VENTED BARRIER SCREW

Stephen J. Derezinski, Ph.D.
Extruder Tech, Inc.

www.extrudertech.com

Degassing or devolitization of polymers is often crucial to acceptable product quality.

Venting

or degassing or devolitilization

When melted, many polymers emit vapors and gases which must be removed to prevent bubbles in the product.

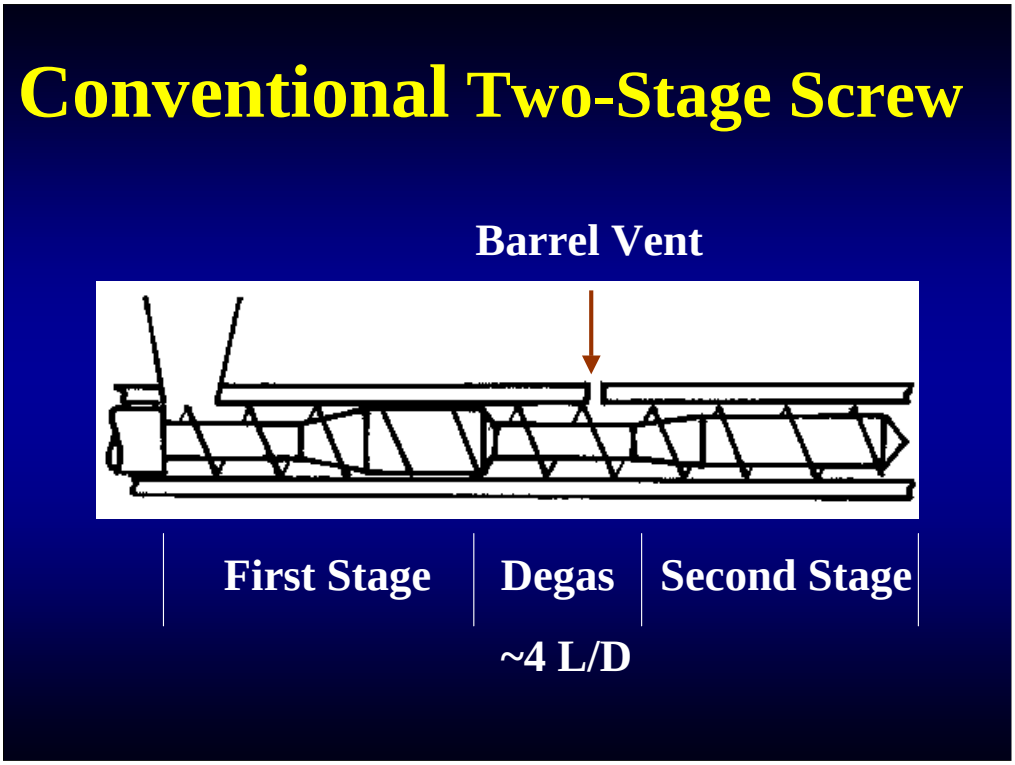
This can be accomplished in several ways. Pre-drying, often is not sufficient. Venting during extrusion is one solution.

Extrusion Venting

Degassing, can be done with the extruder by venting.

The conventional *two-stage screw* uses about 4 diameters of extruder length solely for venting.

Conventionally, extrusion venting is done with a so called, “two stage” extruder. However, this requires about 4 diameters of screw length to accomplish. Screw length is sacrificed which could be used to melt, convey, and develop melt temperature for higher rate.



This figure shows the conventional two stage screw and barrel. For this example, the venting is in the barrel. However, it can be done into the screw by way of a bore between a vent in the screw root and the drive end of the screw.

