The Development of Woven Velours for the Transportation Market

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Abstract

Woven pile fabrics may be found in upholstery, apparel, and industrial applications. This fabric formation technology may produces a variety of pile heights and densities appropriate to the end use. The development of woven velour fabrics for upholstery has become a specialized competency with few training possibilities outside the machinery manufacturers or in house training at the few companies who hold the experience and expertise. This research looks at the fundamentals of pile weaving and in particular, the steps in producing a woven velour for the high performance standards of automotive and other transportation upholstery. This research should be helpful to students, academics and industry as it provides information on the design and manufacturing processes in the US market providing examples for technical specifications and simulations.

Keywords: pile weaving, velour, velvet, automotive upholstery

Introduction

The terms velvet and velour are used interchangeably by many in the textile industry. The difference between the two is based on the weight and density of the fabric being described. Though the term velvet is used most often to specifically describe a woven warp pile fabric, the term velour has come to be used frequently to describe any fabric with a pile. Textile dictionaries offer the following:

Velvet - "From the Latin vellus, meaning a fleece or tufted hair." 1 "A cut warp-pile fabric, originally of silk, in which the cut ends of the fibres form the surface of the fabric" (Textile Institute, 1995).

Velour - "From the Latin vellosus, meaning hairy. The material is a thick bodied, close napped, soft type of cloth. Generally speaking, a velour is a cloth that runs from 10 to 20 ounces per yard, and is given a face finish" (Linton, 1973).

Woven Velvets in the North American Markets

Woven velvets and velours can be found in every textile market: Apparel, Automotive, Home Furnishing, Contract Upholstery, Transportation, and Industrial/Specialty Fabrics. Each use is represented by a uniquely constructed product depending upon the cost, aesthetics, and performance expectations of the customers. The two largest markets for this product are Automotives and Home Furnishings.
Traditionally pile or plush fabrics were used in automotive for not only seat upholstery but also for side walls and window channel lining. (Berry, 1964) The woven pile fabrics used in these markets fit into the velour category. Woven velours used by the U.S. automotive seat manufacturers in 1998 represented about 23% of all automotive seating fabrics or approximately 21.5 million yards. Likewise the usage in the U.S. home furnishings area was 11% of all fabrics used or approximately 34 million yards.

Currently woven velvets are more likely to be found in a rugged vehicle like Chevrolet Truck in North America (Moon, 2004) and Japanese passenger cars.

Woven velvet suppliers to North American market include Milliken, C&A, Guilford, Chatham Borgstena, Suminoe, and Kawashima. Woven velours are widely used around the world in bus, coach and rail upholstery, primarily of wool or a blend of polyester and wool. John Holdsworth of England is a major supplier of woven jacquard wool velvets to the bus, coach, ferry, and rail markets. Culp, Joan, LaFrance and J.B. Martin also have woven velour capabilities in the U.S. but are primarily focused on the home furnishings markets.

**Figure 1. Van de Wiele Jacquard Velour VTR machine (Used by permission of Van de Wiele)**

**Woven pile construction**

Although there are other ways of forming a velour fabric such as the wire method, this paper’s primary focus will be on the production of current transportation velours. The method of choice for producing velours today is to use a double insertion rapier machine. There are two manufacturers of such machines today: Van De Weile and Gunne. These machines produce two pieces of fabric at one time in sandwich form and cut the sandwich by means of a reciprocating knife blade on the front of the machine. Figure 1 shows pile warp yarn being brought in from the yarn creel on the left and separated jacquard fabric pieces being rolled onto frames on the right. These machines run around 300 double picks/minute depending upon the yarns being woven and the nature of the fabric being made. The shedding motion is usually controlled either by rotary dobby or jacquard head. The pile warp yarn is either fed (dobby) or pulled (jacquard) into the feld of the fabric. The sandwich structure is made by the interlacing of the pile warp yarns between the picks of the top and bottom pieces of fabric. (See Figure 2.)
The current, significant design limitations of the dobby double rapier velour machines are:

- Maximum of ten harnesses capable of three position (pile) weaving.
- Maximum of three sets of delivery rolls for pile.

