THE COLLECTIONS OF THE THESES FOR THE SIXTH BEIJING INTERNATIONAL CONFERENCE ON MAN-MADE FIBERS

第六届北京国际化纤会议论文集

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The Organizing Committee of the 6th Beijing International Man-Made Fibre Conference (BIMFC'96)

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DUPONT

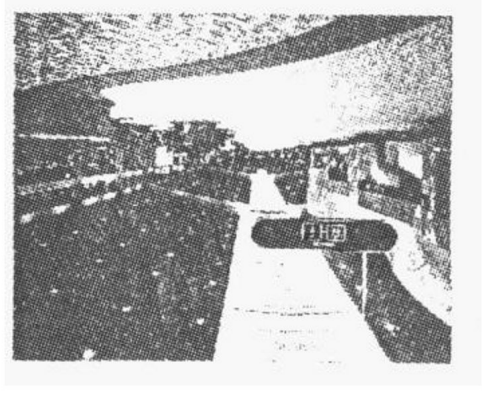
生活更好

目　　录

生产高性能地毯纤维的技术问题

OTTO M. ILG　巴斯夫纤维产品副总裁

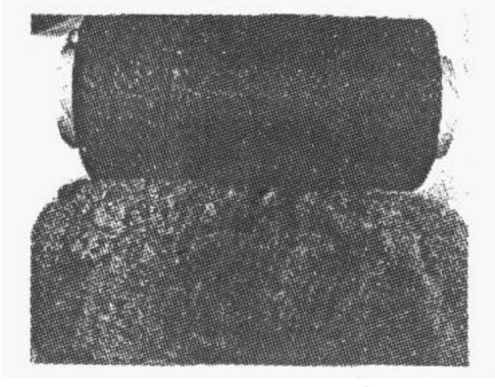
由于铺设简便，容易保养，普适性强及耐用等特性，使地毯在世界范围内成为地面敷饰的首选方式。(幻灯 1)



幻灯 1　典型的商用地毯敷设

在民用范畴内，由于对保暖，舒适感、颜色可选择范围广、易于保养等方面的要求，使长绒地毯极受欢迎。在商用方面，写字楼、旅店、公共建筑和飞机场十分乐意采用地毯。而汽车制造业，则由于地毯的普适性、式样多、美观、耐用而被选用。

在所有以上应用中，恰当地选择纤维的性能，使地毯能达到期望值，是致关重要的。特别于商用方面，地毯往往是要特制的或专门设计的，去满足美观上严格的要求，或具备大客流量建筑物管理所需的经久耐用性能是十分重要的。上述最终用途尤其会选用高性能地毯纤维。

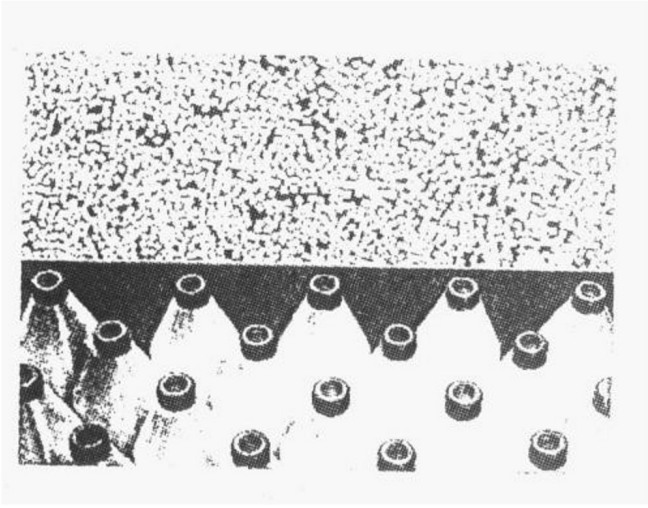


幻灯 2　短纤维和 BCF

对于地毯纤维而言，高性能意味着什么？在过去 40 年尼龙地毯的历史中，有几种要求是不可少的。在地毯纤维中，一个最基本的差别是短纤维和膨体连续长丝(BCF)。(幻灯 2)