The Vented Barrier Screw

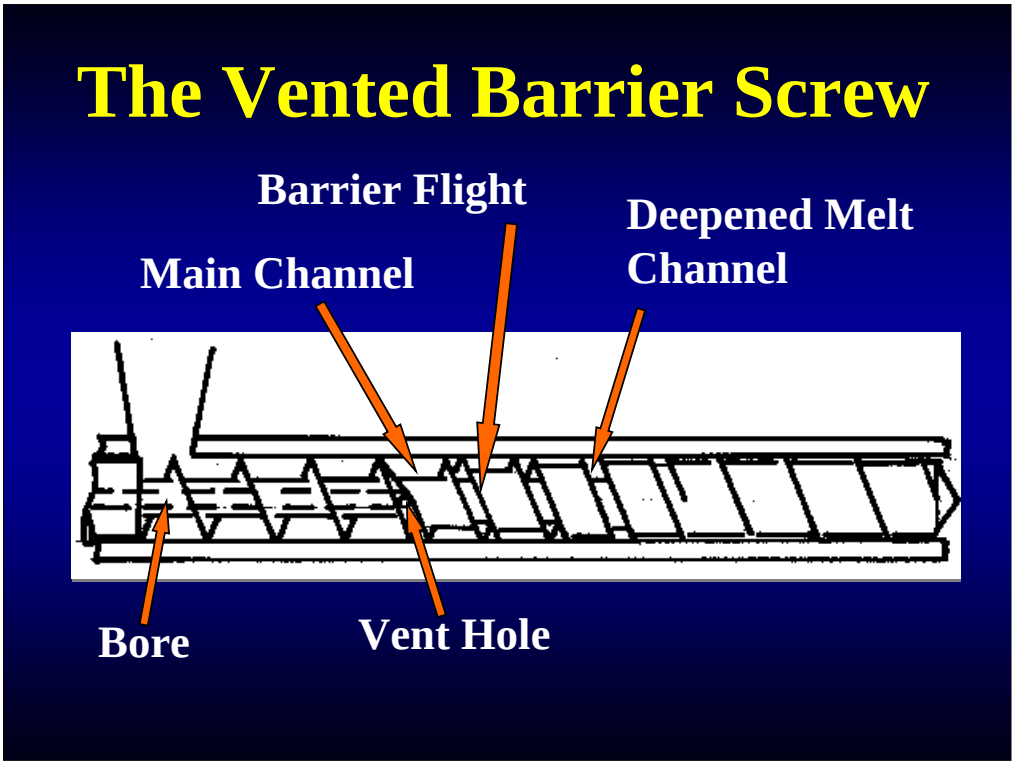
The vented barrier screw vents the gases and vapors from the existing melt channel, thereby conserving screw length.

The vented barrier screw achieves venting without sacrificing any screw length. The existing melt channel is modified to provide for the extraction of gases and vapors.

Primary Components of the Vented Barrier Screw

1. Barrier flight
2. Deepened Melt channel
3. Vent hole connected to a bore
4. Bore to the drive end of the screw

A typical barrier screw design has been modified in four main ways to provide for screw venting.



The figure shows the main components of the modification to the typical barrier screw for venting.

The channel is made to be about 4 times the depth needed for just the melt. This provides for plenty of free surface to release vapor and a path for the vapor to reach the vent hole.

The vent hole is located at the beginning of the barrier section, and it is connected directly to a bore in the screw.

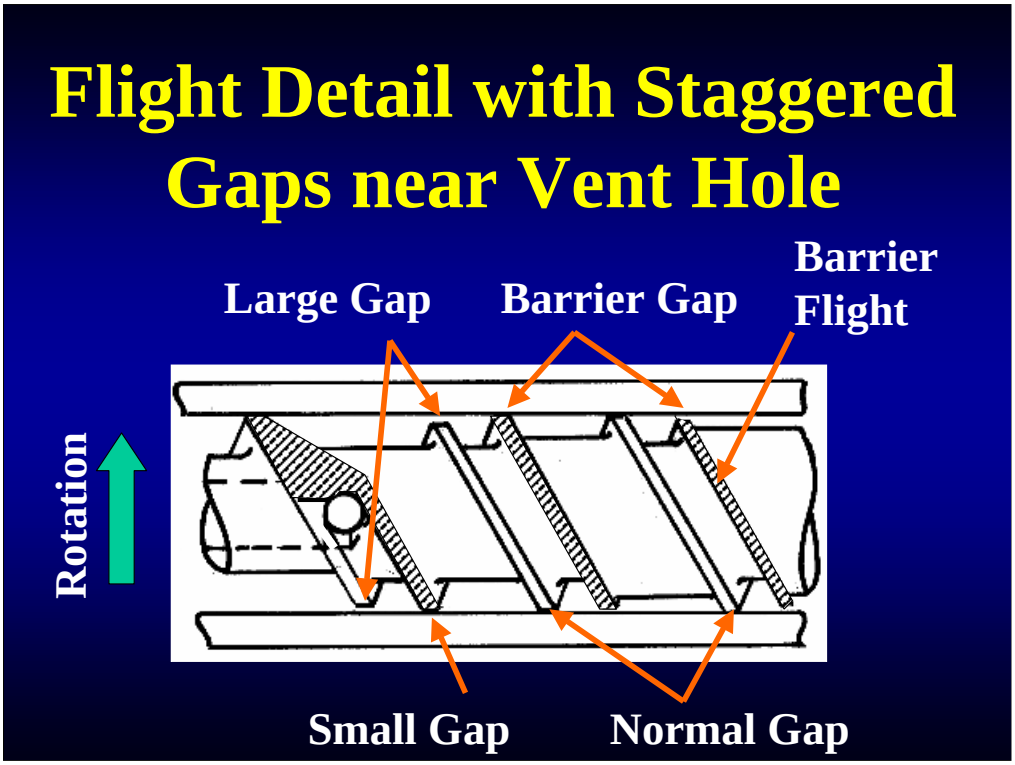
The bore goes to the drive end of the screw. It can be vented to atmosphere or ducted elsewhere by a rotary union and plumbing.