Jacquard controlled pile eliminates these design restraints. In the recent past, the repeat size of a common tie-up could not exceed about 27" even though you might have as few as 2400 ends in the pile. This was because to weave patterned pile fabrics you must have three-position capability for the pile ends - up, down, and center. (See Figure 3). This effectively halved the number of hooks available to be used in your pattern.
Today, with the advances made in Jacquard technology and with the introduction of the super jumbo heads with over 6000 hooks, it is possible to weave full width fabric of approximately 60" without having a repeat in the tie. The switch from mechanical hook selection to electronic hook selection enabled Jacquard controlled velour machines, which in the past ran around 190 picks/minute, to approach the speed of the doby controlled machines. Jacquard controlled looms now run in production around 240 picks/minute. Unlike the doby machines, the Jacquard machines have no delivery feeding systems for the pile. Instead they rely on the use of gauges, thin metal strips that are inserted through the harness pack through the reed and into the feld of the fabric to maintain the distance between the top fabric back and the bottom fabric back. These gauges determine the pile height and therefore, the consumption of pile yarn into the fabric.

Some disadvantages of Jacquard machines are:

- Even with improvements they still run 20% slower than dobbies.
- Because the Jacquard machines pull pile yarn from the creel rather than being fed through delivery rolls, they are prone to create tension streaks in the fabric.
- Jacquard machines require carbon steel reeds because of the rubbing of the metal gauges.
- Jacquard machines require more floor space due to having a creel behind them for the pile yarn. For this same reason it also requires a pencil tube winding process to put the pile yarn on small packages.
- Although there is great flexibility in patterning, there is very little flexibility in changing the construction that a machine creates. The tie-up complete with comber-board and spring-board is virtually one off items that require weeks to prepare, install, and draw. The gauges, which are the means to vary pile heights, require hours to change compared to a doby machine on which pile height can be changed in minutes.
- Higher initial investment. Complete Jacquard set-up costs about 1/3 more than a doby machine.

**Design and Development**

As with any fabric, there are specific parameters that define a particular style. For woven velours as with most fabrics, these parameters are

1) the yarns
2) the arrangements of the yarns
3) the movement of the harnesses
4) the draw-in-draft
5) the density of the fabric and pile height
6) the finishing applied to the fabric.

1. **Yarns**

The ground warp and filling yarns, which make up the base of the fabric, do not usually contribute to the novelty effect of a woven velour fabric since they are covered by the pile. In most transportation applications they are either natural and/or solution dyed. When grinn through, the effect of seeing the ground through the pile, is not an issue the more cost effective natural or undyed yarns are used. These yarns, along with the weave structure, must be selected to lock the pile tufts in the fabric. The size of the ground and filling yarns to be used is dependent upon the:

- picks/inch
- ends/inch
- pile yarn size
- ground weave

In many cases, filament yarns primarily polyester are used for these applications because of the advantages they offer in cost and runability. In cases where better tuft lock is needed, spun yarns can be used. The hairy, rough textures of these yarns tend to provide bulk and slide resistance and
therefore, a better lock of the pile tuft. Other key performance issues to consider in selecting the ground and filling yarns are drapability, moldability, stretch/elongation, and grin (pile break). The drapability and moldability can be improved by using yarns with some rayon content in the ground and filling. This seems to be especially helpful when the fabric is formed using a steaming process.

Figure 4. Pile tufts  (Source: Scotweave.)

