Gravimetric Blending in the Plastics Industry

Introduction

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. Some different types of blenders and dosing units are used in this process, some with marginal and others with better accuracy. Gravimetric batch- blenders and volumetric feeders installed directly at the throat of the injection molding machine are the most common. Gravimetric batch-blenders are applied either as remote blenders or on the machine feed throat.

Remote and central blenders are often used to feed multiple machines with a blend of virgin resins, regrind 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 of a batch-blender on the feed throat of the processing machine is not practical. The blend is then conveyed from the floor standing blender to one or more processing machines by vacuum loaders, where considerable separation of the masterbatch/additives from the virgin resin/s (due to different specific gravities, bulk densities and granule size and free-flowing properties) takes place.

Separation is also typical to batch blenders that are mounted at the throat of the processing machine mainly due to mixing of materials of very different nature and bulk. 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 of this is the waste of expensive Masterbatch.

Volumetric feeder meters the masterbatch or additive into the main flow of material. The metered material is drawn into and distributed in the core of the main material – there is no mixing equipment and thus no risk of separation. However, unlike gravimetric systems, the volumetric dosing device does not possess scale to record or control dosing quantities. The volumetric device has to be calibrated against the material. This has to be done for set-up and for switches of material and batches, as well as for quality testing. Evaluation and calibration take time and tie up workers. Since continual referencing is not performed, changes that occur between test intervals due to variation in bulk density, particles geometry, or free-flowing properties escape detection.

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.

ColorSave 1000

The patented innovative single component gravimetric (loss-in-weight) ColorSave 1000 feeder developed by **LIAD** (**L**eader **I**n **A**dvanced **D**osing) has many advantages. It is the most accurate way to go when masterbatch/additive is to be dosed with virgin resins or a blend of resins. The innovative **ColorSave** series are very precise units capable of dosing 0.1kg/hr–40kg/hr and, with the Micro Dosing option, the minimum possible quantity of one single pellet of masterbatch cycle after cycle.

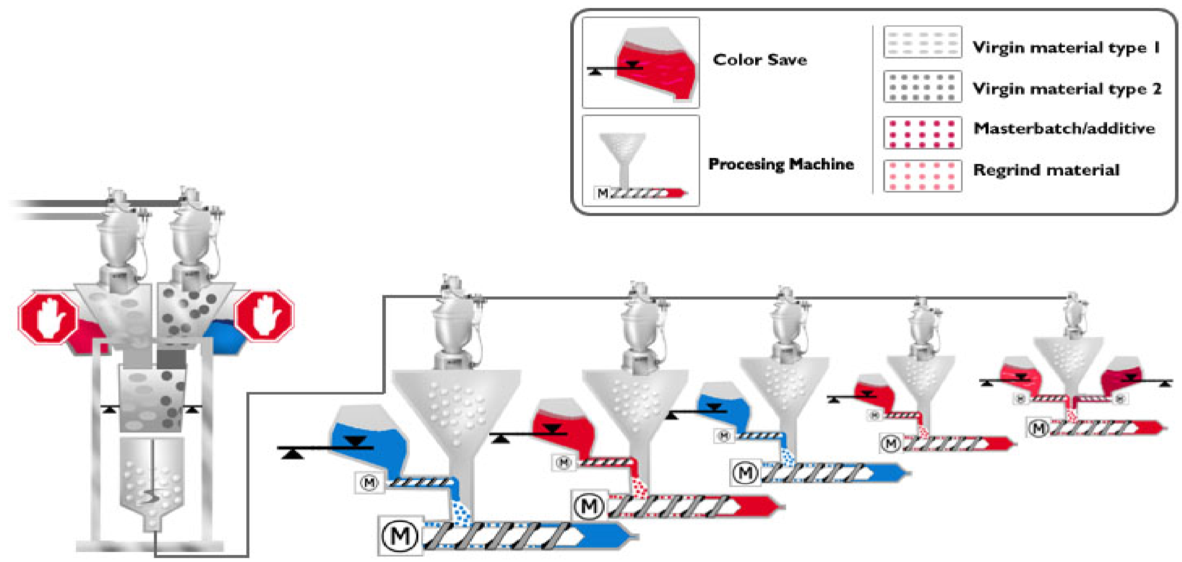
ColorSave series are designed for direct installation on the feed throat of a plastics processing machine. Vibrations transmitted from the processing machine do not affect the weighing cells. An outer shell protects the precision load cell and the hoppers containing various materials. External loads or forces do not affect the function or the accuracy of the unit. The ColorSave series do not require any set-up time or maintenance.

