The ABCs of In-line Cutting Systems

For Edge Trim or Filament Waste

Precision AirConvey - Get-Facts@AirConvey.com
PrecisionAirConvey.com - 302-266-0555

Table of Contents

INTRODUCTION TO "IN-LINE" CUTTING SYSTEMS FOR CONTINUOUS EDGE TRIM OR FILAMENTS

Edge trim from a continuous web or waste filaments from a continuous process are commonly transported to a pneumatic conveying system from the source to the collection point.

The material discharged from such a system is usually bulky, hard to handle and voluminous. The problems associated with dealing with it are substantial in terms of manpower, the size of containers required to hold this low bulk density material, and transporting it to the point of disposal or reuse.

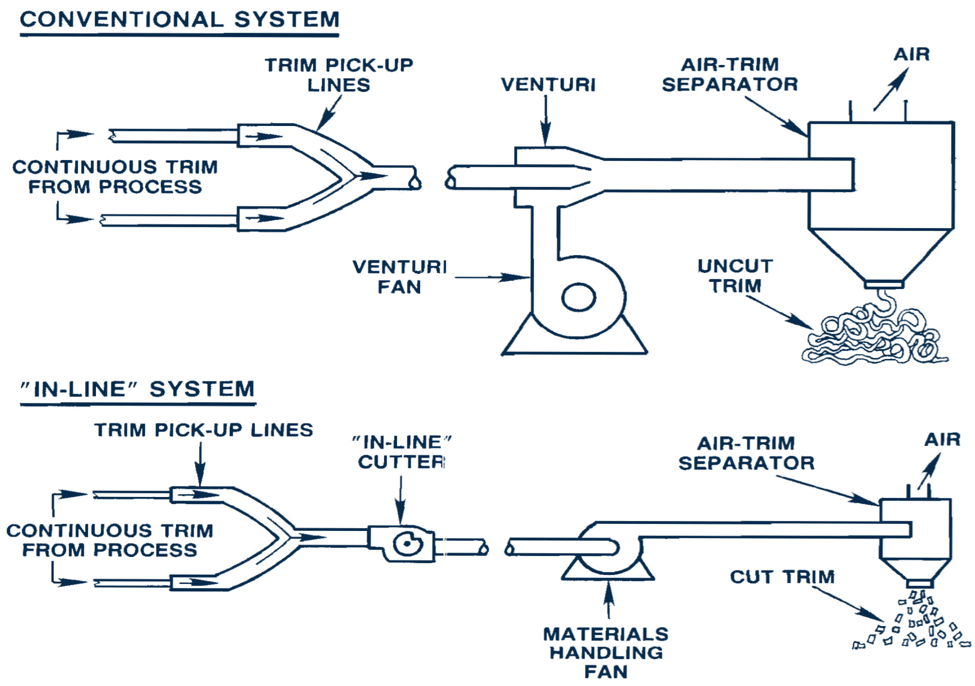
The trim or filament collected is frequently recycled back into the process. This usually requires the manual feeding of the low bulk density, hard to handle, tangled mass into a size-reduction or other processing machine -- a slow, arduous, time-consuming task.

The usual "driver" or "pump" for a pneumatic conveying system handling continuous trim or filaments is a venturi because other "drivers", such as materials handling fans, cannot handle continuous materials without jamming. Venturi units have a very low operating efficiency and, because of this, venturi users are faced with substantially higher energy costs than if a more efficient "driver" is used.

Using an "in-line" cutter in the pneumatic conveying line just downstream of the continuous trim or filament pick-up points can dramatically reduce the problems associated with handling these materials.

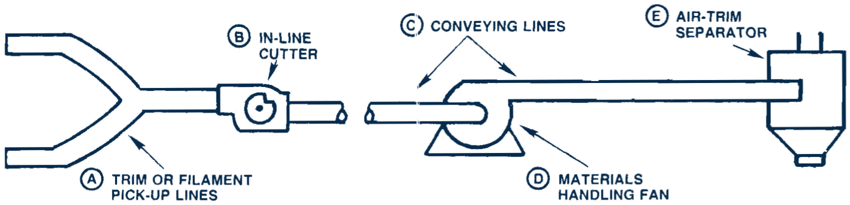
The cutter chops the trim or filament into short lengths to (1) reduce the load on the pneumatic conveying system, (2) substantially increase the bulk density of the discharged material, (3) permit the use of energy efficient fans, (4) eliminate entanglement of the trims or filaments from different sources in a common manifold pneumatic system, and (5) create a manageable, higher density product that is easy to handle, store and feed into most recycling systems.