在早期，合成纤维地毯，通过短纤维的混合以保证地毯的染色均匀，并认为由纱线织造出的艺术效果是受欢迎的，与无伦比的。因此整个地毯界都是将短纤维纺成纱，而且在西半球仍然盛行。由于起来越好的BCF工艺出现，短纤维混纺的必要性就日益减少了；经验丰富的纤维生产者和簇绒加工，可以用BCF制造出与短纤维纱线同样外观的地毯。一般认为，新的短纤维地毯生产线的增设不再会多，并将继续从短纤维向BCF转移。特别是对象中国大陆这样举足轻重的新兴市场，更要选择具备优良性能和高技术能力的BCF，作为未来发展的选择了。因此，我将仅限于讨论BCF的重要参数和技术。

由于以下原因，尼龙6被许多纤维制造者和地毯厂选用为BCF的原料聚合物。它易于捆丝、加工灵活、性能优良，加之可能回用。（幻灯3）



幻灯3　Ultramid®纤维级聚合物

（BASF 尼龙切片样本）

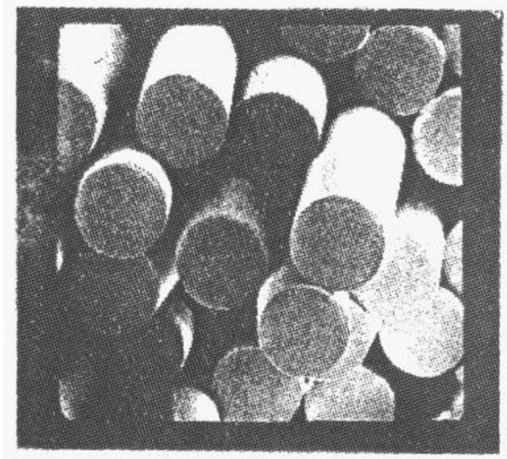
BASF被公认为世界最大的尼龙6及中间体生产厂商，并开发了可提供适合于各种应用的聚合物综合生产线。

幻灯4　纺前染BCF色谱

从优质的聚合物开始，然后根据各种商业最终用途的要求，对纤维进行特殊加工。改虑到着色牢度的严格要求和易于清洗，在许多情况下纺前染色法是最佳的选择。纺前染的纱不仅有非凡的批间色泽均匀性，而且大批量生产时，也能获得均匀的色泽。（幻灯 4）

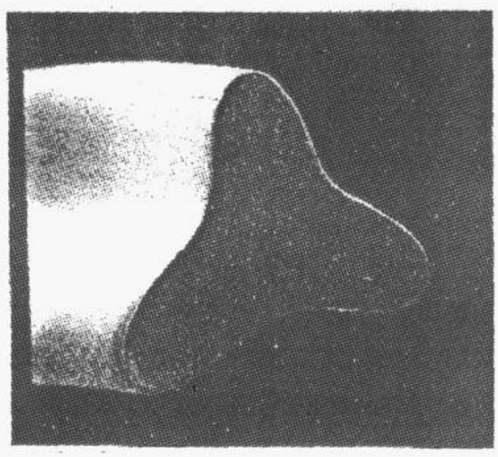
藉助于正确选择彦料和着色剂，可以获得较任何纺后染地毯都卓越的光牢度和耐强力洗涤剂性能。最终取缔印染浴排放液和污水处理，对于清洁的环境和省去污水处理设施的费用是极有意义的举措。正因为始终以纤维高性能和工业卫生高标准为宗旨，BASF 明智地选择与环境友善的着色剂。在过去 20 年的纤维纺前染色过程中，对于着色剂的选择，配色和色泽控制积累的丰富经验，使我们游刃有余地满足客户的利益。