Experience has proven that the ColorSave series saves an average of **33%** of masterbatch when compared to volumetric feeders 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 dosing systems to cover the needs of plastics molders directly on the feed throat of the processing machine is not LIAD's only great achievement. The company has also developed software to remotely control multiple ColorSave 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 have the answer right at your fingertips. Changing a parameter and 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.

The ColorSave technology combines the advantages of gravimetric monitoring and control of throughput, with the advantage of volumetric metering, into the main flow of material, without any of their disadvantages.

As illustrated in the picture below, **the optimized feeding method - that should result in huge savings of up to 50% of your masterbatch consumption - is to convey the virgin material/s through remote station/s that serve a number of machines and to meter the masterbatch with ColorSave 1000.**



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Practical experiences by customers confirm much lower masterbatch and additives consumption, improved quality, and very simple operation.

- ***Up to 50% savings in masterbatch/additives consumption when compared to volumetric feeder***
- ***Up to 35% savings in masterbatch/additives consumption when compared to remote batch blender***
- ***Up to 15% savings masterbatch/additives consumption when compared to batch blender on machine throat***

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 that 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 recycled by being collected, reground and blended (mixed) with virgin resin in certain percentages to reduce material cost and to help 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 necessary to blend two or more different types of plastics in order 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 batch-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.

Solid color grains (masterbatch) are the most common materials used in the plastics industry — pumping liquid dies (ink or color) is a messy and rarely used method. 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 wasteful and therefore more and more blending accuracy is required. Only the gravimetric blending (dosing) system is applicable when 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 blender outlet) is very important so as to avoid material separation during 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, grain geometry and free flowing properties of the material transferred. The bulk density, particle geometry and free flowing 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 batch-blenders are disadvantages when used in blending different colors of masterbatch and additives.
Optimizing the masterbatch percentage in a remote gravimetric batch-blender is a prolonged and complicated process, resulting in waste of time and materials.
Changing the masterbatch type in the remote batch-blender requires tedious and time-consuming work to empty and clean the complex blending system and the loading and long conveying tubes.

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 can not be mixed properly due the significant difference in the nature and bulk of the virgin material/s and the masterbatch/additives and due 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 very 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 is enhanced by using a type 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