The net result is a substantial savings of money, manpower and storage space.

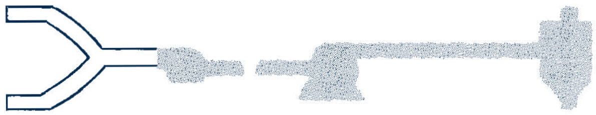


BASIC SYSTEM COMPONENTS

Trim and filament pick-up lines start close to the point of origin of the edge trim or the filaments and continue to the junction point of the lines just before the cutter.



A TRIM OR FILAMENT PICK-UP LINES



Each leg of the pick-up line system should be the same <u>length</u> and be placed as <u>symmetrically</u> as possible to insure an equal, balanced air flow in each line.

Most systems require that the trim or filaments are taken away under tension to effectively release the trim from the trimming knives and parent web and the filaments from the thread line.

The conveying air passing by the trim or filaments in the pick-up lines creates this tension in accordance with the following formula:

Tension = X *(times)* L *(times)* V^2

Where X = a factor associated with the surface shape, velocity and other characteristics of the trim or filaments and with the density of the conveying air.
L = length of the trim or filaments subject to the conveying air.
V = the velocity of the conveying air.

X is usually fixed for any given situation leaving **L** and **V** as the controllable design factors. Therefore, for any given situation the tension generated in the trim or filaments is proportional to the length of the "pick-up" lines and the <u>*square*</u> of the velocity of the conveying air.

The recommended minimum velocity of the conveying air in the "pick-up" lines is 4500 ft./min. with a velocity of 5000 ft./min. or higher being preferred. The velocity of the conveying air must <u>*always*</u> be substantially higher than the velocity of the trim or filaments.

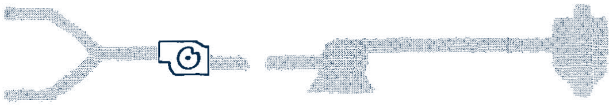
In most situations a "pick-up" line length of 6 to 12 ft. in conjunction with a 4500 to 5500 ft./min. conveying air will provide adequate tension.

The length of the "pick-up" lines to the cutter must not be overly long. Trims or filaments cut or broken off close to the source rapidly accelerate and "bunch up" in the line due to the difference in the velocity of the trim or filaments and the conveying air. This "bunching up" action in an overly long "pick-up" line will result in the formation of a large, undesirable bundle of material which can, in the extreme, jam the cutter or fan.

This bunching action will have virtually no effect for the suggested 6 to 12 ft. lengths but lengths substantially longer than this should <u>*not*</u> normally be used.

The size of the "pick-up" lines should be as small as possible compatible with air flow and the physical size and characteristics of the trim or filaments to be conveyed.

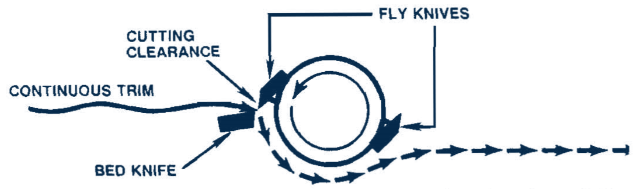
B "IN-LINE" CUTTER



For instance, a very stiff 6" wide edge trim will require a relatively straight "pick-up" line with a dimension somewhat greater than 6", but a 6" wide thin, flexible trim can easily be conveyed in a 4" curved or bent "pick-up" line.

The "in-line" cutter's function is to cut the continuous low bulk density, hard to handle trim or filaments into short, easily conveyed and handled, relatively high bulk density particles.