Stretch is a primary concern for many woven velour users. The need to lock the pile by the ground and filling yarns greatly limits the weaves that can be used. The ground weave is most commonly a one-up/one-down two by two basket weave (best tuft lock) or a plain weave (used for "w" weave pile or very dense "v" weave pile). These weaves yield poor stretch results. The use of specialty yarns such as Lycra or PBT to overcome these construction limitations has been a more expensive but, successful way manufacturers have addressed the need for more stretch. The use of such specialty yarns often required additional finishing processes to maximize their contribution. The stretch comes from shrinkage of the fabric and usually included overfeed and relax drying in the finishing. Needless to say, the shrinkage adds to the cost by increasing the density. To keep the fabric cost down and the density of the finished fabric at a target construction, the griege material can be made less dense to account for the gain in finishing. The challenge in this is the handling of the greige fabric which is now even more susceptible to damage. Another draw back to allowing the fabric to shrink is that most of the capacity to manufacture woven velours is at maximum on-loom widths of just over 65". This yields off-loom greige widths of about 60". To get stretch from shrinkage the fabric must be quoted at less than the standard 69" width for automotives.

In very limited application such as stage curtains, the fabric performs better with as little stretch as possible. In such a case higher tenacity yarns used in the ground and filling in conjunction with calendaring the fabric back gives very low stretch.

The recent trend in automotives among the transplant OEM's is to require less grin or pile break. Grin or pile break is the tendency of woven velours to open vertically (warp wise) when bent or to be so under constructed that the ground shows through. These customers now prefer lower, more dense pile. This can be obtained by increasing the greige density and/or by shrinking the fabric in finishing. Using higher shrink yarn is also an effective way to minimize pile break but, poor hand usually result from the curling of the pile yarn when it shrinks. Yarn manufacturers continue to experiment with hybrid yarns of differential shrinkages and high shrink yarns with lower DPF (denier/filament).

As it is the aesthetic part of the fabric, the pile yarn is the most critical component of the product. It usually comprises most of the content by weight of all raw materials and therefore heavily affects the cost. Being the surface effect, the pile yarn bears the brunt of wear and testing. Damage to the pile can be easily seen. As with other fabrics, the properties that yield the desirable characteristics are conflicting. Many applications require soft hand that requires lower DPF, denier/filament. For good abrasion and resiliency you need higher DPF. For better coverage you need...
larger pile yarns or more tufts/inch, which means more dents/inch or picks/inch since the pile tufts wrap around the picks.

It is important to remember that small changes can add significantly to the cost. Luster is a critical aesthetic and performance factor. Dull yarns are harder to cut and harder to dye but they are better for "whiteing-out" and "finger marking". Bright yarns in low light can give a luxurious sheen. A great deal of effort goes into finding the optimum balance of cost and characteristics for each automotive customer’s performance standards and design/brand image. The selection of the yarn to be used for the pile has greater impact on the nature of the final product than any other raw material decision.

2. Warp Yarn Arrangements

As with any fabric, the arrangement of the various yarns used in the pattern is one parameter that determines the fabric style. In most woven velour applications, the pile warps are the only "planted" or patterned element. Obviously, not all styles require patterned warps. The order of these ends is displayed in similar manner as other textile constructions since the beaming or, in the case of Jacquards, the creeling processes are similar. Fabrics using patterned ground warps and filling stripes are found from time-to-time but are rare and most often are found in conjunction with areas of fabric without pile (cutouts).

3. The Weave

The motion of the harnesses determines how the fabric is physically put together. In the case of woven velour fabrics there are two separate but interrelated parts of the weave; the ground weave and the pile weave. The ground weave must interlace with the pile weave in such a manner as to provide a good lock for the pile tufts. In most cases in which a "v" tuft or one of its derivatives are used for the pile, the ground weave is a two-by-two plain weave with the pile in the center of each pair of two ground ends. This is the most common ground weave.
The pile weave is generally depicted by a cross sectional view of the harness motion showing the relative position of each harness, up, center, or down, on each pick in the pattern repeat. There can be more than one pile end used to create a column of pile tufts. The use of more than one pile end/dent adds to the cost due to yarn being "buried" or "incorporated" into the ground when not being brought to the face. This technique adds to the design capability of the construction and is often used to create multicolor, full-face designs. Today in the U.S. most constructions have from one to three pile ends/dent. Most Jacquards use only two "frames", a term referring to the sectioning of the creel but for our purposes meaning two pile ends/dent. The three end/dent pile constructions are generally found in dobby velours to expand their design capabilities further. Rarely, a four end/dent dobby can be found due to excessive cost. Once the cross section and the ground weave have been determined, this information is translated into a pattern chain which is then used to set up the machine.

