GRAVIMETRIC BLENDING IN THE PLASTICS INDUSTRY

Molded plastics are often a blend of two or more materials. Colors (masterbatch) and other additives are often mixed (blended) with the raw plastic material prior to the molding process in molding plants. Many different types of blenders and dosing units have been used in this process; some with marginal and others with better accuracy. Some blenders are installed directly on the feeding throat of a processing machine and others are applied as a remote blender.

Remote and central blenders are often used to feed multiple machines with a blend of virgin resins, recycled material, masterbatch and other additives. The remote blenders are also used to feed a single processing machine to avoid transmitting vibrations from the processing machine to the blender aiming for high blending accuracy and longer life. They are also applied when direct installation on the feed throat of the processing machine is not desired. The blend is then conveyed from the floor standing blender to one or more processing machines by vacuum loaders or other loading systems, where separation of the blended components (due to different specific gravities, bulk densities and granule size) takes place. Separation can also happen in the storage bin installed on the feed throat of the processing machine. The product quality varies and the color grade changes from cycle to cycle when the blend separates. It is easy for the machine operator to notice the difference between the color grades, and this usually results in increasing the percentage of masterbatch to achieve a uniform color. The down side is the waste of expensive masterbatch.

Pumping liquid dies (ink or color) into the material flow on the feed throat of a processing machine is a messy method and rarely used in the plastics industry. Two blending methods (volumetric blending and gravimetric blending) are widely used to blend different materials including masterbatch. The volumetric blending method is far less accurate, when compared to the gravimetric blending method, but gravimetric blenders are more expensive. Gravimetric blending is more sophisticated and the majority of gravimetric blenders are sensitive to vibrations and, therefore, only applicable in a batch system.

The remote or central blending system is not the right type of equipment to be applied when different colors are used in different processing machines. Both the volumetric blenders and the remote blending systems are suggested when blending virgin resins with recycled plastics or blending different types of resins in high percentage and where tight tolerances are not required. It is suggested to apply a gravimetric blender directly on the feed throat of a processing machine when it comes to dosing masterbatch, which is normally blended in very low percentage (in many cases less than 1%). The accuracy of the gravimetric method, if not sensitive to vibration is very welcome, no separation can be expected and no loading system cleaning is necessary after changing colors.

The revolutionary gravimetric blending systems developed by **LIAD** (**L**eader **I**n **A**dvanced **D**osing) have many advantages. It is in fact the most accurate way to go when masterbatch is to be blended with virgin resins, a blend of resins or resin / recycle mixture. The innovative **ColorSave** series are very precise MICRO-DOSING units capable of dosing the minimum possible quantity of one single pellet of masterbatch cycle after cycle. ColorSave series are designed for direct installation on the feed throat of a plastics processing machine. The weighing cells are not affected by vibrations transmitted from the processing machine. The precision load cell and the hoppers containing various materials are protected by an outer shell. External loads or forces do not affect the function or the accuracy of the unit. The ColorSave series do not require any setup time or maintenance. Experience has proven that the ColorSave series saves an average of 33% of masterbatch when compared to volumetric blenders mounted directly on the feed throat. In many cases the ColorSave was able to save more than 50% of the masterbatch. The simplicity of the units and the genius design with protected load cells in opened hoppers (no gates to open or close) insures high reliability.

The development of many gravimetric blending and dosing systems to cover the needs of plastics molders directly on the feed throat of the processing machine was not the only great achievement of **LIAD**. The leading company has also developed software to remotely control multiple blenders and dosing units from a central PC and to analyze the collected data from every unit. All blenders and dosing units developed by LIAD are equipped with interface for data transfer and the standard software is individually adaptable to cover to suit the operating system in different molding plants. The managing staff can observe the entire machine operation on a single or multiple screens. Questions like “how many tons of a specific material did we process in the last ---?” or “how many pieces of ---- did we make in red or blue during the last ---?” are easily answered. Machine down time and operation hours of the processing machine is directly readable whenever you need to know. Just ask for it and you surely have the answer right at your finger tips. Changing a parameter, increasing or decreasing the dosing percentage of an additive or masterbatch in any one of the units is enabled on the microprocessor on the unit and the central software in the manager’s office.

