The purpose of this paper is to provide an overview of extruded plastic netting and its uses in the filtration industry The paper focuses on the physical properties of extruded netting relative to other materials and the product's performance characteristics in various filtration applications. Although plastic netting has been used in filtration applications for decades, there is very little published on the material. This paper is intended to be the "short course" for extruded plastic netting.

For those not familiar with extruded plastic netting, it's perhaps best to begin by discussing what extruded plastic netting is not. It is not woven. It is not perforated. It is not molded. Although all of these processes produce materials with holes, each process has it's own nomenclature for defining what's there (i.e. strands, joints, etc) and what's not there (holes). The same is true for the extrusion process.

The Extrusion Process

The extrusion process is a continuous process, which involves melting plastic pellets and pushing them through a die in "meat-grinder" fashion to create a plastic net. Two important elements of the process are that it is continuous, and the product is produced in its final form as a net. (It always seems to surprise people that the product is extruded as a net.)

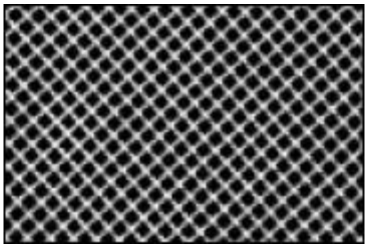
As the netting exits the die, which forms the strands, the material is drawn over a forming mandrel and into water to cool the material. As the material is drawn over the mandrel, it is stretched slightly. Although the extrusion process is very stable, when compared to other processes there is typically more variation in such product attributes as strand diameter and material thickness than with the weaving process or injection-molded process.

Plastic netting is a unique process that belies classification. If it is not woven, perforated or molded, than it really falls in the category of nonwoven, even though it doesn't have the drape characteristics typically associated with nonwovens.

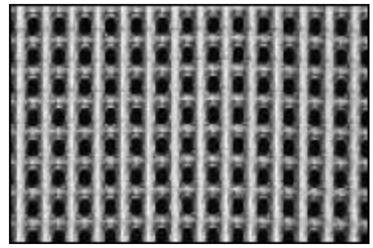
Types of Plastic Netting

There are fundamentally two different kinds of plastic netting in terms of strand structure, diamond netting and square netting. Further, there are two different processes that result in distinct product characteristics; extruded (or cast) netting and oriented netting.

Diamond and square netting refer simply to the shape of the hole made by the strands. Diamond netting results from two strands overlaying each other, typically at a 90-degree angle but ranging from 40 degrees to 105 degrees, to create a diamond hole pattern. Diamond netting is the most common type of extruded plastic netting. Square netting results from strands being formed along the x and y plane, creating a square or rectangular hole pattern. Both types of products are produced in a wide range of configurations, ranging from fine "filtration-grade" netting that would resemble a woven product, to more course extrusion typical of plastic construction fence.



Diamond Net - 4411

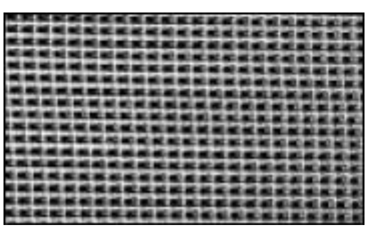


Square Net - 1588

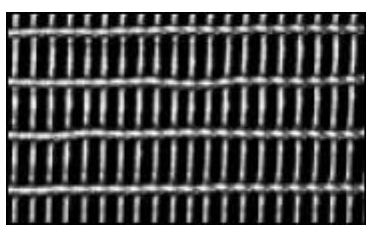
Extruded netting can be subsequently heated and stretched to produce lighter-weight materials. This process is called orientation. Essentially, the plastic is heated and stretched under conditions that optimize its tensile strength. A common application for oriented diamond netting is the produce and packaging markets, where plastic netting is used for potato bags, onion bags, turkeys and other packaging applications.

