

Bin Level Indication Applications in the Plastic Processing Industries

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Introduction

What is Plastic Processing? Simply, it is the processing or converting of raw plastic material into a finished or work-in-process part. Plastic material is produced by chemical plants in pellet or resin form. Most plastic processing involves converting plastic pellet by injection molding or extrusion. Blending resins to form plastic materials like PVC is also common to produce pipe and other components. Whatever the plastic conversion process, bin level indicators serve a vital role that keeps production running and impacts the profitability of the business. We will briefly review two methods of plastic processing and discuss bin level applications within these reviews, as well as discuss the application of inventory management at the end of this white paper.

Injection Molding [Wikipedia](#)

Injection molding is a manufacturing process that converts raw plastic pellet into parts for sale as components or a finished end product. The injection molding process can convert either thermoplastic or thermosetting materials. The most common is the thermoplastic type.

A little technical talk: Thermoplastic material is a plastic that melts to a liquid when heated. It freezes to a brittle, very glassy state when cooled sufficiently. Most thermoplastics are “high-molecular weight polymers” whose chains associate through weak Van der Waals forces (like polyethylene); stronger dipole-dipole interactions and hydrogen bonding (like nylon); or even stacking of aromatic rings (like polystyrene). Thermoplastic polymers differ from thermosetting polymers (like Bakelite and vulcanized rubber) as they can, unlike thermosetting polymers, be melted and molded repetitively. Many thermoplastic materials are “addition polymers”, e.g. “vinyl chain-growth polymers” such as polyethylene and polypropylene.

The bottom line is that the difference between thermoplastic and thermosetting plastics is that thermoplastics become soft, re-moldable and re-weldable when heat is added. Thermosetting plastics, however, when heat is added will chemically decompose so they cannot be welded or molded. On the other hand, once a thermosetting is cured it tends to be stronger than a thermoplastic.

The most common thermoplastics are polystyrene (low cost; lacks strength and longevity), ABS (acrylonitrile butadiene styrene) used for a wide variety of parts from Lego blocks to electronic enclosures, polyamide (chemically resistant, heat resistant, tough and flexible; used for combs), polypropylene (tough and flexible; used for containers), polyethylene and polyvinylchloride PVC (more commonly used in extrusion of parts rather than injection molding).

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The injection molding machine is used to convert the raw plastic pellet into the desired part. The shape of the part is determined by the mold. The injection molding machine or “press” is rated by tonnage, which expresses the amount of clamping force that the machine can exert. This force keeps the mold closed during the injection molding process. Tonnage can vary from < 5 tons to 6000 tons, with the higher figures used in comparatively few manufacturing operations. The required force is determined by the material used and the size of the part, larger parts require higher clamping force.

The mold, a.k.a. die, is typically constructed from hardened steel, pre-hardened steel, aluminum and/or beryllium-copper alloy. The choice of material to build a mold is primarily one of economics. Steel molds generally cost more to construct, but their longer lifespan will offset the higher initial cost over a higher number of parts made before wearing out. Pre-hardened steel are less wear-resistant and are used for lower volume requirements or larger components. The steel hardness is typically 38-45 on the Rockwell-C scale. Hardened steel molds are heat treated after machining. These are by far superior in terms of wear resistance and lifespan. Typical hardness ranges between 50 and 60 Rockwell-C. Aluminum molds can cost substantially less, and when designed and machined with modern computerized equipment, can be economical for molding tens or even hundreds of thousands of parts. Beryllium copper is used in areas of the mold which require fast heat removal or areas that see the most shear heat generated. The molds can be manufactured by either CNC machining or by using Electrical Discharge Machining processes.

Let’s focus a little more on the injection molding machine because this is where the bin level indicator usage can be seen. As we know from other white paper document discussions, the typical point level bin indicator is used for high and low level monitoring in a bin or silo. They can also be used in smaller hoppers and this is what we’ll see with injection molding.