Until recent years, woven velour design has been done almost exclusively by hand. With only a handful of manufacturers, the potential market for a woven velour CAD system was unattractive to software developers. Most manufacturers of Jacquard woven velours use Sophis flat woven design software in conjunction with a modified input method to roughly simulate velour designs. The designs are accurate but the simulations are still two-dimensional. ScotWeave began development of a true...
woven velour software package in the late 1990's. It has evolved into a technical design system for woven velours capable of producing all of the outputs necessary to manufacture the fabrics - cross sections, warp arrangements, harness draws, lifting plans, and specification sheets. This software has limited simulation capability and can be used in conjunction with their drape software.

When designing woven velours, it is important to remember that differences between the top and bottom pieces of the sandwich may exist. These differences may manifest themselves in:
- appearance
- weight of the fabric
- tuft-lock/pile-lay

Some may be correctable in the finishing process while others will have to be corrected by altering the design and construction. Some, in particular, twills cannot be corrected and must be marketed as two different looks with two different stock keeping units or part numbers for each side of the fabric. Many of these differences stem from the fact that the two sides of the sandwich are usually mirror images of each other. This is the case of twill direction and asymmetric color or motif direction (See Figure 6).

![Figure 6. Variation in Top and Bottom Fabric Pieces (Manley, 1999).](image-url)

Weight differences may stem from the incorporation of the unseen pile yarns in the ground of the top and bottom fabric. This is usually done in an every-other-dent arrangement (top/bottom/top/bottom) in order to keep the 50:50 ratio of ends, the need to form a shed for the rapiers to ride through, and to lock in the pile tufts. If you use different sized yarn in a pattern that always puts the smaller yarn in the even dents, then one side of the sandwich will be lighter in weight than the other. This may or may not be negligible. For this same reason, sides of the sandwich can look different on
the back of the fabric due to the color pattern although the pattern looks identical on the face. This is probably not a problem but, needs to be explained to and understood by your customers. Differences of tuft-lock or pile-lay probably relate to differences between the ground weaves of the two sides of the sandwich and should be corrected.

Weight differences between top and bottom may also be a processing issue on the loom. Care must be given to insuring that the pile is being slit in the center of the fabric sandwich. See Figure 7. As the knife blades wear the presentation of the knife edge may change. There must be frequent procedures for comparing top to bottom tuft length and maintaining the cutting system.

The use of cutouts is an economical method to create patterns without the use of different pile yarns. A cutout is simply a place in the pattern where the tufts have been left out. When using cutouts, the ground warp and filling yarns may become part of the aesthetic quality of the fabric requiring the use of fancy yarns and/or arrangements. Cutouts offer texture to the fabric that in some cases is a desirable quality. Because the use of cutouts reduces the density of the pile, the remaining tufts must bear the abrasion and crushing of testing and usage. Sometimes, it is necessary to "beef-up" the pile by doubling the density in those areas that still have pile. This of course adds cost back and forces you to utilize a less desirable ground weave to lock in the pile-on-every-pick weave. It is noteworthy that cleaning of fabrics with cutouts is more of an issue since the deep voids act as traps for debris, earning them the name of "crumb catchers" in some circles. There are other methods to arrive at similar effects without the complexity of the set-ups required to produce true cutouts. Using high shrink yarns in addition to low shrink yarns achieves a faux cutout with less of the crumb catcher issue. Embossing, etching, and pattern shearing are also patterning methods that yield similar looks.

