nexstar ***excellence in producing paintbrush fibers***

Paintbrush applications may demand complex shapes i.e. cross sections of fibers for technical reasons or for cost advantages. Extruding a perfectly round solid or a properly shaped hollow (single or triple hole) or quad or spoked is an art which requires advanced manufacturing technology.

Paintbrush manufacturers usually lack the equipment required to inspect shapes and even if they do, they are still not able to utilize the advantages offered by non solid shapes due to the technical inadequacy of products available from low cost manufacturing centers. The following microscope pictures are self explanatory.

A typical Hollow Cross Section. Most fibers are crushed and have not fused. Brushes made from such fibers will quickly deteriorate.

Nexstar Hollow – all the fibers are properly fused and not crushed. Such a fiber will have better bend recovery, will carry more paint and is economical as its lighter.

Nexstar Spoked Cross Section has a well defined mini-hole and fins like ribbed. This special cross section will allow the fabrication of more robust brushes as compared to hollow at a marginal cost increment.

A typical Mini Hollow Cross Section. Most fibers have solidified and the 'hole' has disappeared.

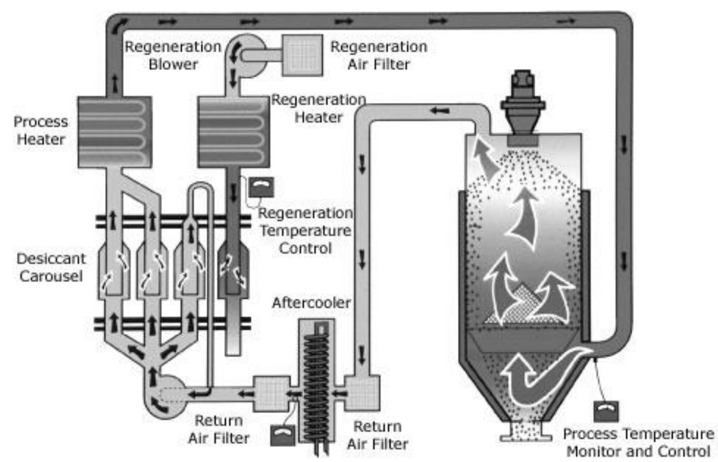
Nexstar Ribbed Cross Section fibers are well formed, will carry more paint due to their shape and low packing density and will be economical to use as they are lighter. They also flag and wear better than the mini-hole.

The technology used by Nexstar to manufacture stable fibers is detailed on the following pages & is meant to familiarize paintbrush manufacturers with the extrusion process.

1. Raw Material Drying

Polyester and Nylon are both hygroscopic materials – they pickup moisture from the air which interferes with the extrusion process. Nexstar uses computer controlled desiccant drying technology to remove the moisture from the granules as the first step to achieve quality.

Typical Desiccant Dryer



Air is heated inside a hopper which flows through the granules stored inside, carrying moisture with it. This air is then routed through a carousel containing desiccant beads which trap the moisture. The cycle is repeated until the desiccant is full of moisture and ceases to function effectively. The air path is then changed and a second carousel becomes active while the first is regenerating.

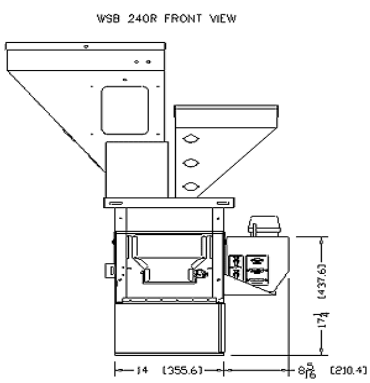
The temperature inside the hopper is carefully monitored so that overheating does not happen and material properties are not lost.

The desiccant beads, filters and seals are expensive and require timely changes. At full load, a typical dryer will have a substantial electrical load. Low quality manufacturers tend to save these costs as Polyester can take about 4-7 hours to be sufficiently dry.