For some polymers, a vacuum is needed for complete venting. This can be achieved by connecting a vacuum source through a rotary union to the bore at the end of the screw.

Flights of the Vented Barrier Screw

The vented barrier screw has flight gaps that are staggered to minimize melt reaching the vent hole.

Of concern is the vent hole in the screw becoming plugged. To this end, the flights near the vent hole have their corresponding gaps (space between flight and barrel) staggered to minimize the polymer melt from reaching the vent hole.



Here is shown how the gaps are staggered.

The barrier flight near the vent hole has a small gap to create as small as possible a layer of polymer on the barrel wall.

The main flight near the vent hole has a gap that it larger than the barrier flight gap. This way it will not contact the melt left on the barrel by the barrier flight.

About a diameter downstream, the flight gaps are returned to normal configuration. The barrier flight is made normal size to pass melt to the pumping channel. The main flight gap is made to be of normal dimension for the size of screw that is being used according to accepted tolerances.

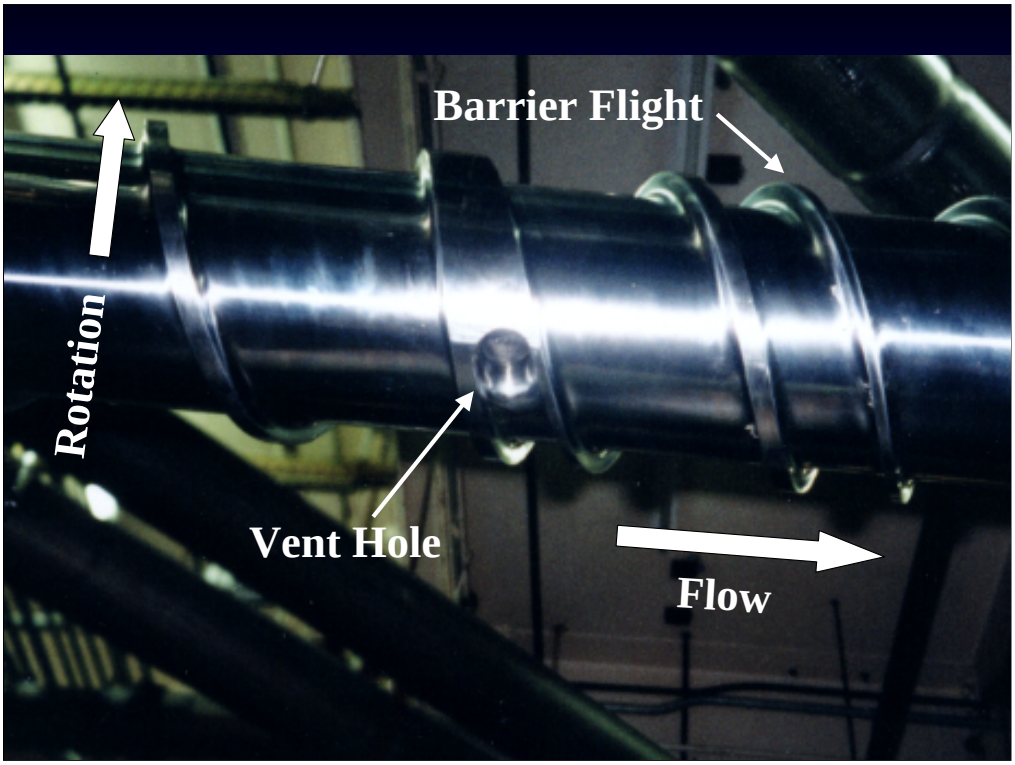
The Vent Hole

The vent hole is made as large as possible and the edges are rounded.

This minimizes the accumulation of any melt in the vent hole to avoid plugging inside of the screw.