纤维截面形状的选择，在获得膨松度、覆盖性、耐用性、耐龌龊、易清洗等的性能平衡方面是致关重要的。（幻灯 5）



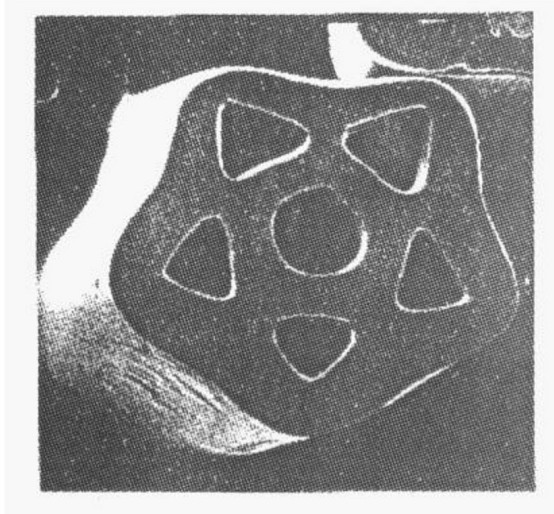
幻灯 5　圆形截面

圆形截面仍然是衣用纤维的主要形状，一般地毯用纤维已被三叶形代替。（幻灯 6）

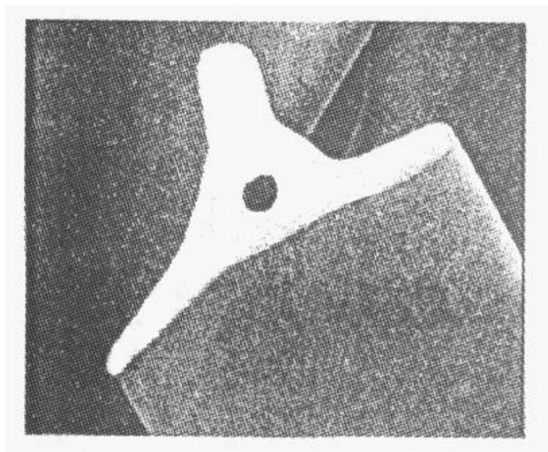


幻灯 6　三叶形截面

现在已知若干截面有耐脏的特点，并已投入生产，如这里所演示的五边中空纤维。（幻灯 7）（幻灯 8）

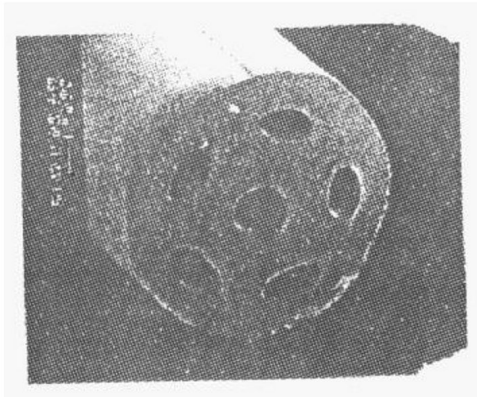


幻灯 7　Zeftron 500®断面形状

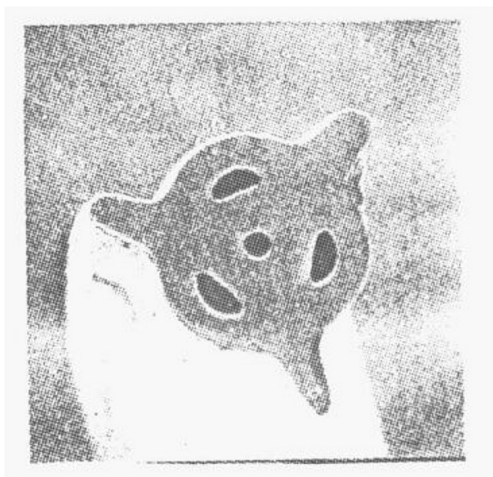


幻灯 8　中孔内凹截面形状

实践表面，孔洞有耐脏效果，而光滑的表面容易去污。取决于所需的效果，可以选中孔圆截面纤维。（幻灯 9）**或中空圆形和三叶形组合纤维。**（幻灯 10）



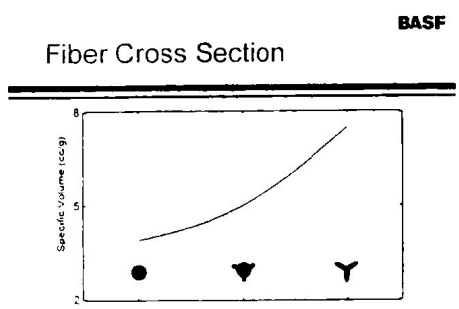
幻灯 9　图形五孔截面



幻灯 10　中空圆形/三叶形截面

为能连续稳定地生产这类特殊形状的纤维，在聚合物流变学、喷丝板设计和纤维固化方面的种种专门技术是必不可少的。

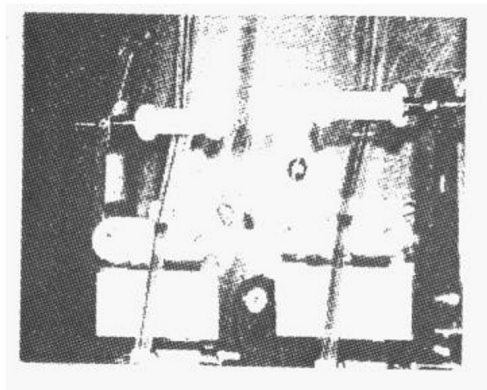
广泛研究截面效果，导致了对地毯膨松度、外观和敷地性能影响的深入且定量的理解。（幻灯 11）



幻灯 11　膨松度对截面形状

除了纺丝参数、膨化和热定形条件而外，截面形状显然起着主导作用。必须时刻注意，就最终应用而言，最大的膨比度不总是决定性的因素。为了达到特殊的性能和外观属性，常将不同截面形状或旦数的纤维混纺，以便取得成功的效果。