Oriented Diamond Net

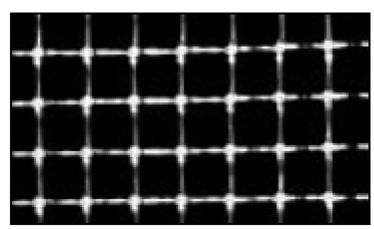
Plastic netting can also be stretched on larger tenter frames. This process is capable of producing wider goods, as wide as 17' or more. The tentering method of orientation will always result in square (or rectangular) netting, as the material is pulled or oriented along its x and y-axis. Either square or diamond extrusion can be tentered, though diamond netting must be cut on the bias in order to be oriented on a tenter frame. There are many applications for oriented square netting, but it primarily provides reinforcement for other substrates.



Extruded or Cast Form - 3019



Stretched One Direction - 3350



Stretched Both Directions - 3018

All extruded plastic netting is extruded in tubular form. It is most common for the tubular netting to be slit open longitudinally during the process to create a flat roll of material. In some cases, however, the netting is kept in its tubular form. The oriented produce bags for packaging referenced earlier is one such example. Another example in the filtration industry is rigid plastic (netting) tubes for center cores or outer sleeves (cartridge filtration). Tubular structures are also produced to be flexible or stretchy, as is often seen on the outside of cartridge filters. There are other applications as well for rigid and flexible tubular plastic nets.

The range of products and markets for plastic netting are quite diverse. To see all of the products and uses, one might think many processes were used to produce such products. But, in fact, the extrusion and orientation processes are capable of producing an ever-widening array of products for the filtration industry and other markets. Let’s explore some of the specific characteristics of these products.

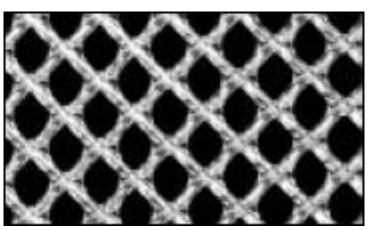
PRODUCT CHARACTERISTICS

Joint Structure

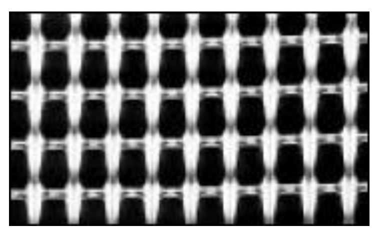
Although both diamond netting and square netting are both extruded, the processes used to produce the products result in quite different product characteristics, which may be important in some applications.

Diamond netting is produced with the strands in each direction overlaying each other. The joint structure of the product can be described as a strand over another strand. The overall thickness of the product will essentially be twice the thickness of each strand, although there may be some melding of the strands at the joint. Normally, the strands in each direction are produced uniformly, and the product looks the same from one side of the material as the other. This type of netting is marketed as "bi-planar", as both sides are structurally the same, the strands forming a plane or channel along the net.

The joint structure on square netting is quite different. The two strands that form the joint, the "machine direction" strand running the length of the roll and the "cross direction" strand running the width of the roll, are not stacked one over the other as in diamond netting. Generally, the machine direction strand is thicker than the cross direction strand. The overall thickness of the netting is mostly comprised of the machine direction strand thickness.



Diamond Joint - 4700



Square Joint - 2950

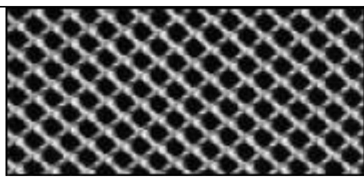
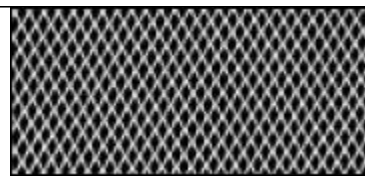
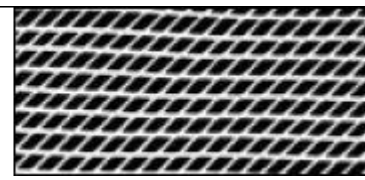
In diamond netting, the overall thickness of the netting is the summation of the thickness of the two overlaying strands. For example, two strands each .015" thick overlaying each other results in a diamond net that is .030" thick overall. Whereas, a .030" thick square netting will likely have a .030" machine direction strand and a smaller cross direction strand, perhaps around .024" thick, for example.

