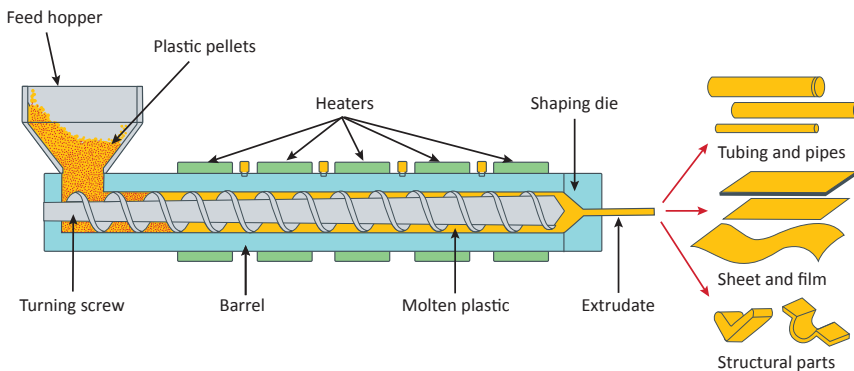


PLASTICS EXTRUDER DEGASSING

edwardsvacuum.com

EXTRUSION:

Extrusion is a common process used to create objects of a fixed cross-sectional profile using extruders. The raw material – usually in pellet, powder or bead form – is conveyed by a screw in a heated barrel of the extruder. The plastic is melted by friction and heat to a viscous liquid, which is then forced through a die into its final shape. Vacuum is applied before the die to remove trapped gases, which can create voids or other imperfections in the final product and after the die for cooling and forming of the final product.



Plastic items such as pipes and tubing, thermoplastic yarn, window frames, plastic films, sheet, wire and cable coating as well as polymer pellets used to produce above mentioned items are manufactured by the extrusion process.

TYPES OF EXTRUDERS:

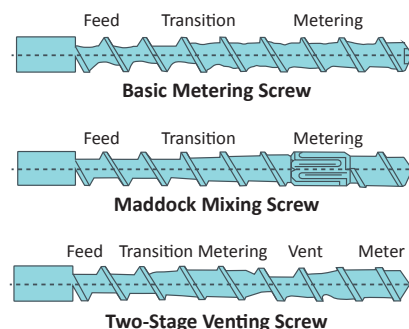
Extruders are categorised by the number of screws they hold, which serve different purposes. Quite often, a combination of these screws is used for specific operation.

Single Screw

Single screw extruders build pressure in polymer melt so that it can be extruded through a die or be injected into a mould. Most single screw extruders are plasticising – they bring in polymer pellets or powder, melt them and build pressure. Single screw extruders are usually used for conveying rather than for mixing or homogenising of polymers. Sometimes a vacuum port may be used on the extruder. Part of the way along the extrusion barrel, the diameter of screw root is reduced to decompress the melt. A vacuum vent is located at this point for degassing (when venting is not needed, the vent may be plugged and not used). Then, the vapour-free melt is sent towards the die and re-compressed by increasing the diameter of the screw root.

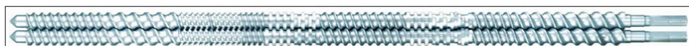
A dam or torpedo section is integrated on the screw just before the vent to make sure that melt does not escape. Due to the

design and operation of the vented single screw extruder (a variable screw geometry and a high L/D ratio), the vented single screw extruders produce excellent mixing.



Twin Screw

Twin screw extrusion is used extensively for mixing, compounding, or reacting polymeric materials. The two screws may be corotating or counterrotating, intermeshing or non-intermeshing. In addition, the configurations of the screws themselves may be varied to achieve particular mixing characteristics. Almost always, twin screw extruders include the provision for degassing ports; sometimes as a critical factor in the process, and sometimes as an after-thought.



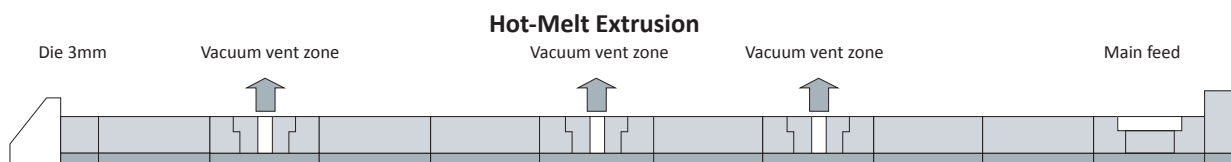
Planetary Extruders

The planetary system consists of one hollow barrel and a main spindle (screw) with several satellite screws (spindles) which work together to achieve better mixing and plastification as compared to twin screw or vented single screw extruders.

Planetary extruders are available as modular units which can be installed as a section in a conventional twin screw extruder. This provides larger flow cross section allowing the possibility of extensive degassing in a shorter time period.

USE OF VACUUM

Various plastic extrusion methods utilise vacuum for degassing the polymer and/or for cooling of the formed product.



