Application Example
Production of Textile Fibers

About the Process
Typically the production of man-made colored textile and carpet fibers involves the feeding of two or more components into a single screw extruder, where they are mixed and extruded as a filament. Filament pumps, nozzles and further processing equipment ensure the fibers have the correct form and thickness. The key concern of the manufacturer is that the color of the fiber is uniform and consistent, with no visible variations in color.

To ensure consistent color in the final product, resin/dye blending is increasingly performed gravimetrically by weight rather than by the less accurate volumetric approach. Blending by weight continually adjusts for variations in density of the components, providing consistent end products.

The thermoplastic filaments are produced with special gear pumps called spin pumps and heated spinneret die heads capable of extruding up to several hundred filaments simultaneously. Because the filament will be stretched to the desired dernier (thickness), it is especially important that the diameter of the extruded filaments do not vary. Uniform melt distribution and temperature are highly critical. The spin pumps provide the required smooth, constant melt flow, independent of small variations in the extruder rate.

After forming, the filaments drop vertically into a continuous cooling tower where the strands solidify under forced air. Depending on the application, the filaments then move on to one or more cycles of stretching. Here the filaments are routed through a set of godets whose speed differentials are closely controlled to produce the specified strength and dernier.

Where a texturized filament or strand of filament is desired, the product may be passed through a texturizing unit before or after spinning. A typical texturizing unit uses high-pressure compressed air to form the filament or strand. The filaments then pass to a bobbin winder either as individual filaments or spun strands. At that stage the product is ready for sale or further processing.

Choosing the Right Solution
New solutions are constantly appearing in today's quickly changing marketplace, but know-how is an important component of any technical solution. The three solutions presented here represent the extensive feeding and blending know-how of both the K-Tron Feeder Group and K-Tron Colormax, now united in the K-Tron Process Group. K-Tron PCS, with its years of experience in conveying bulk solids, rounds out the know-how of the Process Group.

K-Tron has long served the plastics industry, supplying feeders, blenders and refill systems for resin production and demanding extrusion processes, such as textile fiber production. We recognize that applications range from quite simple to very complex and we have the know-how and experience to provide the optimal solution for each case. A comparison of the technical requirements of your process and the features of the various solutions K-Tron has to offer will guide you in selecting the right solution for your textile fiber process.

Textile Fiber Production
K-Tron offers a variety of solutions for supplying the base resin, color masterbatch and additives to the extruder. See the following pages for more details.
Choosing the Right Solution for Your Process

Typical Ingredients
The typical throughput range is 100 - 500 kg/hr (220 - 1100 lb/hr). Depending on the number of color masterbatches, feed rates are generally as follows:

**PP / PE / PA Pellets**: 50 - 500 kg/hr (110 - 1100 lb/hr) at a bulk density of 0.4 - 0.6 kg/dm³ (25 - 37 lb/ft³).

**Color masterbatch and stabilizer pellets**: 0.2 - 5 kg/hr (0.44 - 11 lb/hr) at a bulk density of 0.5 - 0.8 kg/dm³ (31 - 50 lb/ft³).

To ensure the coloration of the fibers is consistent high feeding accuracy is required for the masterbatch: ± 0.2 to 0.5 % 2 Sigma at a sampling time of 10 - 20 seconds.

Product Quality
Volumetric blending limits blend ratio accuracy to ± 2-10% by weight, due to material density variations. Off-line batch weighing can lead to batch-to-batch inconsistencies and leaves the formulation vulnerable to ingredient segregation in storage, transport and handling. However, continuous gravimetric feeding or blending with one of the solutions described here ensures a much higher blend accuracy and therefore end product quality.

When critical ingredients must be delivered to the process at specific proportions, K-Tron's digital load cells allow the processor to reduce overfeeding while maintaining product specification. Significant savings can be realized for processes with expensive color concentrates and additives.

More accurate blends also result in less scrap and regrind. For processors this means less cost in terms of time, energy, manpower and equipment related to wasted or recycled products.

Solution 1
The base polymers PA, PP, PE, etc. are fed into the main inlet of the single screw extruder. Simultaneously, a compact loss-in-weight feeder feeds the color masterbatch into the continuous main polymer stream via a special inlet section, in proportion to the main flow. The throughput of the main flow of polymer is determined by the screw speed of the extruder.

The loss-in-weight feeder controller regulates the mass flow of the masterbatch, increasing and decreasing the rate in a linear fashion depending on the number of pumps/nozzles which are online. K-Tron's compact single and twin screw feeders are ideal for accurately feeding the color masterbatch.

The patented weighing technology features a resolution of 4'000'000:1 in 80 ms.

The disadvantage to this process is that the main stream of base polymer is not actually measured and therefore it is not possible to calculate an exact ratio between base polymer and masterbatch.

Solution 2
All ingredients, the base polymers PA, PP, PE, etc. as well as the color masterbatch, are fed into the extruder using individual loss-in-weight feeders. Since all components are fed gravimetrically in this process, an exact proportion by weight of base polymer and masterbatch can be ensured at all times (completely true to recipe).