The vent hole should not be the most restrictive part of the flow path for the vapors. This will minimize accumulation of any melt there to prevent unintended blockage of the venting. Therefore, the vent hole is made as large as possible, and it is made to have rounded entrance edges so that any melt that reaches the vent hole will tend to pass through to the bore.

The bore can be easily cleaned or “reamed out” without removing the screw from the machine if need be.



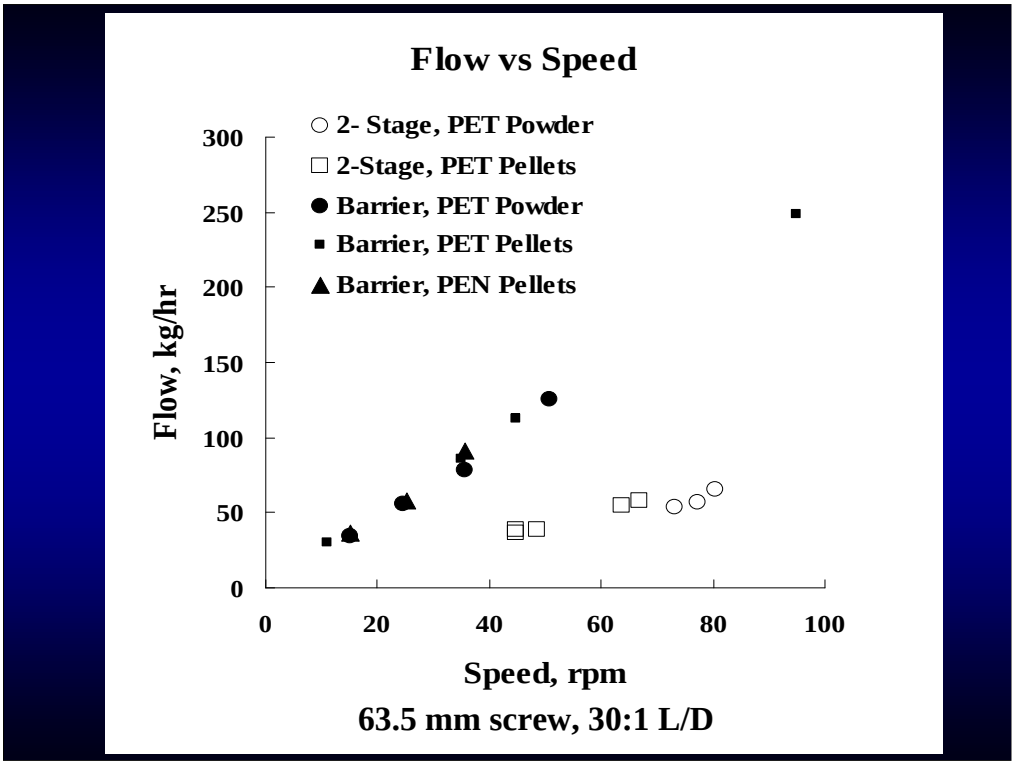
The figure demonstrates how an actual vent hole appears. It is not apparent that the flight gaps are staggered, but they are. Apparent is the fact that the vent hole is as large as possible and has rounded edges.

Notice also that the melt channel is deep to provide for the release of vapors and a path for them to reach the vent hole.

Performance of the Vented Barrier Screw

The vented barrier screw provides *more flow* than a conventional two-stage screw of the same size.

Flow rate of traditional barrier screw performance is achived.