The cutting action takes place between a bed knife and two rotating fly knives . The cutting clearance between the bed and fly knives and the uniformity of this clearance across the width of the cutter are the factors that determine (a) whether the trim or filament can be satisfactorily cut and (b) if it can, the time, for any given wear rate, it will continue to be satisfactorily cut. The material can only be truly cut when the cutting clearance is <u>less than</u> the material thickness. At this point the knives must be re-sharpened and adjusted to the original cutting clearance.



Clearly it is advantageous to use a cutter that can be accurately set to a minimum clearance. This minimum clearance provides the versatility of cutting all materials down to the very thinnest ones. The closer the starting clearance the longer will be the operating time before the knives will wear to the point they will no longer cut. *Example*, Assume that a cutting clearance of 1¼ mil is required to cut 1½ mil thick polyethylene. A cutter that can be set to ¼ mil will have a 1 mil wear life before the critical 1¼ mil clearance is reached whereas a cutter that can only be set to 1 mil minimum will have only a ¼ mil wear life before the critical 1¼ mils clearance is reached. PAC's "in-line" cutters can provide <u>*controlled*</u> clearances down to less than <u>*0.00025*</u> ins. to effectively cut even the thinnest web or finest filament and to provide maximum knife life before the knives have to be re-sharpened.

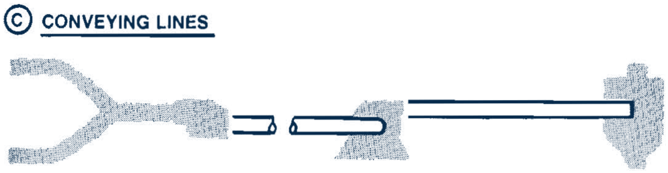
Knife wear rate is directly related to the abrasiveness, strength and other physical properties of the material to be cut and to the physical properties of the knife. The subject of knife material selection for any given application is beyond the scope of this treatise. It is recommended, therefore, that specific questions on knife material selection be directed to PAC's technical personnel, or other competent authorities in this area.

Cutters with a rotating shaft in the cutting chamber <u>*should be avoided*</u> as these are a major source of "shaft warps" and cutter jamming, key problems with filaments and fibrous or stringy trims. PAC's exclusive design has the rotating shaft <u>*outside of the cutting chamber*</u> to completely <u>*eliminate*</u> the "shaft warp" problem.

The cutter rotor should be designed for minimum pneumatic pressure drop across the cutter to reduce the materials handling fan requirement and the energy cost of operating the system. PAC's exclusive design has rotor side members located outside of the cutting chamber and an "open" rotor to insure both the free passage of the cut material through the cutting chamber and minimum pressure drop under all operating conditions.

Cut length is determined by dividing the trim or filament velocity by the number of cuts/min. Example, PAC cutters have two rotating knives and one bed knife. When driven at a nominal 1750 RPM they make 3500 cuts/min. Using this cutter with the trim from a web processed at 400 ft./min/ will produce cut pieces that are $\mathbf{\frac{400 \times 12}{3500} = 1.37}$ **ins. long.**

PAC's cutters are regularly available with a wider than usual 300 to 3500 RPM range. A simple, trouble-free, direct drive is used and speeds can be readily matched to most requirements. Other drive speeds can be supplied for special applications.



Using conveying lines as small as possible will materially reduce investment and installation costs. The minimum line size is dictated by the size and physical characteristics of the trim or filaments and the pressure drop the fan can handle. The line pressure drop is directly proportional to the square of the conveying velocity and inversely proportional to the line size.

Cut trim or filaments are much easier to convey and cause lower pressure drop than continuous trim or filaments by eliminating "bend drag" and other losses associated with continuous lengths.

Using the small conveying line sizes that are practical with these cut materials results in savings beyond those associated with buying and installing the small conveying line. The air flow required to develop the recommended 5000 ft./min. conveying velocity is inversely proportional to the square of the line size. *Example*, A 6" line requires an air flow of approx. 982 CFM to develop 5000 ft./min. velocity whereas a

12" line requires 4 times this airflow, or 3928 CFM, to develop the same 5000 ft./min. conveying velocity.

Reduced air flows result in substantial savings on those system components of operational aspects having an investment, space requirements, installation or operating cost which is based on the volume of air to be handled.

Examples are:

The material separator at the discharge end of the line will be sized and priced according to the system air flow. The lower the air flow the smaller and less costly the material-air separator will be.