As a second step, once the material is dry, it must stay dry until it reaches the extruder. A dry material will become wet within 15 minutes of exposure to the air. At Nexstar, we have air sealed non corrosive piping connected to the drying hoppers to which discharge material directly into intelligent material management systems.

2. Material Management & Blending

Most fibers are made with a blend of compatible materials. Even color is in the form of a granule which is normally added to the material blend. Nexstar uses precise PLC technology to achieve the blends.



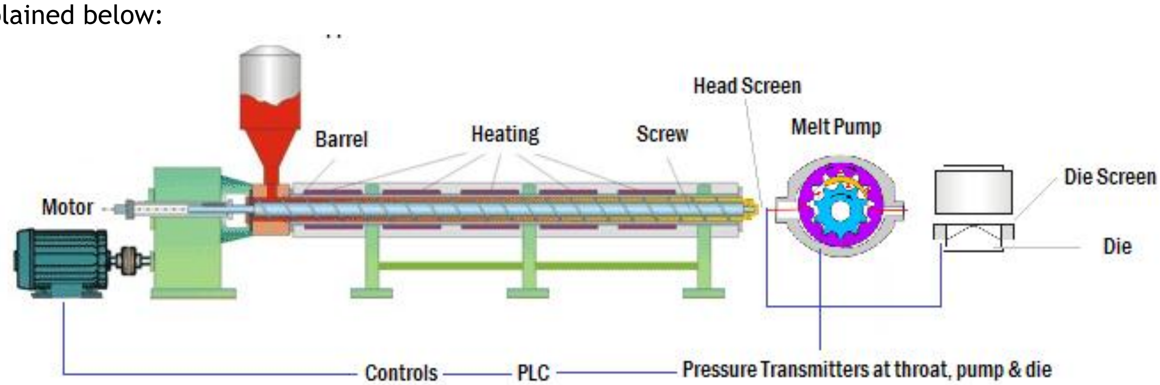
Dry raw material is conveyed to individual air tight hoppers from where a computer weighs the components of each batch, mixes them with a rotary cylinder and makes the blend available to the hopper mounted on the throat of the extruder.

The extruder operators will typically program the percentage components on this machine which is called a gravimetric blender. Mix ratios in fractions of a hundred can be programmed and the machine will function with a high level of accuracy batch to batch. A typical batch would be as small as 1 kilo so that all components are nicely blended.

Most Asian manufacturers do not have such equipment and instead, prefer to mix by hand or with manual tumblers. This method is imprecise and variable.

3. Extruder Controls

Extruder control is extremely important for consistent product quality. Nexstar uses a closed loop control system explained below:



3.1 PID Heating Controls

Low heat to the barrel will not melt the polymer sufficiently and high heat will burn the material, causing its properties to be lost. Most manufacturers use a simple on/off controller which does not provide the desired level of control. Proportional integrative derivative controllers calculate an error value as the difference between a measured process variable and a desired set point and attempt to minimize the error by adjusting the process control inputs. P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process via the power supplied to the barrel heaters.

3.2 Melt Pump & Pressure Control System

Extruded products can have an outside diameter that can range from 0.07mm to 0.38mm. With the many profile shapes, walls can become etremely thin - as low as 0.02mm. To ensure quality and repeatability, producers must control extruder variations such as pressure fluctuations, viscosity inconsistencies, and density changes. deliver a constant amount of resin for each revolution.

To achieve this control, the first step is the inclusion of a melt pump which will deliver a constant amount of resin for each revolution to the die pack. It also regulates the back pressure on the extruder minimizing resident time and stabilizing the plasticizing action of the extruder. The pump improves product quality by reducing the polymer's heat history. By allowing the pump to handle pressurization, the back-pressure on the extruder is reduced, thereby reducing the heat imparted to the polymer. We typically use lower processing temperatures (by about 10-14°F) which result in superior fiber properties.