PLEASE READ THE FOLLOWING PAGES FOR MORE DETAILS.

THE BLENDING PROCESS

Molded plastics are often a blend of two or more materials. Colors (masterbatch) and other additives are often mixed (blended) with the raw plastic material prior to the molding process in molding plants. The accuracy of blending materials in specific ratios and the blend homogeneity are the main two factors to consider.

BLENDING ACCURACY

Scrap is molded but undesired parts of a molded plastic product which are normally trimmed off and separated from the product after the molding process. Scrap is very often produced in the majority of plastics molding processes. Depending on the molding process, the mold construction and the shape of the product, scrap may weigh more than the finished product. Scrap is often collected, reground and blended (mixed) with virgin resin in certain percentages (recycled) to reduce material cost and save the environment. The mixing ratio of recycled plastics and virgin resins varies depending on the type of material and the desired product quality. High accuracy in the mixing ratio is normally not required. Simple proportional vacuum loaders with marginal accuracy are often used to blend virgin resins with regrind and feed it to the process. Reasonably priced volumetric blenders are also applied in blending both virgin and regrind materials when more accuracy is required and the more sophisticated gravimetric blenders are applied only when high accuracy is necessary.

It is often required to blend two or more different types of plastics to manufacture certain products with specific mechanical properties. More accuracy is normally required and, therefore, volumetric or gravimetric blenders are used to supply the processing machine with the specified material blend. Chemicals and other additives are often blended in smaller quantities with virgin resin or with a blend of virgin resin and regrind material in volumetric or gravimetric blenders prior to the molding process.

A major share of plastic products is manufactured in different colors. When high production volumes in a specific color are required, the molder may elect to purchase the main virgin material in the desired color from the resin supplier. It is more economical to blend colors (color dosing) with main materials in molding plants prior to the molding process when low production volumes are required or low production volumes in different colors are desired.
Pumping liquid dies (ink or color) into the material flow on the feed throat of a processing machine is a messy method and rarely used in the plastics industry. Solid color grains (masterbatch) are the most common materials used in the plastics industry. Masterbatch is blended in very small amounts (usually lower than 4% and often below 1%) with virgin resins in blending units prior to the molding process. A higher ratio of masterbatch normally does not show negative effects in the product quality but masterbatch is expensive. Higher ratios of masterbatch are a waste and therefore more and more blending accuracy is required. It is fair to say that only the gravimetric blending (dosing) system is applicable in blending masterbatch with the main material prior to the molding process in molding plants.

BLEND HOMOGENEITY

Blend homogeneity **at the feed throat of the processing machine** (not at the outlet of the blender) is very important. It is important to avoid material separation after the blending process and on the way to the processing machine.

Blenders of different types can be applied either as a central (remote) system to serve one or multiple processing machines or in direct installation on the feed throat of a processing machine. The blend must be transferred from the remote blender to the processing machine. The performance of material loaders depends on the bulk density of the material transferred. The bulk density of plastic resins, powders, regrinds, additives and masterbatch can vary dramatically and, therefore, material separation is more likely to happen in a remote blending system.
Remote and central blenders are disadvantages when used in blending different colors of masterbatch. Many system components and long pipes have to be thoroughly cleaned after every color change.

Blenders of different types can be specified as either continuous blenders or batch blenders. Batch blenders of all different types blend different components and dump the blend in a storage bin. The next batch is dumped into the storage bin when the blend in the bin is consumed. Material separation is likely to happen as the blend is falling by gravity through the storage bin.

Material separation is not great when the components are blended in higher percentages. Additives and masterbatch are normally blended in small quantities. When separated the product quality is normally unacceptable. The machine operator is often forced to increase the masterbatch ratio and waste money to overcome the separation.