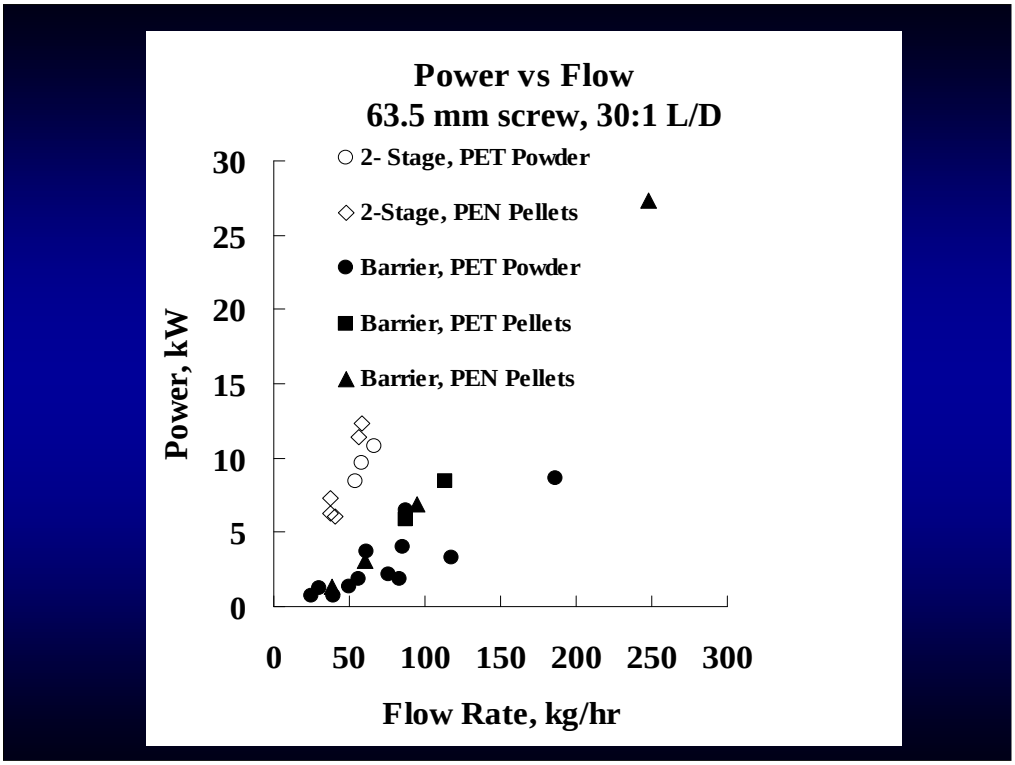
The flow rate for three polymers was tested for the vented barrier screw and a conventional two-stage screw in the same 63 mm extruder. The polymers are from the same batches and dried in the same drier.

The rates for the barrier screw are easily twice that for the conventional screw at the same speeds.

Performance of the Vented Barrier Screw

The vented barrier screw uses *less power* per unit flow rate than a conventional two-stage screw of the same size.

The efficiency of the barrier type of design is also achieved for the vented version.



Data for three polymers clearly show that the power required for the vented barrier screw is about ½ that for the conventional screw. The conventional screw requires significant cooling in the pumping section to maintain the proper melt temperature. The barrier screw does not require this cooling, so the power consumption is much lower per unit flow.

Venting Performance

Major venting was accomplished by venting to atmospheric pressure by leaving the screw bore open to the room.

The screw vented very well when the bore was left open to the atmosphere. This was determined by examination of the cast sheet. The cast sheet for all polymers was clear, so any bubbles could be seen.

The cast sheet was studied under lighting that would magnify the existence of bubbles or other imperfections.

Venting Performance

Blocking the vent bore in the screw produced great numbers of bubbles in the sheet product.

To be sure that the venting was working, the bore in the screw end was plugged to block the release of gas. Massive numbers of bubbles soon appeared everywhere in the cast sheet.

Venting Performance

A rotary union was attached to the bore in the drive end of the screw to connect to a vacuum for complete venting of PET (also needed for traditional two-stage venting.)

Complete venting of PET requires a vacuum. Otherwise, bubbles were seen in the edges of the cast sheet.

The vacuum was supplied by a rotary union to the end of the screw. The vacuum was about 60 cm of mercury. No trace of any bubbles anywhere were found when the vacuum was used.

Such a vacuum system is common for the two-stage extrusion machine, too.

Venting Performance

The gas flow from the rotary union was passed through a "bubbler" to observe the gas venting to atmospheric pressure.

To check the flow of gas from the venting system, flexible tubing was connected to the rotary union. The end was passed through a container of water to observe the release of gas as bubbles in the water. A steady flow of gas was always observed.

