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Review Article

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Use of Feeder Tanks and Self-Cleaning Nozzles for Glue Systems to Maximize Productivity and Reduce Downtime in the Packaging Industry

Animek Shaurya

New Jersey, USA

ABSTRACT

In the overall packaging sector, whether it is for the food or beverage industry, apparel industry, or retail industry, the goal is to deliver high-quality untampered products to consumers by ensuring that the package is intact and remains secure during production, transportation from the production line to a warehouse or from warehouse to distribution centers. To deliver products at this highest level of quality, any packaging company must research and select the best glue/adhesive system available in the market for their production lines. In this theoretical paper, we review the technologies available in the field of glue systems and the challenges faced by the companies that lead to production loss, higher operational costs, recall, and reworks. The study aims to perform a root cause analysis of the issues faced, like missing beads of glue on the packages and blockage of nozzles, to provide solutions using the new technology of using a feeder tank fill system for glue units and the use of self-cleaning nozzles to eliminate them. This paper also illustrates the advantages of utilizing this new technology and its impact on production lines.

***Corresponding author**

Animek Shaurya , New Jersey, USA.

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Introduction

In the early 19th century, water-based adhesives were popular among the packaging industries. Still, it had limitations as the humid climate drastically affected its application and use. There was a shift in the use of adhesives that could improve sealing and bonding applications when Pau Cope of Proctor & Gamble invented hot melt adhesive in 1940. This new hot melt adhesive was solid without toxic composition, water, or solvent. It would provide permanent bonding for a wide range of materials. After this vast technological advancement, hot melt adhesive gained popularity and momentum in the packaging industry. The next challenge that evolved was developing and identifying equipment that would easily dispense this hot melt adhesive onto the boxes to seal and bond them. Initially, companies started using handheld guns manually operated on the production lines to seal boxes as they came from the machines. Sooner, the companies realized this process was very labor intensive and would increase operational costs to manage the production line smoothly without interference. This process was also susceptible to downtime as the unavailability of resources to manually apply glue using the handheld guns on the boxes would cause downtime and slow the production rate of the machines. The companies soon realized these problems and started looking for better solutions for the smooth running of their operations. This led to the evolution of a new generation of machines that can store hot melt adhesives and melt them. The molten glue would be pumped through hoses to the applications with nozzles attached to them to dispense the glue onto the boxes for sealing and bonding application.

Problem Statement

The major challenge in the packaging industry is using and applying hot melt adhesive to bond cartoon boxes on production line machines like case sealers, case former, etc. Every company usually spends a lot of capital when selecting a glue system to match their production requirements, with higher investment in procuring higher quality hot melt adhesive from top manufacturers. Irrespective of the high capital investment made in state-of-the-art technology, industries still struggle with the issues of cartoon boxes not being glued together or popping open even before they reach the customers. The inefficiency on the production line poorly reflects the customer satisfaction levels and leads to product recalls and complaints. The effects of not having a continuous, reliable glue supply to close boxes also lead to production loss, downtime for the repair of the machines, extra labor costs, and time associated with rework activities, etc.

By performing a detailed analysis of the above issues that are common in any packaging industry, it is evident that the root cause of the problem does not lie in the quality of the hot melt adhesive bought from suppliers but is more ingrained in the type of the system used for feeding the hot melt adhesive and the type of nozzles used for dispensing and bonding the boxes.

To overcome the issue of boxes not being appropriately sealed using the hot melt adhesive, most of the workforce, whether operators or maintenance personnel in any packaging industry, lean towards the most common and widely used solutions, i.e.,

Increase the Pump Pressure

This solution is related to increasing the line pressure through

which the pump moves hot melt adhesive from the melter tank through a hose towards an applicator that dispenses molten adhesive beads onto the cartoon boxes to assist in closing and sealing the application.

Rasie Temperature Setting

This solution is incorporated to increase the temperature of the hot melt adhesive to reduce the melting time of the hot melt adhesive pellets in the tanks so it can quickly covert it into a molten state and provide a continuous flow of adhesive to the applicator so it can dispense without any beads missing on the boxes.