EXTRUDER DEGASSING

Extruder degassing, also known as hot melt degassing, venting or devolatization, is carried out during various extrusion processes to remove any residual moisture, air, monomers, oligomers, solvents, reaction products, decomposed materials as well as to purify plastics in various steps of plastics recycling.

The vacuum levels used for degassing could be anywhere between 1–200 mbar depending on the end product. Effective degassing has multiple effects on products in the plastic industry, including an increase in the free volume, reduction in the residual moisture content, improvements in odour, changes in the visual appearance, alterations in mechanical properties, prevention of bubbling or foaming, and homogenous mixing. Proper degassing can easily be attained by changing the number, location and geometry of the degassing ports. The degassing process is most effective when used over a conveying section after a mixing section on the extruder.

The greatest effect of extruder degassing is seen on hygroscopic polymers like PET, PA, POM, PBT etc. that readily absorb moisture from the atmosphere. Water vapour must be removed from the polymer melt as it will otherwise degrade the quality of the final product.

Factors that affect degassing efficiencies include:

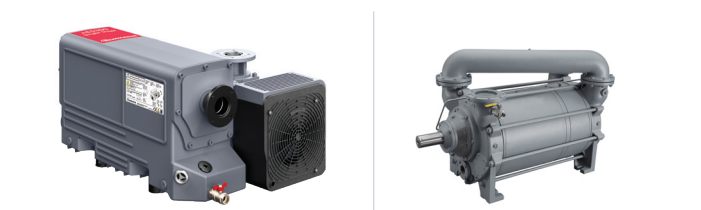
- Residence time under the vent or vents – Longer is better but not usually possible. Oxygen, shear, time and temperature may contribute to degradation and side reactions.
- Surface area of the melt – Higher is better but is a function of screw geometry and operating parameters.
- Surface renewal – Higher is better. Renewed surfaces come from rolling pools and partially filled screw channels.

- Vacuum level applied to vent zone(s) – it can make a big difference in the degassing efficiency. Low viscosity material may require decreased vacuum levels.

Edwards offers a complete range of vacuum solutions appropriate and customisable according to the process. Edwards dry pumps have delivered higher reliability and lower cost of ownership for over two decades now. Their intrinsic features make it possible to achieve a deeper and cleaner vacuum without the generation of waste liquid eliminating the disposal costs.



Edwards has a range of next generation pumping technologies consisting of conventional oil sealed rotary vane pumps and liquid ring pumps with proven performance and low life cycle costs well suited for production sites with excellent waste stream disposal facilities.



EXTRUSION PROCESSES

There are several extrusion processes used to manufacture various plastic articles. Some do not require vacuum as the starting raw material that is used, is usually compounded to user specifications via Pelletisation.

Pelletisation

Pelletisation processes fine particles and agglomerates them into larger granules or pellets during the production of virgin polymers and during compounding and masterbatch production. This process helps reduce waste and improves handling of the material during transport. The die at the end of the extruder is equipped with a cutter which cuts the long strands into granules or tiny beads after cooling. Vacuum is generally used to remove volatiles, moisture, and residual monomers.



Polymer Manufacturing

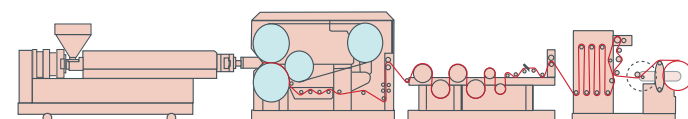
During the polymer manufacturing process, the reacting monomers exit the reactor in the form of powder or fluff. At this stage, there is up to 20% of residual monomers, air and water content which is removed with the help of vacuum degassing. The powder or fluff is extruded into polymer pellets by an extruder for later use.

Compounding & Masterbatch

This involves the addition of colours, plasticisers, stabilisers, and other basic agents to polymers, which give the product the desired quality. This process takes place prior to the actual extrusion of the plastic product. Compounded polymers are highly refined; however, hygroscopic polymers may absorb as much as 2% moisture by weight in storage. This moisture must be removed during the manufacturing process.

Film & Sheet Extrusion

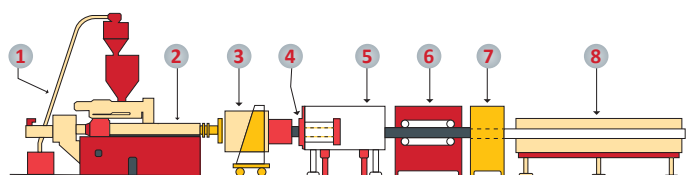
Films and sheets are cast, blow moulded or calendered. Vacuum is used for degassing if the manufacturer is compounding at the site and also during the cooling process. The flat die at the end of the extruder is under vacuum, providing a consistent flow of polymer melt on the rollers to overcome the fluctuating discharge pressure of the extruder. These rollers determine the thickness of the final product and are under vacuum for faster cooling of the extruded sheet. The sheets are pulled through a series of three to four rollers which are temperature controlled and cooled by vacuum systems.