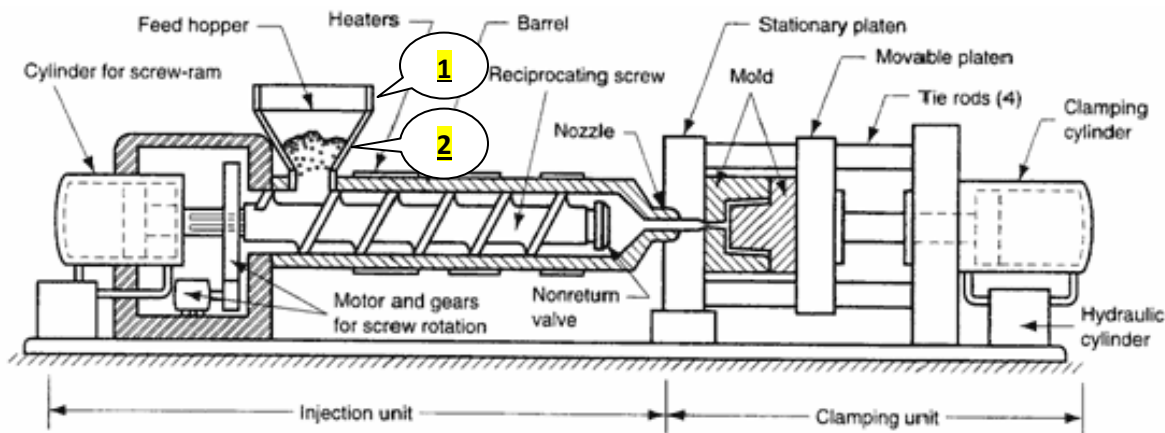


Figure 1: Typical injection molding machine with material feed hopper.

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As shown in Figure 1 on the previous page, the injection molding machine is fed with plastic material locally through the “feed hopper”. These hoppers are not very big and hold enough material usually for one or a little more mold shots. There are two points of possible bin level indication. The first is high level¹ monitoring in case material backs up from a clog in the machine, but the second application is more common, which is a low level² monitoring application to ensure that the machine is not starved of raw material. The bin level indicator will signal to the control system or locally to an operator that a material supply problem has occurred if the material level falls below the point of sensor installation.

Bin level indication in the feed hopper of an injection molding machine is generally handled by one of two technologies, e.g. a rotary paddle or capacitive style proximity switch. Because of the relatively small size of these machine hoppers many manufacturers have begun using the capacitance proximity switch. However, the rotary paddle is still used especially in compact form. Figure 2 illustrates the relative size of a proximity switch.

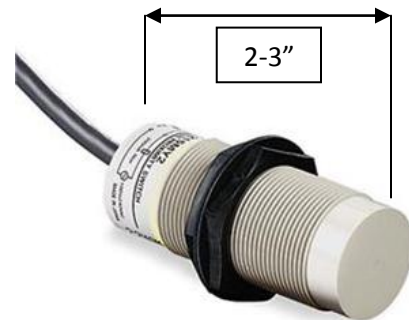


Figure 2: Capacitance proximity switch ~ 1" diameter (M30 x 1.5 thread)

Extrusion [Wikipedia](#)

Plastic extrusion is a high volume manufacturing process in which raw plastic material (thermoplastic) is melted and formed into a continuous profile. Extrusion produces items such as pipe/tubing, weather stripping, window frames, plastic sheeting, vinyl siding, adhesive tape, wire insulation and much more.

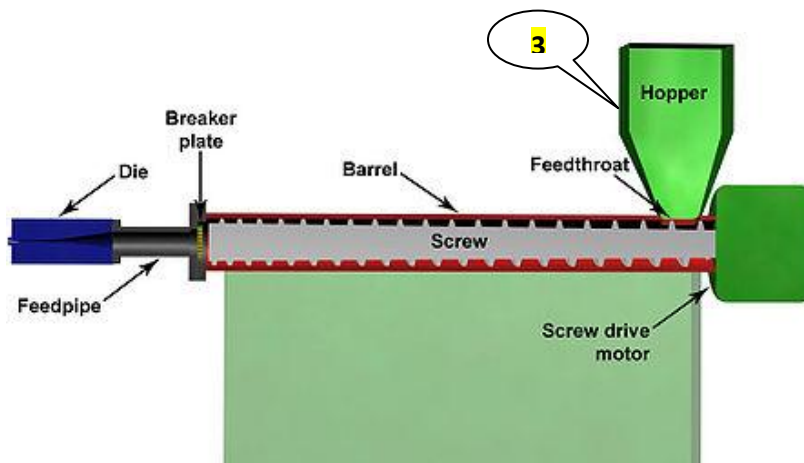


Figure 3: Illustration of an extrusion machine.

In the extrusion of plastics, raw material (small beads called resin) is gravity fed from a top mounted hopper into the barrel of the extruder. Additives such as colorants and UV inhibitors (in either liquid or pellet form) are often used and can be mixed into the resin prior to arriving at the hopper. The mixture is fed

into the machine and heat and pressure is applied. The material melts and flows the length of the machine with the turning of the screw feeder in the machine. At the end of

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the machine the material exits into a die, which is the tool that forms the melted plastic into the desired shape. Uneven flow at this stage would produce a final product with unwanted stresses in certain points in the profile. These stresses can cause warping upon cooling. Almost any shape imaginable can be created so long as it is a continuous profile.

The product exiting the die must now be cooled and this is usually achieved by pulling the extruded piece through a water bath. Plastics are very good thermal insulators and are therefore difficult to cool quickly. Compared with steel, plastic conducts its heat away 2000 times more slowly. In a tube or pipe extrusion line, a sealed water bath is acted upon by a carefully controlled vacuum to keep the newly formed and still molten tube or pipe from collapsing. For products such as plastic sheeting, the cooling is achieved by pulling through a set of cooling rolls.