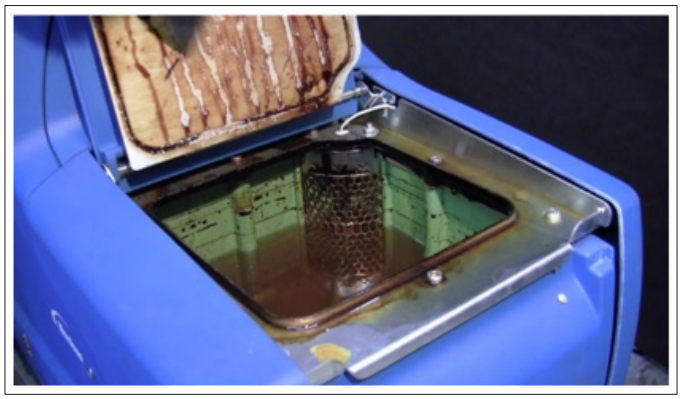

Figure 1: Meting Area of a Standalone Nordson Glue Unit (**Source:** https://www.graco.com/gb/en/in-plant-manufacturing/solutions/articles/safety-in-the-packaging-industry-improves-profitability.html)

Figure 2: Charr Buildup (**Source:** https://www.keystoneparts.com/blog/char-buildup-in-glue-melter)

Although the above two solutions are the most used across all packaging industries, they are incorrect and unreliable, damaging other significant components of the glue unit and causing catastrophic downtimes and safety risks to personnel and products. Instead of focusing on finding the root cause of the problems related to the glue system, personnel tend to use these widely spread wrong practices, which leads to equipment failure and production loss. The two major problems causing the non-sealing or bonding of boxes can be explained as follows –

Inadequate or Missing Adhesive Beads

This happens when impurities or foreign particles other than the molten hot melt adhesive enter the nozzle through the applicator. They block nozzles, restricting the dispense of glue through them and missing the beads on the boxes.

Low Temperature of Adhesive

This results in the adhesive inability to bond to the substrate. Several factors add to this case, like improper refilling the melter with the hot melt adhesive pellets, leaving the tank empty, etc.

The two leading causes of the problems mentioned above are contamination of the melting tank area and the longer time to refill hot melt adhesive pellets into the melter tank. Fig. 1 shows the area around the melter unit that gets dirty and shows residue of impurities around the walls of the melter unit. Fig. 2 depicts a magnified image of the charr that builds up inside the melter unit, travels through the hose to the applicator, and causes nozzle blockage.

Proposed Solution

The problems and the root cause mentioned in the above sections of this review paper can be addressed and resolved using a separate feeder tank connected to the central melting unit and self-cleaning nozzles in the applicators. Nozzles usually get blocked due to foreign material introduced with the hot melt adhesive mixture in the melter unit. This all starts with the burning of the glue contaminated with foreign particles in the melter area when the level of the hot melt adhesive is deficient in the melter area. This burning creates solid carbon-like particles. This phenomenon is termed the charring effect. The charring phenomenon usually occurs when personnel on the production floor do not refill the melting tank with the hot melt adhesive. Once the charr is created, it is pumped through the hoses and goes into the nozzles via the applicators. Once they get into the cavities through which the glue is dispensed, they block the narrow cavities, causing blockage and missing beads on the boxes.

The new technology of integrating a melt-on-demand unit using an automatic fill system can eliminate the abovementioned problems and help improve productivity, reducing machine downtime and operational costs associated with repairing the machine or reworking the product. Fig. 3 shows a Nordson unit with an additional feeder tank fill unit attached to the primary melter system. Unlike conventional technologies for the glue system, this one does not have a tank in the melter unit to hold the hot melt adhesive pellets. However, there is a small melting section available in the unit that receives the hot melt adhesive pellets from the feeder tank on demand. The small melting section then heats the hot melt adhesive to a specified temperature per the standard and produces a molten hot melt adhesive. This heating process is done rapidly as there is no overload of hot melt adhesive in the small melting section of the unit. The molten hot melt adhesive is pushed through the heated hoses to the applicator using a glue unit pump. The application has nozzles attached at the very end for dispensing the high-quality adhesive onto the surface of the boxes and products to provide bonding and sealing features.