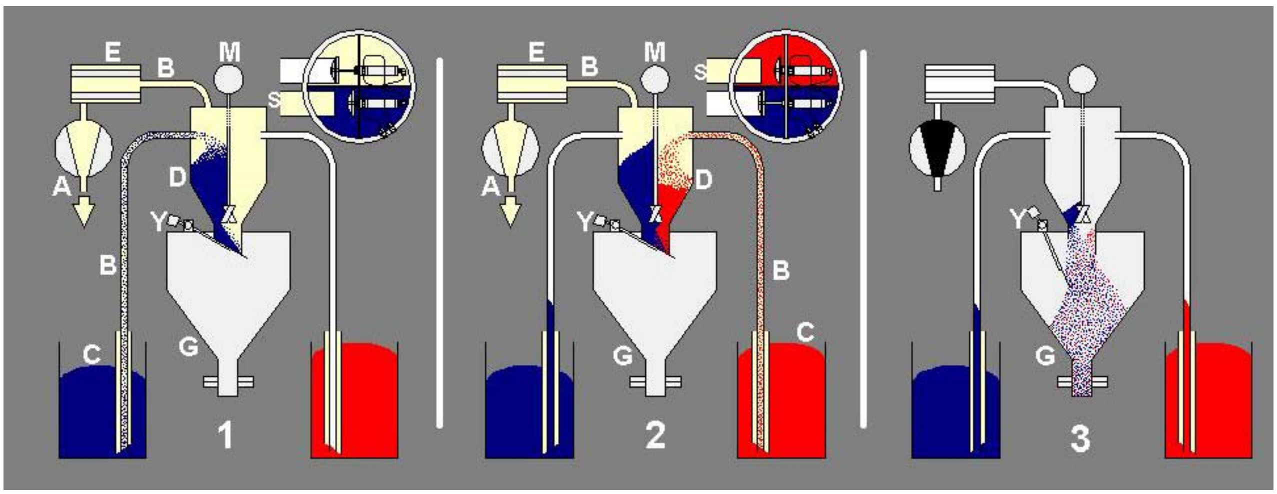
- No initial investment and no installation cost

Disadvantages

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

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.



One suction blower and one filter can suck two different materials from two storage bins through two pipes into a single separating hopper. Different amounts can be transferred into two 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

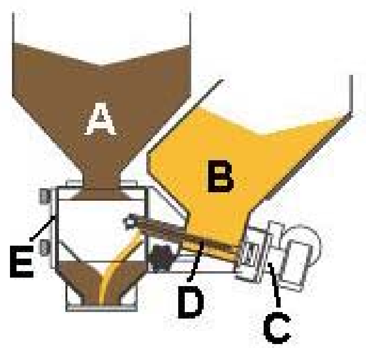
- Simple and inexpensive system
- Loading and blending in one unit