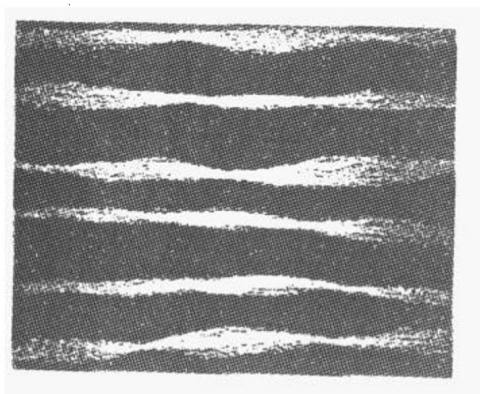
纺丝过程中所用的油剂也是一个纤维制造工艺的关键因素。润滑良好，不易起毛，上油均匀，并含有抗静电成分，才能使高速纺丝，高运转率，高产优质变得可能。（幻灯 12）



幻灯 12　上油装置

但是对已经选择的纺丝油剂，我们还需考虑其对后续加工，如加捻、并合、热定型和簇绒等的适应性。特别是纺前染纤维，因为油剂在上色前和染色期间是不去除的，耐污行为和去污性能就成为油剂组份选择的重要因素了。

在许多应用场合，单股 BCF 纱是与其他纱藉加捻，或空气并合在一起的。（幻灯 13）



幻灯 13　交络 BCF 纱

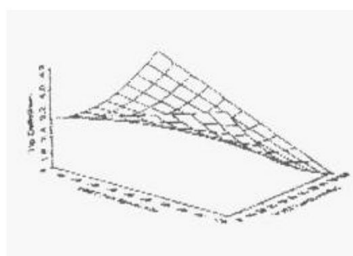
交络的形式，密度及单根 BCF 的空气交络等，都是决定多股纱有效合并的重要因素。即使在纺丝—牵伸—变形加工过程中，为使卷绕无故障进行，恰当的交络度也是一关键工艺参数。交络过程中，藉单纤的缠结，将丝束分成短段，即形成结点。已经发现不但结点的规整性或随机化起着重要的作用，而且结点的紧密度也有影响，于是出现所谓“软结点”和“硬结点”之称。多年来生产和销售单色单股纱和多色合股纱的过程，使我们在设备和工艺方面积累了丰富的专有技术。

对于商用地毯，任何纤维生产工艺，都必须提供抗静电性。BASF 作为首家抗静电纤维的生产者，将提供多种选择。（幻灯 14）

幻灯 14　加有抗静电纤维的 BCF 纱

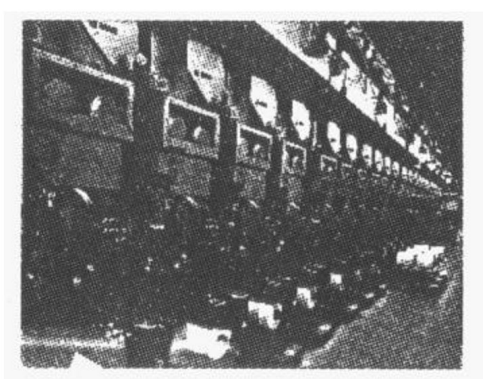
根据最终用途的需要，决定导电纤维的种类和在 BCF 中的添加量。所谓的踩踏实验，是在严格的测试条件下，通过在地毯样品上行走，产生的静电压表示。选择适当的抗静电纤维和用量正确，就可以满足从住宅，一直到要求最严格的计算机房的各种用途的需要。