Filtering of the air discharged from the system is becoming more common to meet the increasingly stringent environmental standards for particulate emissions. As with the separators, filter cost, size and servicing is directly related to the volume of air being handled. Filters for low air flow systems cost substantially less than those for high air flows.

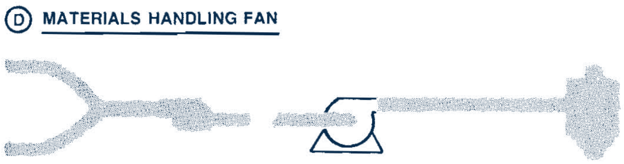
A considerable energy loss results when trim and the conveying air are picked up in a room where the air is cooled, heated, filtered or otherwise conditioned, and discharged to a non-conditioned area. The lower the air flow in the trim system the lower these losses will be.

The savings from using a low air flow system will of course depend on the locality, the control temperature in the room and comparative air flows.

In the central eastern section of the USA, a 1000 CFM of conditioned air (heated in the winter and cooled in the summer) costs approximately $5000/yr. at an increasingly common 10 cents/KW-HR. Using the previous example of a 6" line @ 982 CFM vs. a 12" line @ 3928 CFM for the same 5000 FPM conveying velocity the annual savings from using the 6" line instead of the 12" one will be impressive.

$$\frac{(3928-982)}{1000} \times \$5000 = \$14{,}730/\text{yr.}$$

Savings of this magnitude provide a strong economic incentive to utilize the recommended small conveying lines, an "in-line" cutter and a high head, low flow material handling fan.



This is the "pump" or driver for the pneumatic handling system.

Material handling fans normally have an open or single shroud impeller through which the cut material can easily pass without entanglement or "balling-up".

Fans are available in a wide range of sizes with those designed for high air volume and low pressure heads having wide, small diameter impellers and those for low air volume and high pressure heads having narrow, large diameter impellers.

Actual fan selection will be based on the flow and pressure requirements for the system with which it is to be used.

The air flow required in the trim or filament system to provide (1) adequate “take-away” tension at the “pick-up” locations and (2) a satisfactory conveying capability is first ascertained. The driving pressure or head required to maintain that air flow is then calculated.

The *theoretical* horsepower (HP) required to handle the system air flow and pressure requirements is:

$$\textbf{HP (air)} = \frac{\textbf{weight of air (lbs) x pressure (ft. of air)}}{\textbf{33000}}$$

The *actual* HP required will be the theoretical horsepower divided by the efficiency of the fan or “driver” used.

Example: $\textbf{HP (actual)} - \frac{\textbf{HP (air)}}{\textbf{fan efficiency}}$

The efficiency of a material handling fan is usually *3 to 4 times* that of a venturi system. Simply stated, the energy cost to run the venturi system is 3 to 4 times that to run the fan for any given system. With energy commonly costing $600 per HP per year the savings when a materials handling fan is used can be substantial in even a small continuously operating system. For example, using a 15Hp material handling fan vs. a 50HP venturi to develop the same head and flow required for a system operating 24 hr./day in a location where electricity costs a conservative 10 cents/KW-HR ($652/HP/yr) results in an *annual power savings* of (50-15) $653 = $22,820/yr.

The material handling fan cannot handle continuous trim or filaments as can the venturi. The key to capitalizing on the substantial energy savings from using a material handling fan instead of a venturi is to use an “in-line” cutter to cut the continuous trim or filament into lengths which will readily pass through the fan.

The air and the trim or filament, whether cut or continuous, must be separated from each other at the system discharge point. The conveying air is frequently filtered to remove dust and other contaminants before it is discharged to the atmosphere.

The simplest separation method is to discharge the air and trim into a porous bag, screened box or other perforated enclosure that will retain the trim but not the air. When the enclosure is full of trim the line must be shut down while the enclosure is emptied. This system is normally used only in low productivity, discontinuous operations. It does not meet the needs of modern, continuous, high productivity processes.

The use of an “in-line” cutter markedly increases the trim capacity of the enclosure, usually by a factor of 4 or 5, because the bulk density of the cut trim is substantially greater than that of the uncut trim.

