Hot fill process for beverages is a proven and recognized method for filling of high acid foods (pH less than 4.6) that will be shelf stable at ambient temperatures. As the name implies, hot fill process is a food processing where product is filled into the finished containers and capped the container when they are still hot, and then cooled. The question is; how hot is hot fill process. In this case, “hot” is characterized by temperature that is high enough to assure that all product in the container is at or above the minimum prescribed when the closure (lid) is applied. This is important to provide a product free from microorganisms capable of growing in it at ambient storage. This technology is very simple; and is currently used extensively in the beverage industry. In practice, product is heated (in a heat exchanger), sent to the filler hot, and then filled into container, capped, and the container is then inverted (turned upside down) for 3 minutes and then may be cooled. Inverting the container is needed to make sure that the inner surface of the closure is exposed to the “hot” temperature for decontamination or microbial inactivation. Applying closure at high temperature is a critical step. Following the closure, cooling of the product will create a vacuum inside the container; providing an anaerobic condition unfavorable for aerobic microbial growth.

As suggested earlier, hot fill processing is a popular processing method for beverage industries; since it is a simple and an inexpensive technology; especially for high acid foods and beverages. Basic steps of a hot-fill processing of beverages is illustrated in Figure 1. Since hot filling is always followed by
important to be stressed here that the equilibrium pH of the food after processing that is of particular importance.

Hot fill processing parameters to be controlled properly are heating process, especially temperature \( T_{\text{hold}} \) and time \( t_{\text{hold}} \) at holding tube or holding cell, temperature of filling and capping \( T_{\text{can}} \), in-container holding time \( t_{\text{in}} \). For the same temperature-time process parameters, pasteurization value of heat process experienced by the product is depend on the container dimensions. Filling temperature is very important in minimizing process time and ensuring adequate pasteurization process. It was reported that for hot fill process parameters described above was enough to ensure adequate shelf stability. For hot fill hold procedures of fruits with a pH value lower than 4.0, the National Canners Association recommends the following process: a filling temperature higher than 85°C followed by can sealing and 2 min immersion in steam or water at 88°C before cooling. Guidance from Food Science Australia suggested that in most cases the product should be heated to 90-95°C for about 15-30 seconds; depending on pH value and other microbial factors. The hot product is then filled into the container, holding and then cooling by conduction takes place. Temperature profile of product thermally processed by hot filling is compared to cold filling and aseptic processing can be seen in Figure 2.

To assure the effectiveness of hot fill process, then it is required to have a proper control of the product as well as the hot fill process, including decontamination process of the container and closure. Beside microbial parameter/criteria of raw material; critical aspect need to be controlled is pH value of the product. Value of pH is an important factor in the processing of many foods, especially when a thermal processing is applied for the purpose of inactivating organisms. Consequently, monitoring of pH during production runs must be made regularly; using a proper standardized pH meter. It is recommended for products above that pH.

Hot fill process also effective in reducing oxidation deterioration of product. As we are aware, one of the most damaging effects resulting from oxygen activity in beverages is the oxidative degradation of vitamin C. Oxidation reaction is also closely associated with flavor changes and discoloration of the beverages during storage. Proper hot fill processing will also create natural de-aeration, generating an internal vacuum within the container after cooling. In addition to inhibiting microbial growth, vacuum condition also prevent oxidative damage, so that filling temperature can be done at higher temperature; usually between 90° and 98°C, follow by holding time for 2-3 minutes before the container is cooled in a cooling tunnel. Preheating of glass bottles is necessary before filling in order to reduce the risk of glass splintering. Prior to closure the headspace of the container (can, bottle or jar) may be flushed with steam. Steam flushing is intended to create vacuum, reduces the oxygen content of the neck space and lowers the recontamination risk.

Nowadays, popular packaging material for hot filled beverage products is PET, polyethylene terephthalate, a plastic resin and a form of polyester. Manufacturers of hot filled beverages use PET plastic for its container due to its strength, thermo-stability, transparency, and price. Furthermore, another advantages for PET is lightweight, resealable, shatter-resistant and recyclable. Thermo-stability of packaging is critical for hot fill processing; since filling need to be done at high temperature; capable of causing distortion or deformation of bottle used.

As described earlier, the hot fill generates an internal vacuum within the container (PET bottle) after cooling. This is due to, especially after cooling, the shrinkage of the liquid beverage (by 3% to 4%) coupled with condensation of water vapor in the headspace. Vacuum created by proper hot fill process may reach of up to 0.5 bar (7 psi); consequently, the tightness of closure is very crucial to maintain the vacuum and to avoid post contamination. Recently, special PET technology is specifically developed for hot fill processing, as a PET preforms made from special resins, heated to a higher temperature and blown into hot blow molds in order to reduce shrinkage and more thermo-stability.