为了最大限度地获取膨松度，同时能维持被加捻的各纤维的明晰的外观，在热定型设备中的最佳定型条件起着极重要的作用。（幻灯 15）



幻灯 15　Superba Turbo 风机速度的影响

特别是在某些热定型设备中，联连了所谓的透平冷却箱体，地毯均匀性，最终的膨松度和档次等方面带来的不同是十分明显的。各种工艺参数间的相互作用，再一次表明地毯工业中专有技术的力度。还有某种产品的最佳效果，通过在既定工艺中选择的初始细度和捻度，以获得一定纤维收缩率而实现的。



幻灯 16　Anderson 工厂 SDT 卷绕层

我刚才描述的从聚合物到最终产品的全过程表明：（幻灯 16）在整个工艺过程中的任何一个参数，对纤维的加工、性能，乃至最终产品地毯，都是至关重要的。对高性能地毯纤维，要选择恰当的添加剂和生产条件，才能有成功的产品设计；才能使工厂高效、多产、优质运行；才能长久地满足客户的要求。

TECHNICAL ASPECTS OF PRODUCING HIGH PERFORMANCE CARPET FIBERS

OTTO M. ILG BASF

The ease of installation, the easy care, the versatility, and the long-term performance of carpeting make it the preferred choice of floor covering around the world. (Slide 1) In the residential sector, the feeling of warmth and comfort, the wide choice of colors, and the low maintenance requirements have made plush carpeting highly desirable. In the commercial sector, carpeting has found great acceptance as a preferred floor covering in office buildings, hotels, public buildings, and airports. In the automotive industry, carpet is used due to its versatility and styling potential, its aesthetics, durability, and wear performance.

In any of these applications, the proper choice of fiber properties is critical if the carpet is to live up to its expectations. Particularly in the commercial sector, it is very improtant that the fiber is tailor-made or specifically designed to meet the stringent requirements of the architects and building managers for heavy use and lasting performance. It is for these end-uses that the term "High Performance Carpet Fibers" is especially applicable.

What does "high performance" mean in respect to carpet fibers? In over 40 years of nylon carpet fiber history, several requirements have emerged as indispensable. In carpet fibers, one basically differentiates between staple fiber and Bulk Continuous Filament (BCF). (Slide 2) In the early days of carpeting from synthetic fibers, the blending of staple fibers assured a uniform dyeability in a carpet and the aesthetics of a spun yarn were considered desirable and unique. An entire industry of processing staple fiber into a spun yarn emerged and is still very strong in the western hemisphere. With the emergence of better and better BCF processes, the need for staple fiber blending has become more and more unnecessary; and the skilled fiber maker and tufter can also produce carpets from BCF giving the appearance of a spun yarn carpet. It is generally agreed that new installations of staple spinning equipment for carpeting are not very appealing and the trend away from staple fiber and towards BCF will continue. Particularly for such an important and significant emerging market as the Peoples Republic of China, the high performance standards and technical capabilities of BCF make it the fiber of choice for the future. I will, therefore, limit my discussion to the significant parameters and the technology for BCF.

Nylon 6 is considered the polymer of choice for BCF by many fiber producers and carpet mills for several very good reasons. It offers ease of spinning and flexibility in processing, as well as high performance coupled with the potential for carpet recycling. (Slide 3) BASF, as a recognized leader in the production of Nylon 6 and its precursors worldwide, has developed a comprehensive line of suitable polymer offerings.