The most common, and usually least expensive separator used with continuous process is a cyclone which centrifugally separates the trim or filaments from the air. The air leaves through the top of the cyclone and the material is discharged out the bottom where it is collected in bags or boxes.

Filter bag separators which combine a separating and filtering function are becoming increasingly common, particularly when control of particulate emissions is a requirement.

There are, of course, many other types of separators available to meet specific requirements.

MANIFOLD SYSTEMS

Manifold systems are commonly used when trim or filaments are generated at a multiplicity of sources reasonably close to each other.

CONVENTIONAL MANIFOLD SYSTEM

Conventional manifold systems normally use a venturi or a fan on the upstream side of the air-trim separator. These systems have, in addition to all the shortcomings of a single source conventional system, a major problem with entanglement of the trim from the various sources which results in blockage of the line, the air-trim separator, any rotary or other valves in the system or overloading of any size reduction equipment into which the air-trim separator discharges.

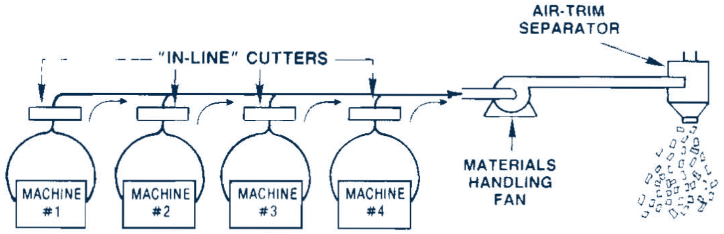
The speed of the trim generated at each machine will be the line or web speed of that machine. Normally the speeds of the several machines using the manifold system will be different from each other. The trims from several machines, traveling together at different speeds in the common manifold, frequently entangle one with the other due to the turbulence in the pneumatic conveying line. The result is that the fastest trim builds up on the slowest trim and forms a ball of tangled trim in the line. The size of the ball generated depends on the relative speed of the trims involved, the length of the manifold and other physical factors. Frequently, when the trim from a “stopped” machine entangles with the trim from an “operating” machine, the ball of tangled trim will build up to the size of the manifold and plug the line. The combination of the tangled trim ball size and the pressure drop across the ball often generates a force sufficient to break the “stopped” trim. The tangled trim ball then moves as a single mass at the conveying speed down the manifold into the air-trim separator with resulting blockage problems in the separator, the discharge valve, or the succeeding process equipment.

This entanglement problem is particularly acute when a bank of slitters are started and stopped with each roll change and are operated over their full speed range to match the slitting characteristics of the web being handled.

In the case of the entanglement of a trim from a “stopped” slitter with that of a slitter operated at 2000 ft./min., the trim ball builds up at the operating slitter speed. *Example*, in only 2 minutes of entanglement 4000 ft of trim will build up on the entanglement ball, a voluminous mass that can readily cause blockage problems.

MANIFOLD SYSTEMS

"IN-LINE" CUTTER MANIFOLD SYSTEM



"In-line" cutters provide the answer to the problems associated with conventional manifold systems.

An "in-line" cutter is installed between the junction of the trim line from each machine and the manifold. This eliminates any interaction between the trims from various machines as well as capitalizing on the many other "in-line" cutter system advantages previously discussed.

SUMMARY

The use of an "in-line" cutter within an edge trim or filament system offers significant advantages in terms of cost savings, space efficiency, and manpower. In systems where trim or filaments originate from multiple sources, the inclusion of an "in-line" cutter becomes crucial to ensure optimal system functionality.

PAC's "in-line" cutters are specifically designed to cater to the unique requirements of continuous trim or filament systems. They feature an exclusive "shaftless-open rotor" cutting chamber, which enables exceptional performance when dealing with filaments, stringy materials, or extremely thin trims. Moreover, these cutters are capable of maintaining cutting clearances as low as 0.00025 inches, guaranteeing superior results in various applications.

NOTES

PAC
PRECISION AIRCONVEY

For Additional Information, contact us at:

Precision AirConvey

465 Corporate Boulevard
Newark, DE 19709
(302)266-0555

www.PrecisionAirConvey.com
Get-Facts@AirConvey.com