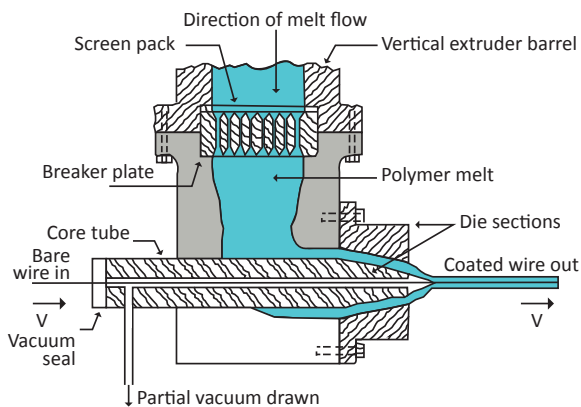
Pipes & tubing extrusion

Pipes and tubing, general purpose and medical, is extruded to specific profiles and specification. The customer may compound raw material on site and use vacuum for degassing or use a ready to use compounded polymer. The melted polymer is then pushed into the die with a spindle (mandrel), forming a tube shape around the mandrel. Low air pressure is usually applied through the mandrel which holds the tube to shape. The tube proceeds to vacuum sizing or calibration tanks which set its dimensions and then to a cooling unit which fixes its dimensions. For larger pipes or tubes a partial vacuum is applied through fine holes in the sizing die. For optimal cooling, vacuum sizing tanks are often used which combine accurate sizing with controlled product cooling.

PVC-U Pipe Extrusion System

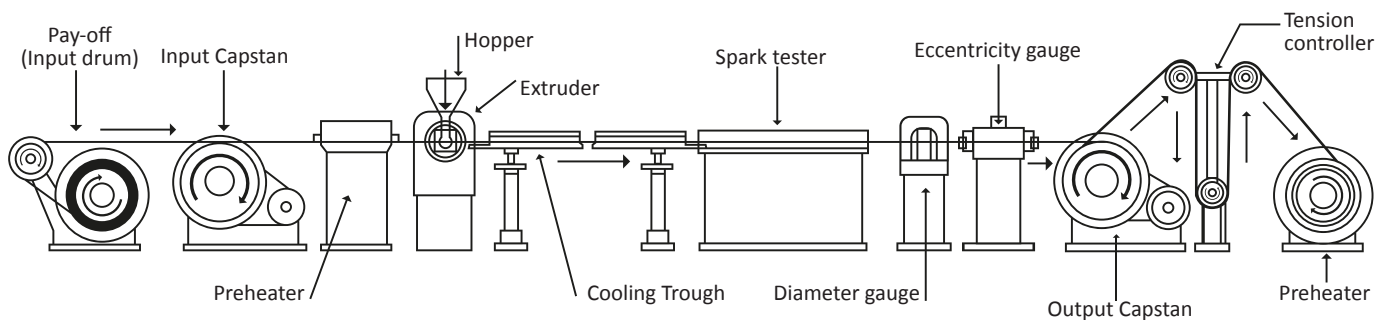


- | | |
|------------------------------|------------------------|
| 1. Raw material conveyor | 6. Haul-off |
| 2. Extruder | 7. Auto Rotary Cutter |
| 3. Trolley-mounted die Head | 8. Auto Socketing Unit |
| 4. Vacuum Calibration System | |
| 5. Pipe Cooling Trough | |



Wire & cable coating

Polymer melt is applied to bare wire as it is pulled at high speed through a die. A slight vacuum is drawn between wire and polymer to promote adhesion of coating. Wire provides rigidity during cooling – usually aided by passing coated wire through a water trough. The end product is wound onto large spools ready for distribution.



VACUUM CALIBRATION / COOLING:

Calibration units influence the profile qualities, like surface aspect and strength, strongly. The cooling rate of the extruded product determines the speed of the extrusion line and hence, optimal design of a calibrator is critical to productive operations. The calibration units can be dry (used for non-hollow profiles), wet or a hybrid of dry and wet.

Vacuum calibrators are often selected due to their greater efficiency, consistency and effective cooling. These are complex heat exchangers which have a double function – to remove heat uniformly and sufficiently as well as to maintain the external profile dimension within the tolerances. Vacuum is applied from thin holes, which forces the profile against the calibrator wall until it cools and exits the calibrator.

These are a few of the process used for plastic extrusion which use vacuum pumps and systems. The vacuum levels vary depending on where it is being used for degassing (1–200 mbar) or for cooling of the formed product (50–500 mbar).

Need for the apt vacuum system

It is often overlooked that vacuum pumps always come in contact with process gases. The correct choice of pump technology is therefore essential for a reliably operating process. In the field of extruder degassing, which can be regarded as a thermal separation process, the wrong choice of pump can result in final products that do not meet quality specifications, and in an extreme case the production process may fail entirely.