle size and the rubber type, between 2 and 5 % of dusting agent is effectively needed for the dusting process. Overdosed dusting agent can be separated from the granules by means of a dusting agent recovery system and reused.

1. Belt conveyor
2. Metal detector
3. Guillotine knife mill
4. Belt conveyor
5. Guillotine knife mill
6. Pneumatic aspiration
7. Dust collector
Guillotine Type Rotor
For economic size reduction of natural and synthetic rubber a special guillotine type rotor was developed.

The picture of the rotor shows that there is no shaft straight through the rotor. The knives are arranged on knife carrier bars that connect the two rotating side discs, leaving the interior of the rotor completely open. This design guarantees a minimum of friction heat created during the granulation of rubber bales. The open rotor form prevents that the rubber granules are recompressed and conglutinated. Large air volume can be sucked through this type of rotor for considerable cooling during the cutting process. Knife mills with guillotine rotors, specially developed for the cutting of rubber bales, have flywheels mounted onto the rotor shaft to increase the rotor mass this prevents a reduction in speed when cutting a whole commercial-sized bale.
Layouts and Technical Data

Rubber bale granulating system, type PS-C feeding a dissolver vessel

Technical Data:
Depending on the required throughput capacity different machine sizes with various throughput capacities are available.

<table>
<thead>
<tr>
<th>Type</th>
<th>PS-C</th>
<th>4-5</th>
<th>4-7.5</th>
<th>6-6</th>
<th>6-9</th>
<th>8-12</th>
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<tbody>
<tr>
<td>Capacity factor</td>
<td>f</td>
<td>1.0</td>
<td>1.4</td>
<td>1.55</td>
<td>2.2</td>
<td>3.7</td>
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<tr>
<td>Rotor diameter</td>
<td>mm</td>
<td>400</td>
<td>400</td>
<td>600</td>
<td>600</td>
<td>800</td>
</tr>
<tr>
<td>Rotor type</td>
<td></td>
<td>G3</td>
<td>G3</td>
<td>G3</td>
<td>G3</td>
<td>WG6</td>
</tr>
<tr>
<td>Motor</td>
<td>kW</td>
<td>55</td>
<td>55-75</td>
<td>75-90</td>
<td>75-110</td>
<td>132-250</td>
</tr>
<tr>
<td>Throughput capacity*</td>
<td>kg/h</td>
<td>200-800</td>
<td>300-1100</td>
<td>350-1200</td>
<td>500-1700</td>
<td>700-3000</td>
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</table>

All dimensions and data mentioned above are for information only and must be confirmed by us. Technical changes to further progress are reserved.

The throughput rate varies with the type of rubber. Other machine sizes available.
3. **Size Reduction of Adhesive Tape**

The optimisation of production processes and the reprocessing of high quality raw materials are important targets of each producing and processing company which cares for its future. The use of a film recycling installation is an important contribution to the set-up of a modern profitable production facility. When reducing film, the highest demands with regard to performance capabilities and mechanical strength are placed upon the granulator. An important pre-requisite for efficiently reducing very thin materials –like film- is the precise setting of the cutting gap. The precision with which the cutting gap can be set is a direct reflection of the efficiency of a granulator. Therefore a precise cutting gap guarantees an accurate cut.

Specially developed film cutting knife mills with open rotors with cross scissors cut guarantees a specific quality of film flakes.
**Principal of Operation**

Specially designed knife mills are able to produce pre-sized film flakes from adhesive tapes. The adhesive tape from the roll is automatically unwound and fed to the knife mill by using a draw-in roller system, type PEV. Alternatively loose material can be fed to the mill from the side of the infeed chute. The material is size reduced between the rotor and stator knives. A screen keeps the material in the grinding chamber until the desired final size is achieved. The cut material is pneumatically sucked out of the machine and discharged into a storage bin through a cyclone separator.