This solution is favored in the textile fiber industry because the mass flow of each individual component can be checked and adjusted at any time. The total mass flow is regulated based on the readings of the level sensor in the collection hopper above the extruder inlet.

In addition to the compact feeder for the masterbatch or additives, K-Tron offers a selection of feeding equipment for the main polymer, i.e. single screw feeders or Bulk Solids Pump (BSP) feeders in various sizes.

K-Tron PCS vacuum conveyors can be used to reliably keep the loss-in-weight feeders supplied with the bulk materials.

Solution 3
The third possibility is to use a gravimetric blender to feed all ingredients, main polymers as well as color masterbatch and other additives. Since here too all components are fed gravimetrically, once again an exact proportion by weight of base polymer and masterbatch can be ensured at all times (completely true to recipe), ensuring a more accurate blend and higher end product quality.

The main advantage in using a gravimetric blender instead of individual weigh feeders is the efficient use of space, clustering the feeders compactly around the extruder inlet.

Depending on each application and its unique requirements, K-Tron offers two gravimetric blender solutions, which can be tailored to the customers’ needs.

The K-Tron Colormax Multi Weigh blender is a simple, economical solution for flood-fed processes.

The K-Tron K4G modular blender offers more features and flexibility for a more customized solution.

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**Process Diagram**
with compact feeder feeding the color masterbatch inside a protective clear acrylic enclosure (Solution 1)
Multi Weigh Blender
The K-Tron Colormax Multi Weigh Blender fits up to four feeders in a compact housing that can be bolted directly to the extruder inlet. Two sizes of feeders are available and combinations are possible. All feeders feed material at the same time at different ratios according to the recipe required. The throughput of each component is measured by the individual digital load cell and the speed of each feeder is adjusted to achieve the desired blend, with the major component running at full speed. Individual cascading material streams are delivered to a common outlet. The blender will continue to feed until the blended material falls below the level sensor, reinitiating the blending operation.

Multi Weigh is supplied with easy to use controls that incorporate a number of standard control routines. Full alarm capabilities for automated monitoring and material throughputs for accurate inventory control and cost analysis is standard. Built in refill controls allow the addition of automated refill hoppers without additional control interfaces. And when interfaced to a host computer, Multi Weigh forms a critical link in the overall Quality System.

Today the need to complete small runs is vital to processors. Shut down and start up costs are often unidentified but can result in significant machine down time and lost production. The screwless Posimax feed device allows for rapid clean out of the blender. Built-in slide gates and reversible feeding allow processors to capture and reuse expensive ingredients for future use.

K4G Modular Blender
The compact design of the K4G integrated system groups one, four or six feeders with K-Tron PCS receivers in a compact base frame which can be mounted directly over the extruder inlet.

A wide variety of K-Tron feeders can be integrated into the K4G single-point weighing system, depending on the feeding requirements. Single screw feeders, Bulk Solids Pump feeders are used for handling free flowing bulk materials. Twin screw feeders are used for powders and non-free-flowing materials. The system is completely modular: feeders, hoppers and receivers can be exchanged or removed as needed.

The system features a modular base plate, pivoting mounting support with a single point weighing system, a central K4G collection hopper with pre-cut feeding ports and a refill support stand. Each system component is suspended from a single point and can therefore be swung out on its axis, independent of any auxiliary devices. This allows easy cleaning or replacement of equipment modules, e.g. the feeder screw, as well as sampling.

The K-Tron SmartConnex control environment provides long term stability, good reproducibility and consistent feeding quality. The K-Tron Control Module (KCM) combines motor control, feeder control and the operator interface in one compact unit mounted directly at the feeder.

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The Multi Weigh Blender provides processors with high accuracy blending of up to four different materials. Synchronized feeding of all components ensures a constant blend and avoids layering and the need for an additional mixing device. The easy-to-use control system incorporates a number of standard control routines, including: calibration, filling and starting an empty blender, and emptying a unit for a production change. As well as running the loss-in-weight feeders, the multi-weigh controller will sequence up to four vacuum loaders and a vacuum pump.

The K4G Feeding and Blending System can be adapted quickly and easily to the material characteristics of the individual materials to be fed. Depending on the requirements, the following types of feeders can be integrated into a K4G system:

- **BSP (Bulk Solids Pump)** Feeders guarantee consistent, linear mass flow with no pulsations.
- **KQx Single Screw Feeders** are ideal for the small feed rates required for masterbatches.
- **BS60 Single Screw Feeders** are ideal for feeding free flowing powders and granulates.
- **KT20 Twin Screw Feeders** are ideal for fine, poorly flowing additive powders.

In order to ensure a consistent flow into the extruder inlet, a level sensor continuously keeps track of the amount of material above the extruder inlet and automatically regulates the feeder throughputs as needed. The exact ratio of ingredients is maintained at all times.

The K-Tron K4G Feeding and Blending System with integrated refill guarantees high short-term feeding accuracy for a wide range of feed rates thanks to the latest generation in SFT weighing technology.

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