MANUAL BLENDING

The simplest blending method is manually purging measured amounts of different components in a container (a barrel or a drum), closing the container and rolling it on the floor to homogenously mix the components. The blend is then fed to the processing machine through a holding hopper on the feed throat. Manual blending was enhanced by using a kind of concrete mixer to blend the manually fed components instead of rolling a container on the floor. It is a batch blending method that is rarely used in the plastics industry today.

ADVANTAGES:

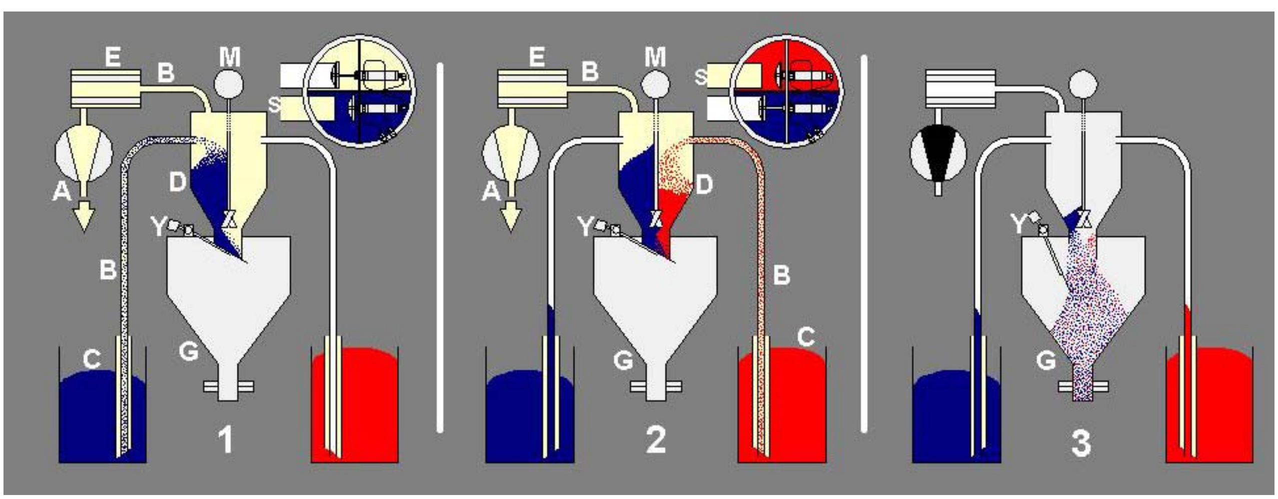
- No initial investment and no installation cost

DISADVANTAGES

- Manual operation with high labor cost
- Inhomogeneous blending on the feed throat
- Discontinuous operation

PROPORTIONAL VACUUM LOADERS

Vacuum loaders are widely used in the plastics industry to transfer virgin resins, regrind or masterbatch from storage sources to processing machines. The illustration below explains the function of a proportional vacuum loading system. A blower {A} sucks large amounts of air through the loading system at high speed creating a low pressure. The pipe {B} is immersed in a storage bin {C} containing the material to be transferred to the processing machine and the material is sucked into the pipe due to the vacuum. A material separating hopper {D} with and a filter {E} are installed at the end of the pipe. The filter allows the air to continue flowing to the blower but the material stays in the hopper and falls by gravity to the bottom of the hopper. The amount of material transferred depends on the size and shape of the pellets (bulk density), the amount of air sucked through the pipe and the vacuum level inside the system.



Two different materials can be sucked from two different storage bins through two different pipes into one separating hopper by one suction blower and one filter. Different amounts can be transferred into two different chambers inside the separating hopper. Proportional loaders load one material at a time using a timer to control the suction time through each suction pipe {S}. Some proportional vacuum loaders include an auger {M} for better blending when the flapper {Y} is opened and the blend is dumped into the holding hopper {G}.