4. Draw-In Draft:

The draw-in drafts for woven velours are similar to those of other woven products but, have the additional pile elements (See Figure 5). Since it takes a week or longer to draw a set of harnesses, install them, install the stop motions, and get the machine into production, selection of flexible draws is a must. These processes are labor intensive, as there are no automatic draw-in machines for woven velour looms. The draw-in draft defines which harnesses work together to produce one column of pile tufts. The draw-in draft also shows how the yarns are to be drawn in the reed. The pile ends can either be drawn in the center of the dent with ground ends on both sides of the pile or in a side draw with a reed wire on one side of the pile and ground ends on the other. The side draw is considered to be better for runability because it tends to reduce the stops and defects related to catches of the pile yarn. The center draw is considered to be better for smooth cutting because it marginally increases the locking of the pile. These are "tweaks" that could help depending on the nature of a particular style. If you have more than one pile end/dent, running a split-by-the-dent reed draw reduces the rolling of the pile ends caused by the rubbing of the rapiers on the yarn shed during insertion and removal and therefore, improves runability. In this reed draw, one end of pile juxtaposed to others is drawn in one dent with the
remaining pile end(s) drawn in the adjacent dent. In styles where crisp clear vertical lines are desired, it may be better to run all of the pile ends making a column of pile tufts in the same dent.

5. Density and Pile Height:

The height of the pile tuft affects dramatically the softness of the face and how the fabric responds to abrasion and distortion. Again, opposing properties creates desirable characteristics. The shorter pile generally performs better in testing and wear while the longer pile gives softer touch and better coverage. Remember, pile height adjustment on a dobby machine is a fifteen-minute mechanical change while the same for a Jacquard machine means changing the gauges.

The more pile that is fed into the fabric the higher the delivery, or rate of consumption of the pile will be. The delivery is calculated by determining how much yarn is consumed in one repeat of the pattern. For example, consider the delivery calculations for a 36 pick/inch fabric with a two pile end/dent draw making the following cross section in a 6 pick repeat:

![Figure 8. Two pick “V” Weave (Manley, 1999)](image)

36ppi / 6 picks/repeat = 6 repeats/in

Therefore; you have for harnesses 1 & 2:

4 tufts/repeat X 6 repeats/inch = 24 tufts/in

We know that the tuft length is roughly equivalent to twice the pile height so to make the tufts required for harnesses 1 & 2 it takes 24 tufts/in X 2 (.110”ph) = 5.28

This is a ratio of yarn consumption to fabric sandwich formed therefore, there are no dimensions associated with the final number.

It is also necessary to determine the part of the delivery required to make the "buried" part of the pile for these harnesses. Based on analytical study, the delivery of the plain weave is about 1.10:1. Consider the number of picks/repeat in the plain weave made by these harnesses (2 picks/repeats X 6 repeats/inch = 12 picks/inch) and divide this number by the picks/inch, the resulting number is the proportion of the time these harnesses spend on this weave in picks/inch. This percentage can be multiplied by the 1.10 delivery to get: (12 picks/in. /36 picks/in.) X 1.10 = .37 which is the delivery that must be added to the tufting delivery to arrive at the total delivery needed for harnesses 1 & 2 to make this weave: 5.28 + .37 = 5.65 total delivery.

When we run through this same procedure for harnesses 3 & 4, we get: 2.64 + .73 = 3.37 total delivery.

Upon comparing the two deliveries, the lower delivery is 60% of the higher delivery. This is important because the machine must be geared to run the higher delivery and the lower delivery is obtained by disengaging an electrical clutch 40% of the time. The newest, most advanced dobby machines use microprocessor controlled, independently driven beam let-off systems that offer better control. Jacquard machines rely on the number of pattern repeats in an inch of fabric.
pulling of yarn into the fabric from a creel. Delivery calculations are still utilized for cost purposes as well as to determine what size to make the pile yarn packages.

Another way to increase the coverage of the pile is to increase the number of tufts/inch. This is done by adding picks/inch or ends/inch. Adding picks is much easier since it is only a gear change or an input to the micro processor. Adding ends/inch requires re-reeding the draw and, if width is to be maintained, the addition of ends to the beams. As mentioned earlier, another method of marginally increasing density is to allow more shrinkage in the finishing process. This method without changes in the construction would result in narrower fabric and less yield.