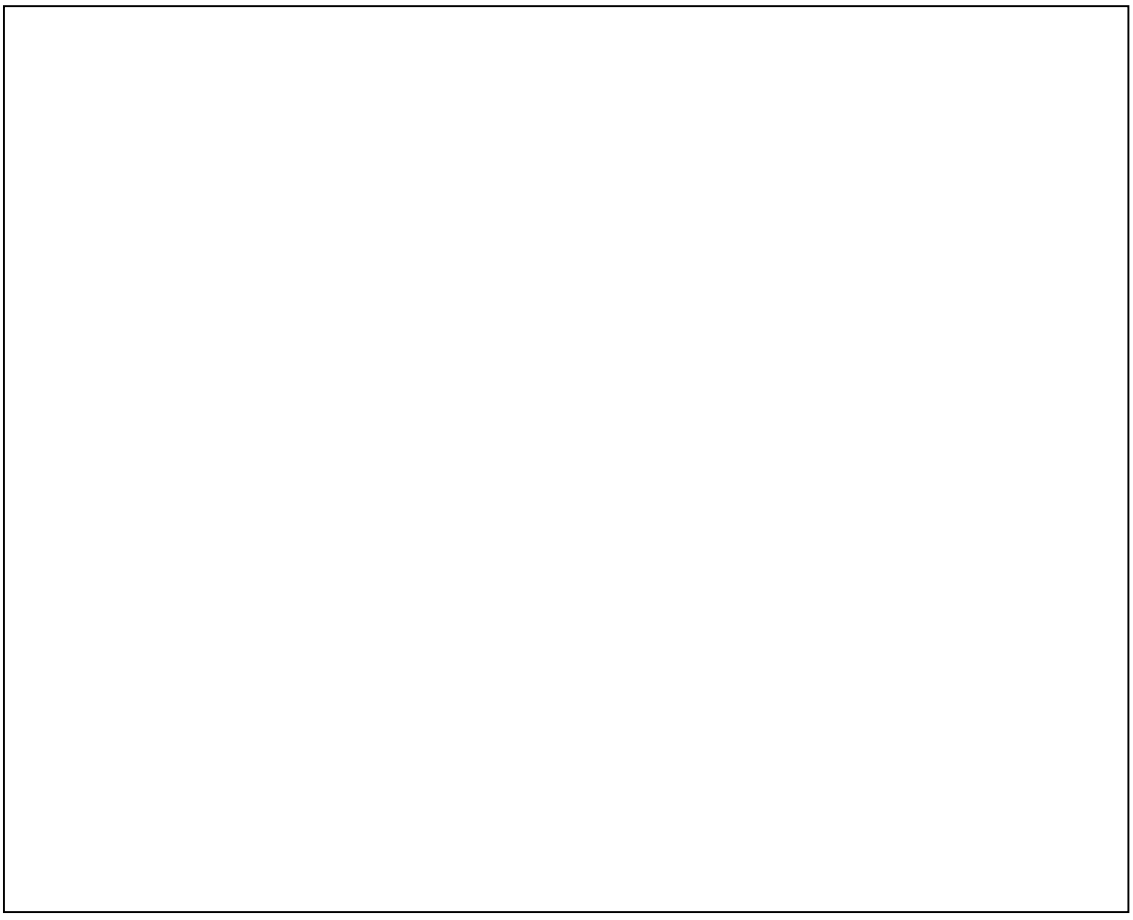
Advantages of the Vented Barrier Screw

1. More flow rate
2. Less power per unit flow
3. Vent powder or pellets
4. Use without venting
5. No barrel vent needed

The vented barrier screw has numerous advantages.