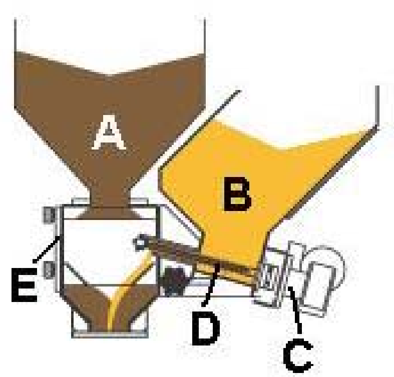
Proportional loaders are also applicable in a remote system. Other loaders such as screw conveyors are seldom applied to proportionally load and blend different components in the plastics industry.

ADVANTAGES:
- Simple and inexpensive system
- Loading and blending in one unit

DISADVANTAGES
- Low blending accuracy
- Inhomogeneous blending

VOLUMETRIC BLENDERS

Volumetric blenders are more accurate than the previous described proportional vacuum loaders. They appear in many different forms in the plastics industry.



One of the common methods of volumetric blending is to feed the additive {B} to the main material {A} through a feeding screw {D} driven by motor and drive {C}. The main material falls by gravity from a receiver through a mixing chamber {E} to the feed throat of the machine. The mixing chamber is designed to blend the main material and the additive homogeneously. The rotation speed of the screw is fixed based on the desired mixing ratio, the groove size of the screw and the size of the additive pellets. When applied on a cycling machine the screw is stopped at the end of every cycle and starts to rotate again when a signal is received from the processing machine.
The machine operator must choose the right screw size for the blending range (see lower illustration), observe the blending ratio and adjust the rotation speed of the screw to achieve the desired results.

Vibrations transmitted from the processing machine to the blender have a big influence on the blending accuracy. The illustrated unit shows a sloping screw, which is meant to decrease the negative vibration effect.
Changing the production rate or the cycle time is accompanied by resetting the blending ratio of the unit, and changing the type of material may require a different screw.

Rotating discs with cavities in different sizes and adjustable rotation speed instead of the screw described above is another way of blending specific volumes of the additives with the main materials. Some volumetric units use feed screws or rotating discs for both main material and additive. Some units blend more than one additive with the main material, but the main idea is very similar in all volumetric blenders. Volumetric blenders are also applicable in a batch system. The blend is dumped into storage bins and then sucked by one or more vacuum loaders from the storage bins and supplied to one or more processing machines.

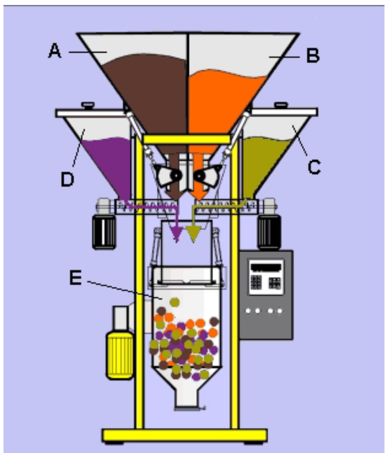
The accuracy of all volumetric blenders depends on the size and shape of the pellets or the bulk density of the powder blended. The level of the material in the hopper above the feed screw makes a difference in the amount of material transferred through the screw. A vibration transmitted from the processing machine to the blender is a factor as well.
As these factors are always changing, the accuracy of the volumetric blender is limited.