6. Finishing Applications

The finishing treatment of woven velours is critical. The pile must be tip-sheared to even the surface and it must be brushed to open up the tufts. Brushing is also necessary to set the pile angle. These processes must be carefully controlled as pile height, fullness, and angle can greatly affect the appearance of the pattern and color of the fabric. The use of heated cans to reduce the floppiness of the fabric near the selvages before shearing or brushing may be necessary to eliminate processing issues. Heating the fabric during brushing using IR heaters often makes the brushing more effective.

Woven velours can be piece dyed, with care, by most methods. However, most of the velours produced in the U.S. today are either package dyed or solution dyed because of the limitations of color contrast and color complexity in the piece dye processes. Piece dyed velours are now being used as bases for pattern finishing techniques such as printing, etching, embossing, and pattern shearing, among others. These patterning processes are certainly not exclusive to velours.

Woven velours are usually back coated with acrylic latex or a hot melt adhesive to improve the tuft-lock. Particularly in the case of automotives, the fabrics are often laminated to poly-ether foam. In applications where the laminated fabric can be certified as a composite, the coating is sometimes omitted. In addition to tuft-lock, coatings also help with FR (flame retardant) requirements, percolation (the tendency of fibers from backings or fillings to work their way to the surface of the fabric), and to stabilize sewn seams so they do not distort under tension. Other treatments include topical applications of softeners, stain resistors, antistatics, antimicrobials, etc.

Construction Comparison

Woven velours for the home furnishings market typically are low pick/inch (30-34) and low sley (19dpi-21dpi) fabrics that utilize less costly acrylic and polypropylene pile yarns in low density constructions and weaves. The pile is more laid than automotive velours (60 degrees) to mask the open construction. Price pressure is tremendous in this market with the sell prices ranging from approximately $3.25 to $6.25 per linear yard at widths of about 54”.

Woven velours for automotive upholstery are usually slightly denser. They generally range from 34 picks/inch to 44 picks/inch and from 20 dpi to 24dpi. Most of the fabrics utilize some variation of the “2 pick ‘V’” weave and are mostly full pile coverage. Pile heights range from .090” to .115” The tufts are most often erect or nearly erect in angle. In order to get more design flexibility from the dobby machines, some 3 end/dent constructions are used. Jacquards are usually 2 end/dent as mentioned before because jacquard controlled machines inherently have much more design capability. The ground yarns are usually solution dyed polyester of about 450 denier and the filling is usually solution dyed polyester of between 450 and 600 denier. The pile yarn is in most cases filament polyester of between 300 and 500 denier.
At present, full dull pile is preferred because it does not appear to finger mark as bad as other lusters. Some, but very little, nylon is used as pile primarily due to cost and environmentally unfriendly dye carrier systems. Polypropylene and wool blend yarns are used for bus fabrics for there improved abrasion and flammability. Novelty yarns used in these fabrics include space dyed, knit-de-knit, dye/twist type, color and slub injected, slub, bright luster, or metallic-like yarns among others. New yarns in the market are various microdenier splitable polyesters (both mechanical and chemical) for improved hand and suede appearance. Selling prices can range from $6 to $13 per linear yard at widths from 54” to 59”.

Woven pile fabrics which have not been separated into two panels are called sandwich fabrics. These types of constructions have potential for other uses in automotives. Research in the creation of woven sandwich constructions for light weight, durable composites continues. These polyurethane or resin impregnated woven velvets create composite panels used in transportation applications such as train flooring, convertible hard tops, boat hulls and other vehicles (Judawisastra, H., 1998).

**Woven Velour Quality Concerns**

Many of the quality concerns of woven velours are shared with other textile products:

- yarn defects
- wrong arrangements
- streaks
- lot-to-lot consistency
- mis-reeds

There are some quality variables specific to woven velours in either occurrence or appearance.