Starting with a high quality polymer, the fiber needs to be engineered, which means tailor-made, for the very demanding end-use in commercial installations. Considering the stringent requirements of color fastness and cleanability, solution dyeing offers itself in many situations as the preferred coloration method. Solution-dyed yarns not only have unsurpassed lot-to-lot color uniformity, but one can also obtain very large lot sizes in a very uniform color. (Slide 4) By the proper choice of pigments and colorants, the fastness to light and even harsh cleaning agents is superior to any post-dyed carpet. The virtual elimination of dyebath effluent and waste streams is a significant step towards a cleaner environment and saves cost in waste treatment facilities. While keeping in mind the high standards of performance criteria for the fiber and highest industrial hygiene standards, BASF judiciously selects only environmentally friendly colorants. In over 20 years of solution dyeing of fibers, a vast experience in colorant selection, color matching, and color control is at our disposal for the benefit of the customer.

The choice of cross section is very crucial to obtaining the right balance between bulk, cover, wear performance, soil hiding, and cleanability. (Slide 5) While the round cross section is still prevalent in textile fibers, it has generally been replaced in carpet fibers by the trilobal shape. (Slibe 6) Various soil hiding cross sections are known and some are in production, as demonstrated by this pentagonal hollow fiber. (Slide 7) Voids or holes have shown to be effective for soil hiding, and the smooth surface offers good soil release. Depending on the desired effect, hollow round fibers (Slide 9) or hollow combinations of round and trilobal are possible. (Slide 10) For consistent production of such specialized shapes, much know-how in the field of polymer rheology, spinnerette design, and fiber solidification is very essential.

Extended investigations of the effect of cross-sectional shape have led to a good and quantitative understanding of the contributing factors to bulk, apparent value of a carpet, and the floor performance. (Slide 11) In addition to spinning parameters, bulking and heatsetting conditions, the cross section clearly has a dominant influence. One has to keep the end-use in mind, however, and maximum bulk is not always the decisive factor. In order to achieve special performance or appearance attributes, the mixing of fibers with certain cross section or deniers has also been successful.

The spin finish or lubricant applied during the fiber manufacturing process is a key factor. Good lubrication, low slinging tendency, uniform application, and the presence of an antistatic component make it possible to produce the fiber at high speeds, high efficiencies, and good yields in first quality. (Slide 12) But already in the choice of the spin finish, we must consider its suitability for further processing of the fiber in twisting, commingling, heatsetting, and tufting. Particularly for solution-dyed fiber, where the finish is not removed prior to or during a dyeing step, the soiling behavior and soil release properties are important factors in the choice of finish components.

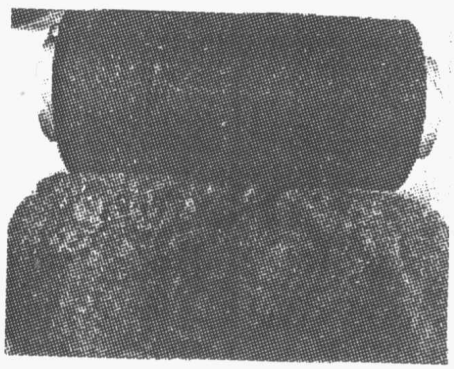
In many applications, the single BCF yarn is combined with other yarns either by twisting or by air commingling. (Slide 13) The nature and the degree of entangling or airinterlacing of the individual BCF bundle is an important factor in allowing efficient combining of the ends. Even for trouble-free winding of the BCF during the spin-draw-texturing process, the right degree of interlacing is a key process parameter. Interlacing produces short segments of interwoven fiber capillaries called nodes. It has been found that not only the regularity or randomness of the nodes is of importance, but also the tightness of the nodes, leading to the term "soft nodes" and "harsh nodes". Years of producing and marketing solid color single yarns as well as multicolor plied yarns have given rise to a wealth of particular equipment and processing know-how.

Providing static protection is an absolute must for any fiber processed into carpets for commercial applications. BASF, as a leader in static protection fibers, offers a variety of options. (Slide 14) The type of conductive fiber and the amount to be combined with be BCF bundle is determined by the end-use requirement. The so-called stroll test expresses the static voltage generated through walking on a carpet sample under precise test conditions. The choice of the proper antistat fiber in the correct amount can meet the requirements of the residential sector all the way to the most stringent needs of computer rooms.