As with the injection molding machine, the bin level indicator use is in the feed hopper as shown in Figure 3. Critical control of raw material³ in these hoppers is needed in order to maintain continuous production. If material supply runs out, someone needs to take immediate action. Capacitive style proximity switches and rotary paddle bin level indicators are both used in these feed hopper applications as they are in the injection molding machine applications.

Inventory Management Application

Raw plastic material is fed to the injection or extrusion machine in each individual feed hopper. However, the amount of plastic consumed by plastic processing manufacturing on a daily, weekly, monthly and yearly basis can be substantial. Because of this, many facilities store hundreds of thousands of pounds of material in outdoor storage silos. Refer to Figure 4.

The monitoring of bulk raw material is critical for several reasons:

1. Ensure Efficient Production. If you run out of any raw material ingredient unexpectedly your entire production operation for a single line or the entire facility will come to a screeching halt. Lost production time means lost profits. A reliable and accurate inventory management system for bulk plastic material storage is important.

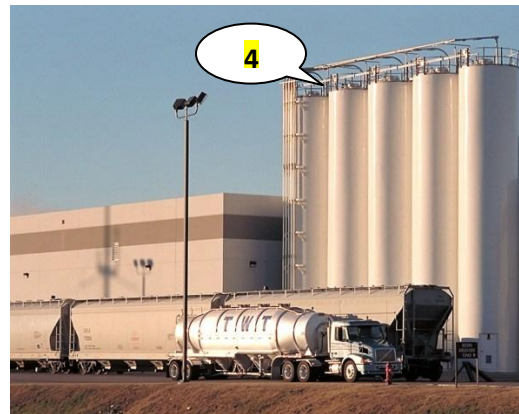


Figure 4: Plastic processing facility raw material storage silos.

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2. Asset and cash management of a high value of inventory has the eye of the financial department, the plant manager who has P&L responsibility, corporate overseers and owners. Cash is king in the business world and managing it means good management of your inventory. In plastic processing one of the largest segments of your inventory is the raw material sitting in your silos.

For these reasons bin level indicators⁴ have played a vital and important role in inventory management. In addition to using high and low level point indicators to indicate emergency high level and material outage conditions, the actual measurement of the amount of raw material inventory is accomplished using continuous level bin indicators. These units help you determine the amount of material you have, and that's what the financial people and plant manager want to know.

Delivery of the purchases of the raw plastic material for silo storage is usually done by truck or rail car. Silos for plastic materials usually hold 45,000 to 225,000 pounds and range from 20 to 60 feet in height. Many are 12 feet in diameter but some are larger. Measurement of material inventory is typically done using continuous level measurement inventory monitors. In plastic processing the most common device is the weight & cable inventory sensor, a.k.a. plumb-bob, yo-yo, bin-bob. No matter what you call it, even cowboy-bob, these sensors are well suited for the task. Refer to the White Paper titled "Application Considerations for Continuous Level Monitoring for Powder and Bulk Solids" for more information about this and other technologies.

Whatever the continuous level monitor technology is that you choose to use, a fundamental issue remains. That is, the conversion of the measured data to inventory units. Continuous level sensors measure the empty space between the material surface and the sensor. They do not measure the number of pounds of material in the vessel. For direct measurement of weight, load stands and weighing systems can be utilized but these have their own problems and are very expensive by comparison to continuous level sensors. While inventory management software and the continuous level sensor itself, in some technologies, can calculate volume and weight based on a set of data you provide in regards to the silo dimensions and bulk density of the material, there exist other pervasive issues that affect the precision of the overall conversion from distance/level to mass.

Issues to be considered when converting from distance/level to mass include:

- Accuracy of dimensions (check the vessel, they may be a little different than the drawings).
- Angle of repose of the material is not usually a flat surface. It has a positive angle during filling and a negative angle during discharge after the transition

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point has been reached. In addition, sometimes there is a crater under the fill inlet from falling material. All of this points to an uneven surface and the continuous level sensor only measures to a specific point on the material surface. And that leads us to the next issue.

- Material packing varies within the pile. This affects the real value of the bulk density, and that is critical to the precision of the calculated conversion from distance/level to weight. In addition, the bulk density of the material may vary slightly from batch to batch.
- Material flow properties present interesting issues, but mainly for powders so we won't worry too much about that right now.

All of these issues, and more, need to be considered when setting your expectation for precision in measuring your raw material inventory. The accuracy of the level sensor will not affect you in the end as much as these issues will. Refer to the aforementioned White Paper on application considerations for continuous level sensors.

Conclusion

Bin level indicators are an integral part of the production and operation of plastic processing facilities. They are also critical to plant profitability and asset management through raw material inventory control when the material is stored in silos or large bins. Rotary paddle, proximity switch sensors, weight & cable inventory monitors are all used regularly by plastic processors, machine manufacturers and systems providers in plastic processing and conversion.