High and Low or uneven pile, some call it wash-boarding, is caused by the action of the rocker-bars (also called jerk-rods) in relation to the delivery and the consumption of the pile. The rocker-bars are the mechanisms that temporarily store the unused pile yarn that is delivered but not used because the ends from more than one harness run through the same delivery. The rocker-bars also serve the purpose of maintaining tension on the pile yarn during harness movement. The mechanical tensioning devices employed by the rocker-bars are springs. The tension exerted by a spring increases relative to its extension. Therefore, the longer the rocker-bar absorbs the delivered yarn, the lower the tension applied to the ends on that harness. Conversely the more the ends on a particular harness are used relative to the other harnesses on that delivery, the higher the tension applied to those ends. A balance between consumption, delivery, and storage of the yarn must be found to minimize the uneven effect. Most often, each harness has its own rocker-bar for maximum draw flexibility however, harnesses that move exactly alike or exactly opposite can run on the same rocker bar.
"J" tufts are usually considered to be an objectionable pile characteristic. This is the result of the cutting action on a fabric sandwich with poor tuft lock. This defect gets its name from one half of the tuft being shorter than the other creating a "J" instead of a "V". Actions that help tuft lock such as using a different ground and/or pile weave, using larger or more bulky ground and filling yarns, or using a center drawn pile (in the reed) should reduce the occurrence of this defect. In some constructions for low-end home furnishing fabrics, "J" tufting actually creates a more desirable finish. In these fabrics, the coverage is very open and the pile is laid virtually flat. The "J" tufts give the effect of higher pile and tend to cover more of the open area. However, it is not recommended that this be intentionally developed into a fabric. The potential for cutting related defects requires continuous maintenance of the blades and the cutting motion. Rough cutting results from dull or improperly adjusted blades and insufficient tuft lock. Chatter marks result from improperly adjusted or worn knife carriage guides. Moiré cutting can be caused by any of the aforementioned items.

Figure 9. Pile Delivery: Rocker Bars (Manley, 1999)

Pile density must be consistent. Barre' when seen in the greige woven velour fabric manifests itself as horizontal bands of more and less dense pile and is usually caused by wear in the ground beam let-off. Another defect in inconsistent pile density is "pinholes"; this is caused by the take-up roller pins actually shifting the picks and therefore the pile in less dense constructions. "Pinholes" look like eyebrow shaped distortions of the pile.

Tuft lock must not only be sufficient to make the greige fabric: the fabric must be tightly enough constructed to make it to and through subsequent processing with the tufts intact. Even still, special care must be used in the handling, transport, and processing of woven velour fabric. Bruised-backing can occur when the back of the uncoated fabric rubs another object. Bruised-backing is the condition of having tufts partially pulled out of the fabric as a result of the rub. Crush marks or compression marks come from the fabric being rolled too tightly or for too long of a period. Temperature and humidity are variables that must be considered in planning for storage or transportation when using certain fibers for pile. In prolonged
periods of shipping and storage, the fabric is usually suspended.

Again, proper pile height, pile angle, and pile bloom makes an importance contribution to the desired appearance and color of the fabric.

**Conclusion:**

Woven velour design and manufacture are complex processes which must be accomplished within the stringent performance and price pressures of the automotive industry. A multitude of variables and their interactions can come together to make a successful or unsuccessful product. Once the physical aspects of the product have been determined, colors and motifs must be chosen that satisfy the design requirements of the automotive customer. It is most certainly a challenge to accomplish this while working within the limitations that exist. It is this challenge to learn new ways to work within and expand these limitations that makes creating woven pile textiles interesting.

**BIO: Scott Manley**

BS, Textile Management, Clemson University (1991)

As Senior Development Engineer / Technical Designer for automotive development within Milliken & Co (1994 - 2003), Scott Manley managed sample manufacturing process for woven velour product line and all aspects of product development. Previous experience included work in the successful start-up of a woven velour manufacturing operation for Guilford Mills as Technical Designer / Production Manager for Automotive.

Manley managed the production weaving, beaming, and finishing departments for woven velvets. Manley was also responsible for product design and development and constructed a cost model for product line.

As Weave **Plant Superintendent** at Collins & Aikman, Manley managed the sample department, all plant capital projects and contractor work, and evaluated and recommended capital equipment purchases for woven velours. Manley began his experience in woven velours as **Shift Department Manager** at Culp Woven Velvets.

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