In looking at a cross section of a diamond net joint, the strands are joined in the middle of the joint, whereas with square net the strands are joined on the bottom side of the joint. As a result of this joint configuration, square netting usually has one side of the material that is smooth, that is, both the machine and cross strands are flush on the same plane, and one side that is "bumpy", where the machine direction strand has a higher profile than the cross strands.

Hole Shape and Size

Beyond the obvious fact that the diamond net process produces netting with diamond-shaped holes and the square net process produces net with square holes, there are wide varieties that are available with both processes.

As mentioned earlier, most diamond netting is produced with the strands at 90-degree angles. However, the process allows for more acute angles as well. Products with machine direction angles at 60 degrees are also common. Further, a single strand can be held constant, running in the machine direction, while the second strand is produced angularly over the constant strand. This produces netting with a more rhombus-like shape. These are process variations that can be done irrespective of the tooling used to produce the product.

		
Diamond 90 Degree	Diamond 60 Degree - 4980	Diamond Rhombus K

Likewise, the square net process can be manipulated to produce various hole shapes. The cross direction strand can be altered to make a square or rectangular shaped hole. Square net can also be stretched in one or two directions to make even more exaggerated rectangular hole shapes.

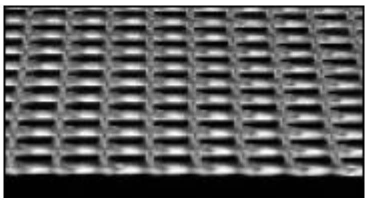
Strand Shape and Number

The joint structure, as discussed previously, is determined by the process itself; that is, whether it is a diamond net or square net process. The hole size and shape are variables that can be controlled within the process. And, although the strand count can be manipulated by the strand angle and the line speed, it is primarily determined by the tool or die that is used in the process. Obviously, there are many different tools used to produce the wide variety of products that are available.

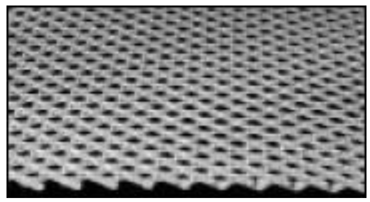
The tool contains a fixed number of slots through which the molten resin flows, producing the strands. A net that has 8 strands per inch in each direction, for example, would be produced from a tool with the proper number of fixed slots in it. If one wanted a net that has 9 strands per inch, it would require a different tool, if all other process parameters were held constant.

The strand shape is also determined by the tooling. Most slots are square, rectangular or trapezoidal in shape, although there are tools with round holes rather than slots. Even though a slot may be square, the strands themselves are not square, because the molten plastic strands become more rounded as it exits the tool and ultimately cooled in a quench tank. Even though there is not a direct relationship between the shape of the slot and the shape of the strand, a tall and narrow slot will produce a strand that is taller and narrower than a strand produced by a square or round slot.

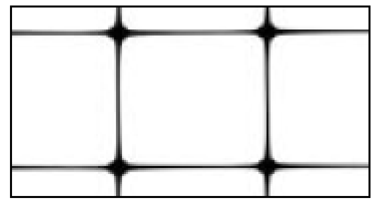
When the netting is oriented or stretched, the strand shape is altered greatly. In this process, there is less control over the ultimate strand shape, as the material is being heated and stretched. Generally, the shape of an oriented strand is somewhat hour-glassed, with the center of the strand necking down and the strands becoming wider as it approaches the joint. Oriented netting also has a higher profile joint, where the joint thickness is greater than the strand thickness.



Diamond Profile - 4700



Square Profile - 2950



Oriented Bird's Eye

All of these product characteristics are important in understanding the role of plastic netting in the filtration industry.

Role of Plastic Netting

The role of plastic netting in the filtration industry is not singular. The wide variety of filtration and separation systems and media results in a wide range of uses and functions for plastic netting. The major functions of plastic netting in filtration can broadly be categorized as 1). Facilitating the flow of fluids, 2). Supporting, 3). Protecting, 4). Reinforcing, and 5) Filtering.