ADVANTAGES:
- Simple and inexpensive blender
- Higher accuracy than proportional loaders

DISADVANTAGES
- Inconsistent blending
- Operator skill and observation are required
- Frequent adjustments are necessary

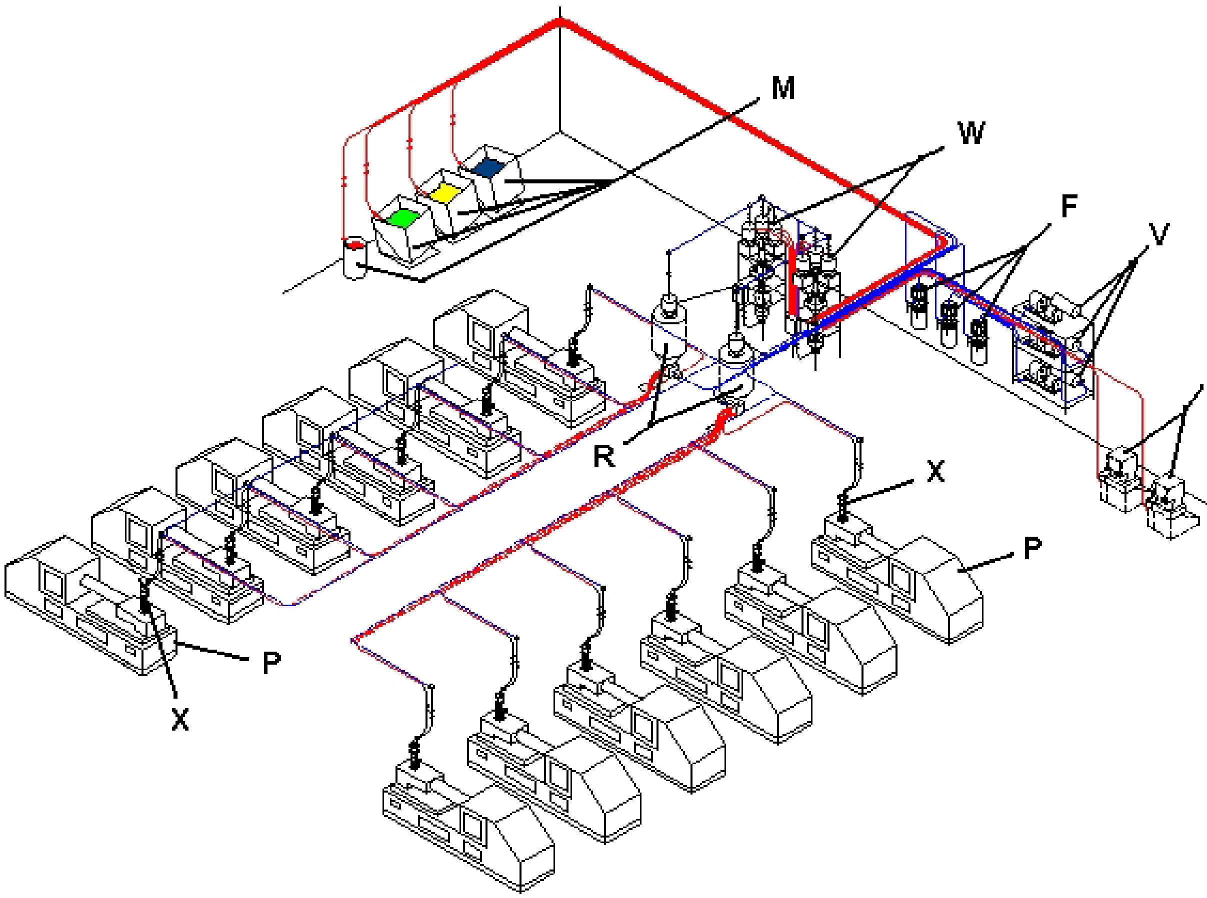
GRAVIMETRIC BLENDERS

Gravimetric blenders are usually much more accurate than volumetric blenders. The additives are blended with the main material based on the mass of the additive and the mass of the main material. The volume of a specific mass varies based on the bulk density of the material, but the mass (weight) is constant.
It is true that the accuracy of gravimetric blenders is dependent on the accuracy of the load cell (weighing device), the mechanical design of the blender and the units operating software. Load cells are usually very sensitive to vibrations and external forces (top or side loads). They are therefore more applicable in a remote system. It is important that the mechanical design not only protect the load cell but must also include a solution for a homogenous blend. A good mechanical design is one that solves the problem with fewer moving parts. The control system and the software are also a very important part of the gravimetric blender. The control system must be designed so that changes in the production rates are automatically detected and automatically readjust the blending parameters to maintain high accuracy and eliminate the need for constant monitoring.