![Diagram of knife mill system](image)

1) Unwinding station  
2) Adhesive tape  
3) Infeed roller system  
4) Hand feeding chute  
5) Knife mill  
6) Blower  
7) Conveying pipes  
8) Cyclone separator

**Technical Data:**

Depending on the requirements of the customers, different sizes of machines are available for different throughput capacities.

<table>
<thead>
<tr>
<th>Type</th>
<th>PS-F</th>
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<th>4-7.5</th>
<th>4-10</th>
<th>4-12.5</th>
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<td>2.0</td>
</tr>
<tr>
<td>Rotor diameter</td>
<td>mm</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Rotor type</td>
<td></td>
<td>G3</td>
<td>G3</td>
<td>G3</td>
<td>G3</td>
</tr>
<tr>
<td>Motor</td>
<td>kW</td>
<td>30</td>
<td>45</td>
<td>55</td>
<td>75</td>
</tr>
<tr>
<td>Throughput capacity*</td>
<td>kg/h</td>
<td>200-300</td>
<td>300-500</td>
<td>350-600</td>
<td>400-800</td>
</tr>
</tbody>
</table>

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The throughput rate varies with the type of film. Other machine sizes available.
4. Agglomeration of Adhesive Tape

As stated in paragraph 3, adhesive tape waste can size reduced to a flake form using a special type of knife mill. Feeding the flakes back into the manufacturing process of new adhesive tape is quite difficult. Therefore it is recommended to produce a free-flowing granule out of the flakes with a high bulk density which is quite easy to transport, store and feed to an extrusion line. For this application, a Plast Agglomerator System, type PFV produces a high quality material out of the flakes. The size reduced flakes are conveyed into the storage bin of a Plast Agglomerator by means of a pneumatic conveying system. The storage bin of the Plast Agglomerator is equipped with two stirrers and a discharge screw. The stirrers keep the material moving and transport it to a discharge screw. The speed of the discharge screw is load-controlled by the drive motor of the Plast Agglomerator. A full and empty stage indicator is installed in the storage bin.

By means of a screw, flanged to the main shaft of the agglomerating vane, the material is fed into the agglomerating chamber of the Plast Agglomerator. With frictional heat, the material is sintered or plastified and pressed through the holes of a special die and cut off by rotating knives at the outer diameter of the die.

Agglomeration Chamber
The agglomerating chamber is water-cooled using a double walled cooling disc and cooling ring. Product caking on the walls and overheating of the material is thereby avoided. The temperature of the material pressed through the holes of the die is measured by an infrared sensor. If the temperature rises over an adjustable set value, the discharge screw is shut off and a malfunction is signalled on the control panel.

The agglomerated material is pneumatically sucked off and transported through a hot-melt granulator into a cyclone with a downstream conveyor fan. The air necessary for the conveying of the material is used at the same time for additional cooling of the Plast Agglomerator and heat dissipation from the hot-melt granulator.

At the draw-in of the hot-melt granulator, the double walled housing is water-cooled.

The end product size of the agglomerate is determined by the hole size of the screen installed in the hot-melt granulator.

The material from the hot-melt granulator is discharged out of the cyclone separator via rotary air lock into a cascade sifter. A sifter fan in the cascade sifter produces an upward air stream. The air quantity in the cascade sifter can be adjusted by means of a secondary air regulator. The sifting fan pulls fines out with the air, which are returned via conveying pipe with cyclone to the Plast Agglomerator. De-dusted agglomerates free-fall to the bottom of the cascade sifter.

A granule conveyor picks up the agglomerated material and conveys it, under negative pressure, to the cyclone with a downstream fan. The granule conveying causes an air exchange in the system and therewith cools the agglomerated material. Depending on the type of material, a one-time product con-
veyance is sufficient for cooling. A downstream granule cooler is optional to prevent caking of the agglomerate.