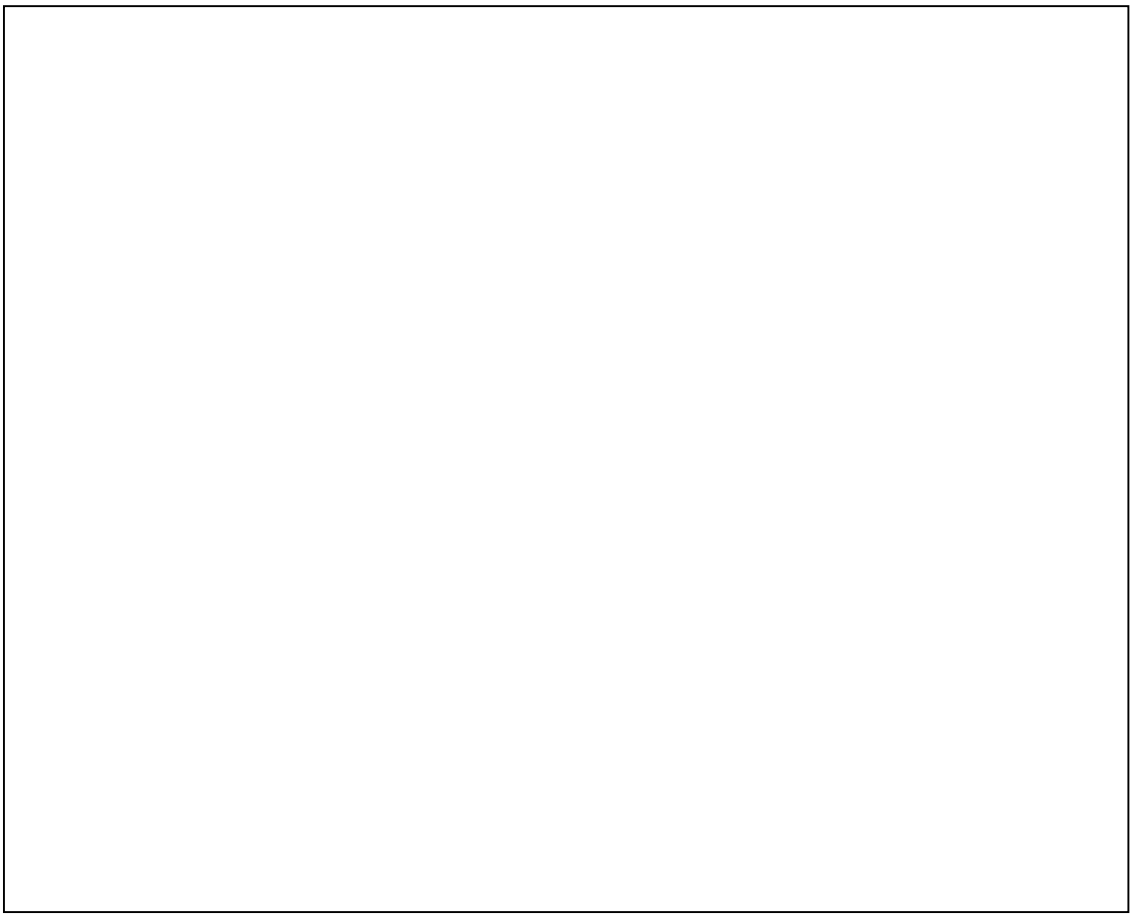
Conclusions

The barrier screw can be vented through a bore in the tail stock for degassing the polymer melt.



Conclusions

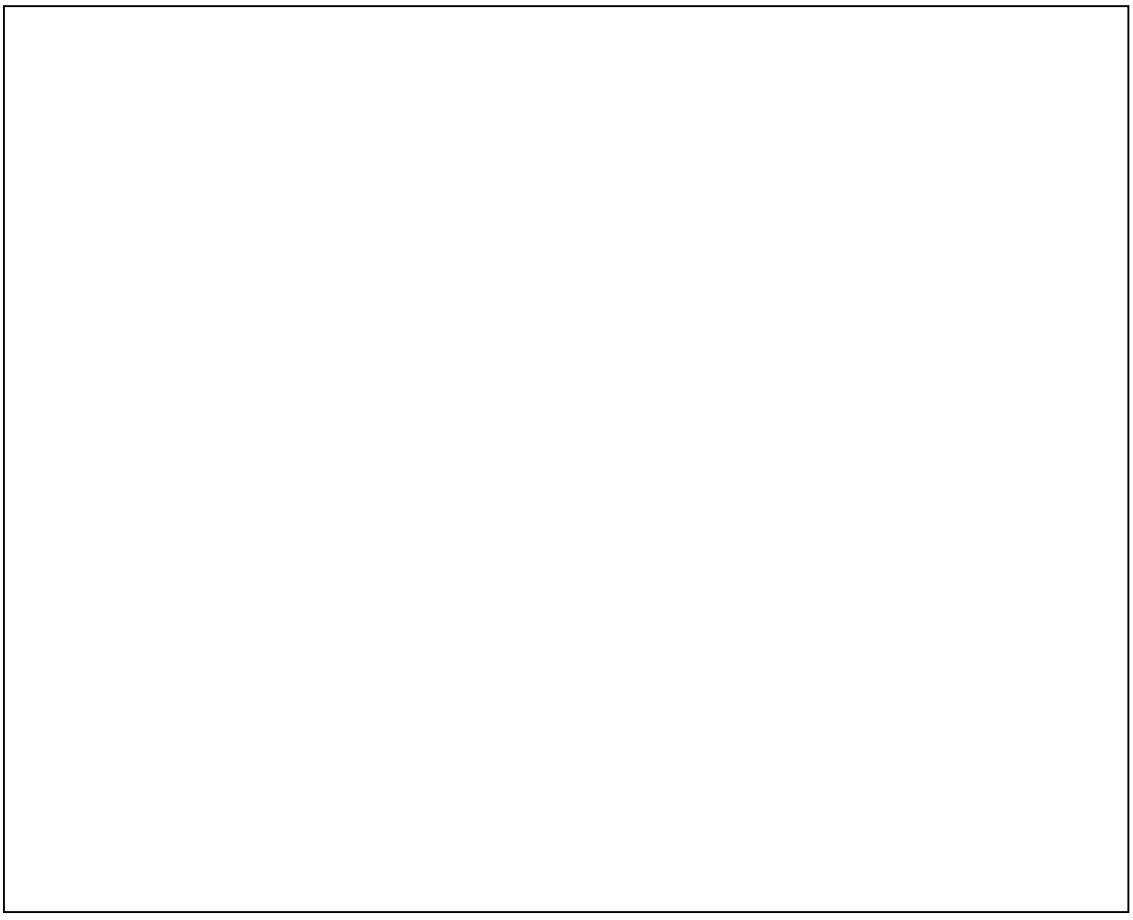
The venting can be done to atmospheric pressure or to a vacuum through a rotary union.