An example of gravimetric batch blenders is illustrated to the left. It mainly consists of 4 hoppers containing different materials to be blended a mixing camber {E} attached to load cells and a control cabinet built on a floor standing frame.
The hoppers {A} and {B} include pneumatically operated gates at the bottom. The hoppers {C} and {D} include feed screws at the bottom.
The gate at the bottom of the hopper {A} containing the main material is opened and the main material falls by gravity to the mixing chamber {E}. The load cells detect the weight of the material falling into the mixing chamber. The gate is then closed when the desired amount of the material is reached.
The same procedure is repeated with recycled material in hopper {B}.
The feed screw in hopper {C} is then started and a certain amount of the additive falls into the mixing chamber before the screw is stopped.
The same procedure is repeated with masterbatch contained in hopper {D}.
The mixer is started at last to mix the materials in the mixing chamber at last and the blend is then ready for loading to the processing machines.

The vibration caused by the feed screws is very limited and the mixer is stopped during the weighing process. The accuracy of the load cells is very good and the desired ratios of the blend can be easily achieved. The design of the mixer is normally sufficient to achieve a homogeneous blend in the mixing chamber, but the key is to maintain the homogeneity until the blend reaches the feed throat of the processing machine.



The material flow and the remote batch blending process are shown in the molding plant layout in the illustration above. The central loading system transfers different types of materials and additives from storage bins {M} as well as recycled materials from the grinders {N} to the remote batch blenders W. After blending the blend is transferred to the vacuum receivers {R} and then to the individual processing machines {P} via individual loaders {X}. The filter units {F} are to protect the vacuum blowers {V} from dust in the suction lines.
It is very clear from the illustration that material separation will take place after the blending process on the way to the individual processing machines. No matter how accurate the blend ratios are at the outlet of the blenders, the blend homogeneity is not guaranteed at the feed throat of every processing machine. The example also shows that only two color blends can be processed in this molding plant.

THE IDEAL BLENDING PROCESS

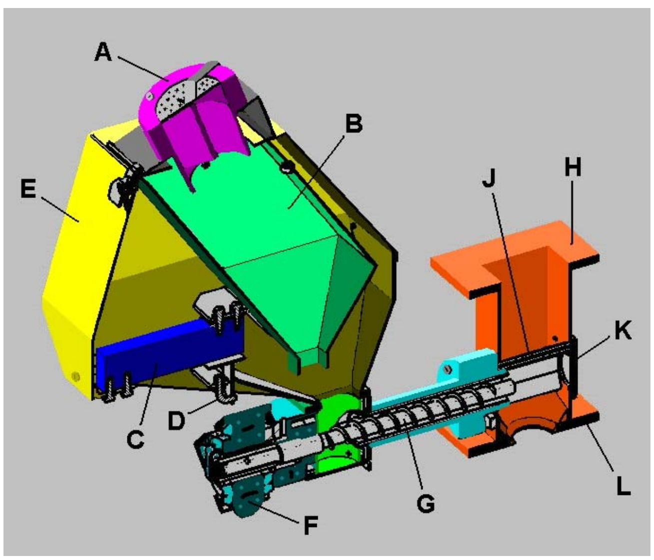
The description of different blending systems and different blending methods made it clear that the ideal blending system depend on the desired accuracy and the importance of the blend homogeneity. Proportional loaders, volumetric blenders and remote blending systems are applicable when both low accuracy and less homogeneity are acceptable.

The **IDEAL BLENDING SYSTEM**, however, is:

- A continuous feeding method
- Installed directly on the feed throat of the processing machine and consisting of one or more
- Gravimetric blenders.