Material fed into the granules cooler via rotary air lock is bathed in an upward airflow and thereby cooled. The amount of cooling air is produced by a fan and can be adjusted by means of a regulating system. The heated exhaust air is discharged at the upper end of the granule cooler. Finest particles, carried away by the cooling air, are discharged in a cyclone and transported into a bin.

Depending on the requirement, the agglomerate can be put into bags, air bags, big bags etc. after the granule cooling process. The base frame must be constructed corresponding to each requirement. If the room height is not sufficient, the material can be conveyed away from the cascade sifter or the granules cooler by means of a granules conveyor and can be filled into corresponding containers.
**Technical Data**

<table>
<thead>
<tr>
<th>Type</th>
<th>PFV</th>
<th>120</th>
<th>200</th>
<th>250</th>
<th>315</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity factor</strong></td>
<td>f</td>
<td>0,1</td>
<td>0,4</td>
<td>1,0</td>
<td>1,3</td>
<td>1,7</td>
</tr>
<tr>
<td><strong>Motor, Granulator</strong></td>
<td>kW</td>
<td>4-7,5</td>
<td>5,5-15</td>
<td>18,5-45</td>
<td>30-75</td>
<td>75-110</td>
</tr>
<tr>
<td><strong>Motor, Agglomerator</strong></td>
<td>kW</td>
<td>7,5-22</td>
<td>18,5-55</td>
<td>55-90</td>
<td>75-132</td>
<td>132-250</td>
</tr>
<tr>
<td><strong>Motor, Hot-melt granulator</strong></td>
<td>kW</td>
<td>3-5,5</td>
<td>7,5-18,5</td>
<td>22-30</td>
<td>30-45</td>
<td>45-55</td>
</tr>
<tr>
<td><strong>Total installed capacity</strong></td>
<td>kW</td>
<td>20-40</td>
<td>40-110</td>
<td>120-200</td>
<td>160-270</td>
<td>280-450</td>
</tr>
<tr>
<td><strong>Cooling water consumption</strong></td>
<td>l/h</td>
<td>100-200</td>
<td>200-300</td>
<td>300-500</td>
<td>500-700</td>
<td>700-1000</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>kg/h</td>
<td>30-120</td>
<td>100-400</td>
<td>300-1000</td>
<td>400-1200</td>
<td>400-1900</td>
</tr>
</tbody>
</table>

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**Customers’ benefits**

- Continuous processing
- High throughput capacity
- Gentle agglomerating with frictional heat, within fractions of a second, right below the melting point of the plastic
- Excellent end product, i.e. free flowing granules with a high bulk density
- High flexibility
- Fully automatic continuous operation, the system is designed for rough 3-shift operation
- Low cost operation
- Little space requirement as the system is constructed in compact, space-saving modular units
- Minimum personnel requirements; material feeding of the granulator as well as the bagging of the granules can be performed by one operator

**Conclusion**

The target of each producing company is to reduce costs. This paper script shows that a simple, small investment can be very effective in reducing the manufacturing costs of adhesives. The paper also shows that in two steps, a free-flowing granule with a high bulk density can be produced out of film or adhesive tape waste. This inhouse waste which is expensive to dump can easily be fed back into the manufacturing process. It saves raw material as well as dumping costs. Since several years a complete adhesive tape recycling unit is installed at the company 3 M . On their web side “paragraph environmental” you can see tape waste as well an agglomerate. A certain percentage of the agglomerated tape waste is mixed with virgin pellets and used to produce new tape.
Acknowledgements

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Recycling of Adhesive Tape Waste with Plast Agglomerator System

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After an apprenticeship in mechanical Engineering, in 1983 Frank Maué
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Germany.
1987 he graduated in Buisiness Administration.

Since 1988 he has been working with Pallmann in Technical Sales for size
reduction machines of plastics.
1995 Frank became Area Sales Manager for the North American and Middle
East Market.
Since 2001 Frank has been Product Sales Manager for applications of the
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