The second step is the inclusion of 3 precison melt pressure transmitters which will keep both the extruder output and melt viscosity constant by calculating delta P and sending signals to a Logic Controller/Frequency Drive which in turn will control the RPMs of the extruder by chaning its revolutaions depending on delta P. Once the opearator sets the desired pressure in PSI, the extruder runs in auto mode and no manual adjustments are necessary.

4. Quench Tank

All filaments are formed in the quench tank which is a tank made from marine grade metal & contains water. Exiting from the die, the filaments are basically a stream of hot liquid (around 500°F). As this 'stream' hits the water, the fiber takes shape. For hollow fibers, a critical process called fusion also takes place within the tank. The space between the face of the die and the level of water is called an Air Gap. The air gap is also an important determinant of quality and can be as low as 1/8".

To maintain a proper air gap, it is essential that the tank is capable of vertical (up/down) movements. Over tanks have hyraulic packs which makes it easy for us to lower a tank (to change dies or do maintainance) and then raise it up to the desired position.

It is also important that the water in the tank has a flat temperature which is optimum for a particular type of fiber being extruded. Our tanks have recirculating water and heat exchangers which are in turn cooled by a compressed refrigerant. We maintain quench tank temperatures with a very low degree of varience. It is obvious that without controlling the temperature of the water, it would get hot rapidly and the air gaps would then start fluctuating widely (due to evaporation). Secondly, as the water gets hot, the fiber properties would also start fluctuating. These defects would include non fused or weakly fused fibers with a very variable cross section geometry.

5. Take Off Units/Stretch Rolls/Relax Rolls

Collectively called Godets, these are rolls over which the fibers exiting from the quench tank travel. It is essential to have an extremely high level of speed control over these godets as even a minor varitaion could lead to a major variance in quality. Our Godets are driven through drives which receive constant feedback about the actual speeds being achieved and make changes to current to maintain uniformity.

Our special controls allow us to reclaibrate the rolls electronically. As these rolls experience high torgues, it is common for them to get out of sync.

Finally, our rolls allow us to heat/cool them and maintain uniform temperatures depending on the type of fiber being produced. The fiber which exits from the tank is usually quite hot and will heat up the rolls over time which will impact the fiber quality. At the time of machine startup, the rolls would be cold. Control over roller temepartures is an essential for achieving superior quality.

6. Ceramic Radiant Panels

Normally, extrusion companies would use a water strecting bath to soften the fibers before the stretching stage. The temperature of the bath cannot be more than 200°F as the water starts steaming and evaporates. At Nexstar we use radiant ceramic panels to soften the fibers before the stretching stages and do not use water baths at all.

Use of these panels allows us to load very high heat loads up to temperatures of 1000°F & beyond, depending on the type of fiber being produced. The fiber beomes very malleable which in turn allows us to put high draws of up to 1:4.6 to obtain superior fiber properties. Draw ratio is a major determinant of bend recovery & stiffness.

6. Inline Annealing

Annealing stabilises the molecular structure of the fibers by relaxing them. Properly annealed fibers will not bend or curl under normal circumstances. Fibers can be annealed inline during the extrusion process by passing them through a ot air oven (arrow mark on the picture) or post extrusion i.e. by winding a lot of fibers on a jig and placing them in an oven.

Inline annealing is the preferred method because each and every fiber is separate and is exposed to the heat evenly. The process however requires that pre annealing stages are producing perfect fibers otherwise the annealing process will play havoc with the production. For example, if all fibers are not properly stretched, the defective ones will curl in the annealing oven. Consequently most manufacturers in low cost manufacturing centers do not prefer inline annealing. As a short cut, the fibers are wound i.e. clumped on jigs post extrusion and in this process, it is not possible for all the fibers to be evenly exposed to the heat and have uniform properties.

7. Controls

To synchronise all the devices, receive constant feedback and make automatic corrections where required or possible, advanced controls are necessary. It is humanly not possible to make all the adjustments which are required to produce fine quality if the controls are not synchronised.

At Nexstar we use advanced industrial computers which not only keep the processes running but also record system faults and errors. These help us train people and take timely corrective actions.

C O N C L U D E D