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

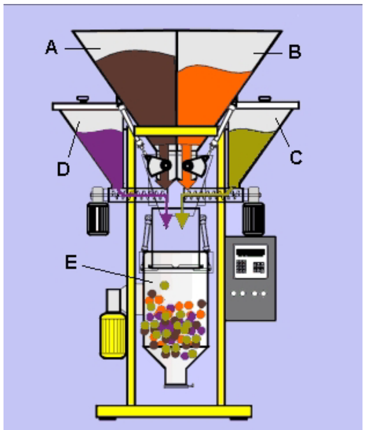
Disadvantages

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

Gravimetric Blenders

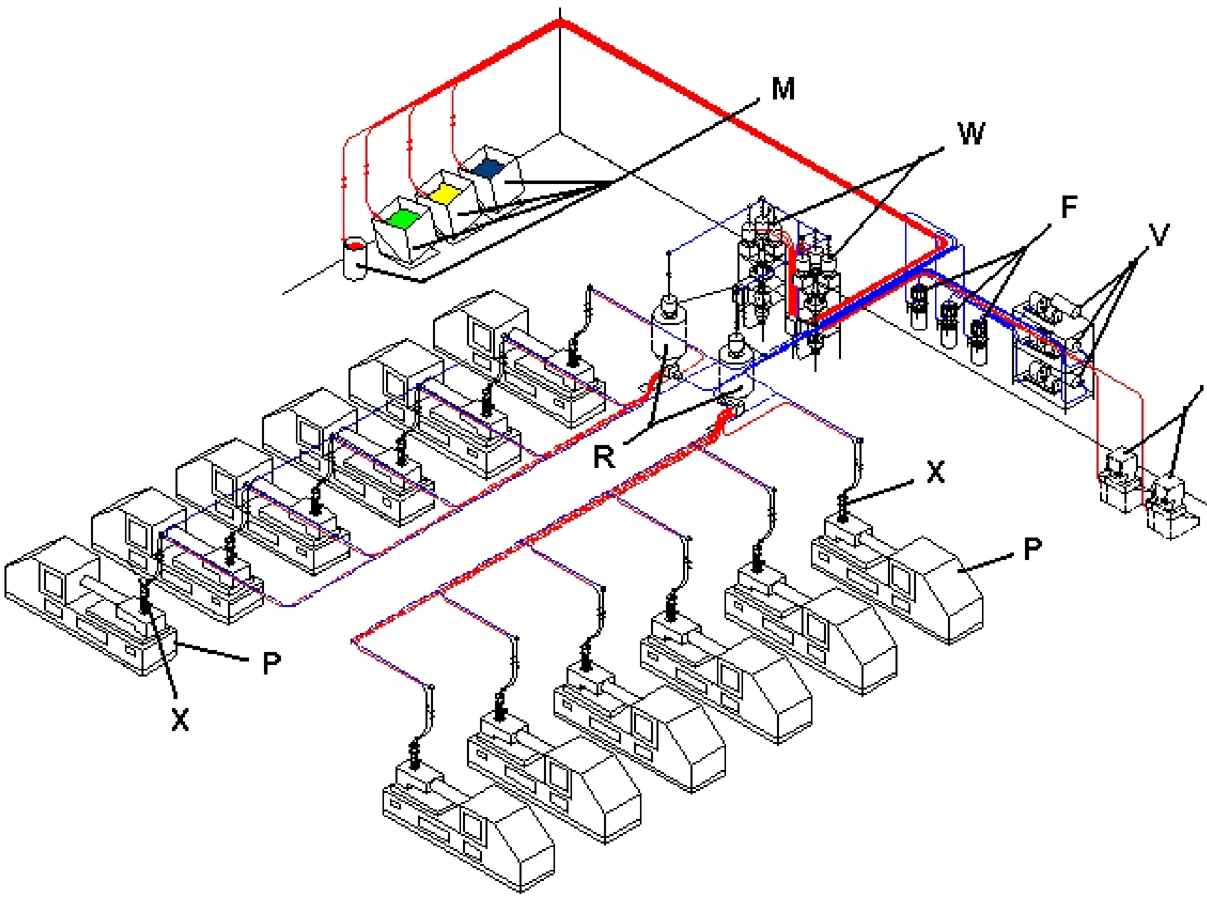
Gravimetric blenders are usually much more accurate than volumetric blenders. The additives are blended with the main material based on the mass of the additive and the mass of the main material. The volume of a specific mass varies based on the bulk density of the material, but the mass (weight) is constant.

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 protects the load cell but also includes 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 an essential part of the gravimetric blender. The control system must be designed so that when changes in the production rates are automatically detected, the blending parameters are automatically readjusted in order to maintain high accuracy and eliminate the need for constant monitoring.



An example of a gravimetric batch blender is illustrated to the left. It includes 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 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 almost a homogeneous blend in the mixing chamber, but the key is to maintain 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

These descriptions of different blending systems and various blending methods clearly show that the ideal blending system depends on high accuracy and blend homogeneity. Proportional loaders, volumetric blenders and remote blending systems are applicable when both low accuracy and less homogeneity are acceptable.

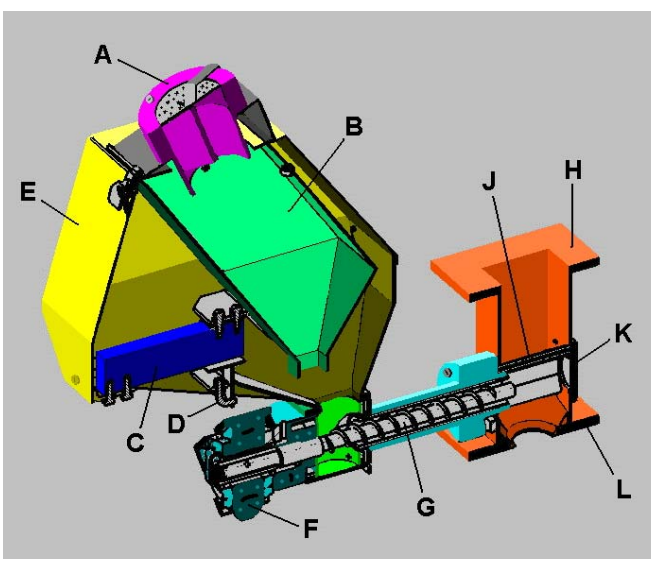
The **ideal blending system** comprises a:

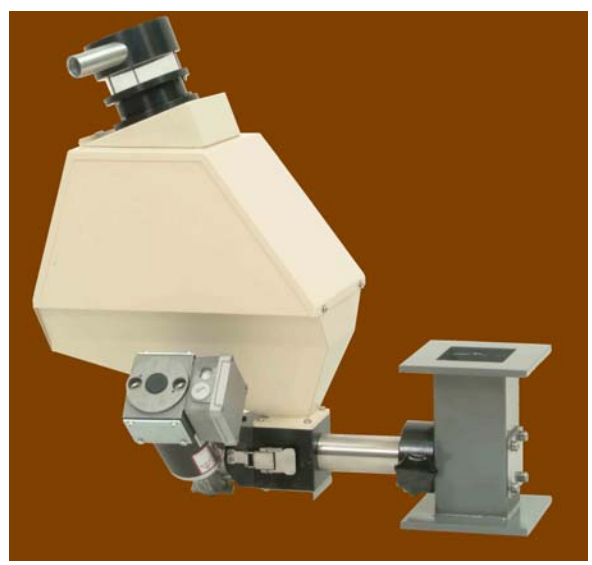
- Continuous feeding method
- Installed directly on the feed throat of the processing machine, and consisting of one or more
- Gravimetric blenders.
- Metered material is drawn into and distributed in the core of the main material – there is no mixing equipment and thus no risk of separation.

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

- Accuracy of the load cells
- Isolation of vibrations transmitted from the processing machine to the blender (noise isolation)
- Mechanical design of the blender
- Control system and software

The ColorSave 1000





The **ColorSave 1000** gravimetric blender developed by LIAD, illustrated above, has been shown to be the ideal blending (dosing) system available in the market for applications in the plastics industry.

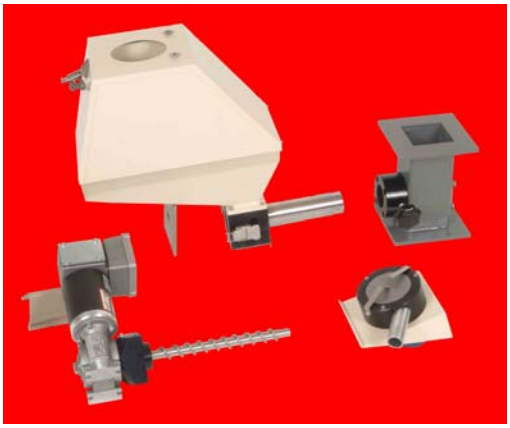
How the ColorSave 1000 works

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 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 simply enters the shot weight and the desired percentage of the additive. The unit is 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 towards the 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 illustration below left). 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 illustration below right).

All products are available in high quality stainless steel. The main material hoppers and load cells are protected to ensure 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 can be 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 four components:

- Hopper and load cell with the protective cover
- Motor and drive with exchangeable feed screw
- Venturi loader
- Feed throat piece

LIAD (**L**eader **I**n **A**dvanced **D**osing) has been developing gravimetric blending systems for various industries for many years. Since its introduction to the plastics industry, the **ColorSave** series of gravimetric blenders and dosing systems have become ***the*** choice of high quality plastics molders.

Experience has proven that the ColorSave saves an average of 33% of masterbatch when compared to volumetric blenders mounted directly on the feed throat. In many cases, the ColorSave has saved 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.