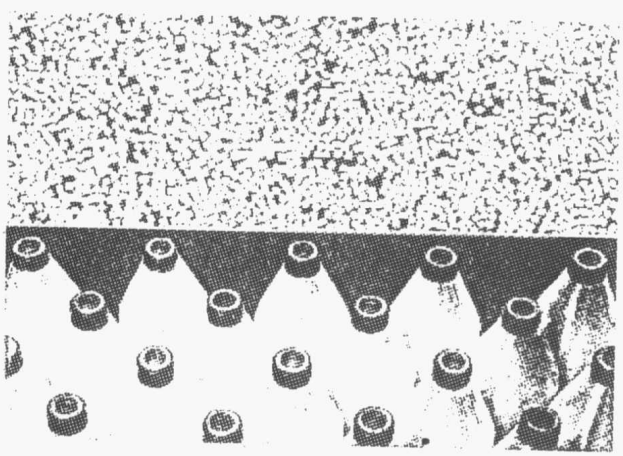
In order to maximize the development of bulk and yet maintain a distinct definition of the individual twisted fiber tips for a clean appearance, the optimum settings of the heatsetting equipment can have a very significant impact. (Slide 15) Particularly with the advent of so-called turbo cooling chambers in connection with certain types of heatsetting equipment, the differences in carpet uniformity and resulting bulk and value can be quite obvious. The interaction of processing parameters again demonstrates the know-how intensity of this industry. The fiber shrinkage to be expected in a given process has to be considered in the choice of initial denier and in the applied twist level in order to optimize once again the product for the intended application.

As the journey from the polymer to the finished product which I have just described shows (Slide 16), any one parameter in the entire process is crucial in the processing and performance of the fiber and ultimately the carpet. For a high performance carpet fiber, the selection of the right ingredients and conditions is the formula for a successful product design, an efficient plant operation with high yield of top quality product, and lasting satisfaction of a pleased customer.

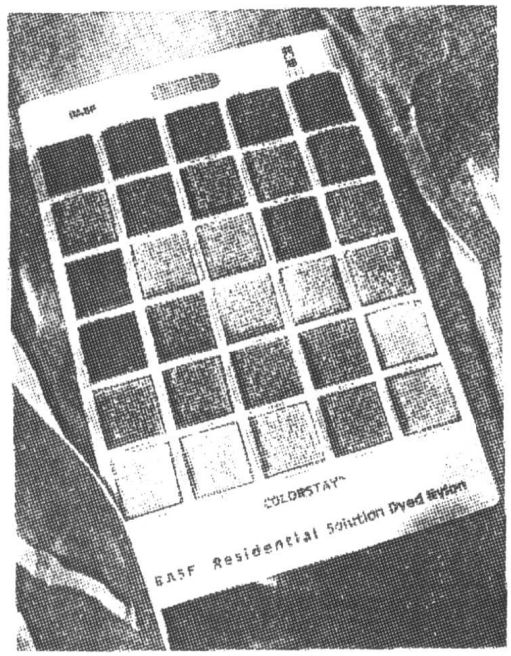
Slide 1. Typical Commercial Carpet Installation



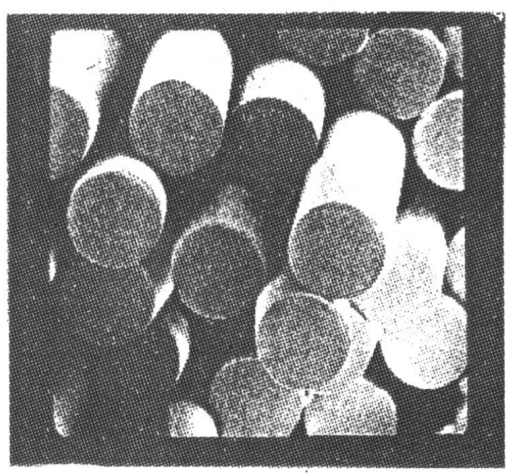
Slide 2. Staple and BCF



Slide 3. Ultramid® Fiber Grade Polymer
(BASF Nylon Chip Brochure)



Slide 4. Color Spectrum in Solution Dyed BCF



Slide 5. Round Cross Section