A major role for plastic netting in the filtration industry is to facilitate the flow of fluids, typically, through the filter element. A number of filter element configurations require a liquid stream to flow through layers of filter media, and plastic netting can serve as a spacer between such layers, allowing the fluid to be channeled across the filter medium.

The largest application for this "flow channel" function is with spiral filter elements. In this application the plastic netting, usually bi-planar diamond netting, serves as a "feed spacer" allowing the liquid stream to flow across the membrane surface.

Plastic netting is more likely to support another substrate which functions as the filter medium, whether that substrate is a woven, nonwoven or membrane-based material. As extruded plastic netting is more rigid than a woven or nonwoven material, it can provide support to the medium in helping it retain a given shape or support the material against the liquid or air stream. One major application for plastic netting is as a pleat support material in pleated cartridge filters. The pleat pack must be supported, with relatively uniform separation between the pleats. Plastic netting provides enough rigidity to keep all of the pleats uniformly exposed to the stream, thereby improving the filters' efficiency.

Diamond netting, because of its bi-planar joint construction, and square netting, because of its higher profile strand construction, can provide support for the medium with minimal contact against the substrate, to reduce the effects of blinding. In some filters, the support netting serves to protect the medium from handling as well.

Plastic netting also serves a support function when used as a rigid tube for center cores in cartridge filtration. In this application, flow characteristics are also important, but the primary role of the netting in this application is structural support.

Plastic netting serves as support in other ways beyond pleated cartridges. Panel filters in air filtration will often include a plastic netting screen to add support to the filter medium contained within the structural frame.

Plastic netting is also used to protect the filter medium from damage during use and handling. Rigid tubes, described earlier as structural support center cores, are also used as outer sleeves to protect the filter element. Lighter weight, flexible tubular "sleeve" material is also used in this application, where different colors are often used to identify specific filters.

Plastic netting may also be used as a screen in a number of filter element configurations to prevent damage from handling, such as in a panel filter.

Another role for plastic netting is to reinforce another substrate. Often times the netting is incorporated in a nonwoven, for example, to provide improved performance characteristics to that substrate, such as strength, tear resistance, etc. When the netting is incorporated into another substrate, by means of lamination, needle-punching, etc., it is part of the composite medium, improving the performance attributes of that medium, and does not have a separate function in the filter element.

At first exposure to the industry and plastic netting, one might think plastic netting functions as a filter medium. But in fact, plastic netting is least used a filter medium itself, unlike similar-looking woven materials, which are commonly used as a filter medium. In cases where extruded netting is used as a filter screen, the applications generally involve very crude filtration, either large particles or even debris.

Across the many filtration applications for plastic netting, the primary product or performance attributes desired can be described as thickness, rigidity, or flow.

In some applications, plastic netting is required to fill a certain volume; a spacing between layers of substrates, for example. In such applications, the products' thickness is of primary concern. In other applications, the rigidity of the product is important, as it helps support the medium or the filter element itself. In other applications, the flow rate is of primary concern. In such applications the hole size may be important or the depth of the flow channel along the strands.

In spite of the many applications for plastic netting in filtration, the essential qualities that are required relate to the products' thickness and the hole size. Beyond that, more subtle attributes such as strand height or shape, are manipulated to optimize filtration performance in a given application.

Outlook

Many of the uses for extruded plastic netting are derived from woven applications, where extruded products displaced woven materials because of a cost advantage. Plastic netting is also advantageous because of its welded joint and non-fraying characteristics. By expanding the process capabilities to cover a wider range of products, extruded plastic netting manufacturers can offer the industry a wider choice of materials.

Plastic netting has mostly been available in polypropylene and polyethylene; with mesh counts typically lower than woven materials. It has only been recently that products have become available in other resins, while synthetic woven producers have been able to provide materials in a broader range of materials for years. Development efforts by producers have resulted in a further expansion of the product line into higher mesh count products and resins, which will contribute to further growth of this industry.