The accuracy and reliability of the ideal gravimetric blender depend on:

- The accuracy of the load cells
- The isolation of vibrations transmitted from the processing machine to the blender (noise isolation)
- The mechanical design of the blender and
- The control system and the software.

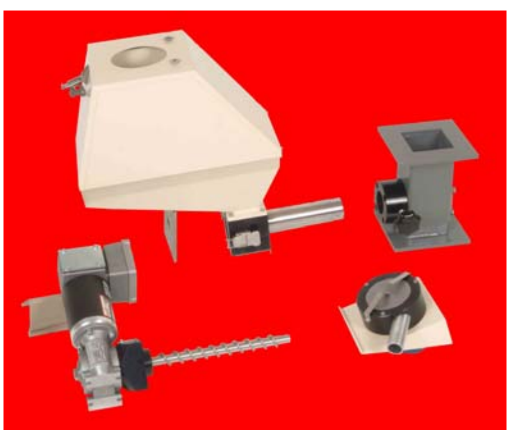


The gravimetric blender (ColorSave by LIAD) illustrated above was found to be the ideal blending (dosing) system available in the market for applications in the plastics industry.
The venturi loader {A} loads the additive or the masterbatch from a storage bin continuously to the opened hopper {B}, which is mounted on precise load cell {C}. The additive hopper and the load cell are both protected against external forces and damage by the separate external shell {E}. The additive falls by gravity to the feed chamber of the feed screw {G}. The motor and drive {F} rotate the feed screw (different screw designs are available) in a specific speed for a specific time when a signal is received from the processing machine is received indicating that the molding cycle has started. The software is designed to time the cycle and calculate screw rotation speed and time to precisely dose the desired amount of additive and distribute it over the feeding time. The additive is transferred by the feed screw to the feed throat piece {H} where the main material in falling by gravity to the processing machine. A deflector {J} is installed inside the feed throat piece to enhance the blend homogeneity and a sight glass {K} is installed for inspection. The entire unit is flanged {L} on the feed throat of a plastics processing machine. A safety pin {D} is designed to lock the load cell and protect it from transportation damage and during the cleaning process.

The machine operator is to simply enter the weight of the shot and the desired percentage of the additive. The unit operates fully automatic. The load cell detects the amount of the additive being blended with every cycle. The rotation speed of the screw and the rotation time are automatically calculated to distribute the dose through the filling time. Any changes in the cycle time are detected and the dose is always perfectly distributed.

When applied in continuous extrusion process the unit measures the main material flow by load cells in a separate hopper to determine the main material consumption and blend the desired ratio of the additive as described above (see the illustration to the left below). A variety of combinations between main material and additive hoppers are provided to suit every blending and dosing application in the plastics industry. Up to four additives can be precisely and homogeneously blended with the main material on the feed throat of the processing machine (see the illustration to the right below).

All products are available in high quality of stainless steel. The main material hoppers and load cells are also protected for high accuracy and high reliability.



No maintenance is required and cleaning the unit when changing colors or additives is made very simple. The entire blender is removed from the feed throat piece by loosening the set screw and pulling the unit out.

It is also easy to exchange the units between different processing machines.

The unit consists of only four components:

- The hopper and the load cell with the protective cover
- The motor and the drive with the exchangeable feed screw
- The venturi loader
- The feed throat piece.

LIAD (**L**eader **I**n **A**dvanced **D**osing) has been developing gravimetric blending systems for various industries for many years. The company introduced the described **ColorSave** series of gravimetric blenders and dosing systems to the plastics industry and they became the choice of the high quality plastics molders.

Experience has proven that the ColorSave series saves an average of 33% of masterbatch when compared to volumetric blenders mounted directly on the feed throat. In many cases the ColorSave was able to save more than 50% of the masterbatch. The simplicity of the units and the genius design with protected load cells in opened hoppers (no gates to open or close) insures high reliability.