Conclusions

Flow rates comparable to an unvented barrier screw are achieved.

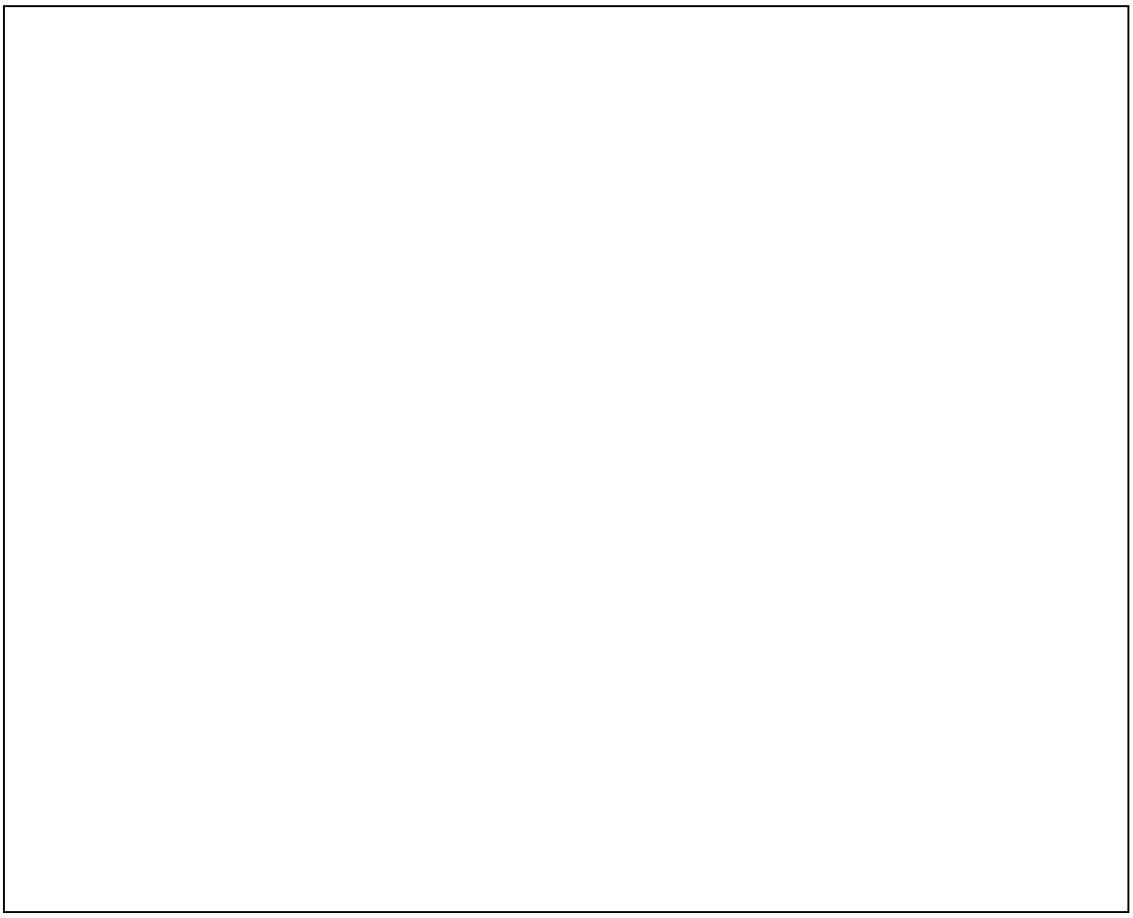
About double the flow of PET and PEN over that for a two-stage screw were achieved.



Conclusions

The vented barrier screw has efficiency similar to an unvented barrier screw.

Power/unit rate for the barrier was achieved at about half of that for PET and PEN with a conventional two-stage screw.



Conclusions

The vented barrier screw provides the versatility of efficient barrier screw processing with or without venting.