Figure 3: Fulfill® Retrofit Adhesive Fill Kit (**Source:** https://www.nordson.com/products/adhesive-dispensing-systems-products/fulfill-retrofit-kit)

This innovative technology eliminates the occurrence of charring phenomena in the glue units and helps improve machine reliability and production efficiency. Another advantage of using a feeder tank system is the reduced manual intervention of refilling the tank with hot melt adhesive from time to time. Production personnel are tasked to periodically perform this tank refilling in conventional systems. Any delay in this process of refilling would lead to a melting unit, starving of the adhesive and running dry, causing damage to the unit itself and subsequent charring phenomena. The manual refilling process is also very time-consuming and messy as it causes spillage around the unit. It is also a prime source of contamination due to the opening of the lid every time the refilling must be done. The new technology of using a feeder tank eliminates all these issues, as the feeder tank has a higher storage capacity that can hold enough hot melt adhesive pellets for multiple day's consumption. Also, these feeder tanks are designed to have a sight glass on one side of the tank itself that helps the operators to visually keep track of the level of the hot melt adhesive in the tank, which they can check based on their periodic operational checklist plan as created by the managers. Table 1 explains the benefits of this new technology, which improves safety, productivity, and machine reliability features.

Table 1: Advantages of Glue System with Additional Feeder Tank

Areas	How It Is Achieved
Sustainability	Reduced adhesive waste, charring, downtime, and rejects
Adaptability	Adaptable to any application with hose length and multi-feed options
Reliability	Minimized maintenance and downtime associated with adhesive char, degradation, and contamination
Efficiency	Elimination of poor bonding and missed beads due to low or empty melter tanks.
	Improves product quality and bond strength by maintaining consistent adhesive temperature, purity, and bead volume
Productivity	Maximizes plant operating efficiency by increasing maintenance cycle and parts life while minimizing char and pop-opens
Safety	Improves safety by preventing exposure to hot adhesives and surfaces
	It prevents manual overfilling and spilling and reduces broken tank lids.

Another technological advancement that can help the process of bonding and sealing boxes or cartoons in packaging industries is using self-cleaning nozzles on glue applicators. The self-cleaning nozzle design utilizes an integrated needle and reduced cavity through which the glue is injected into the boxes as beads, as shown in Fig. 4. The design of the needles breaks down any charr or impurities that get introduced into the nozzle due to repetitive vertical movement of the needle in the cavity. This eliminates the possibility of impurities in the nozzle cavity, causing blockage and leading to missing beads on the boxes.

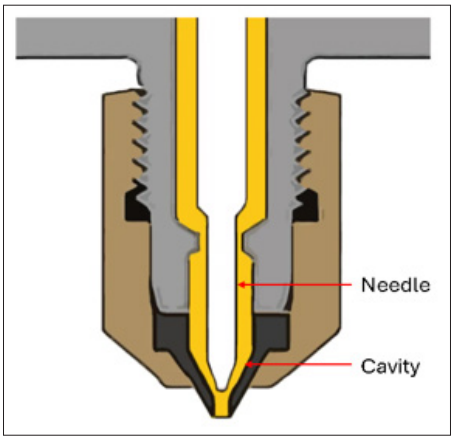

Figure 4: Self-Cleaning Nozzle Breakdown (**Source:** https://www.hotmelt.com/products/infinity-bond-clean-shot-self-cleaning-hot-melt-applicator?variant=42607950463193)

Conclusion and Future Scope

The new technological advancements in the adhesive application of packaging industries have revolutionized operations and helped companies improve their productivity with interruptions from machine breakdowns. The use of the feeder tank fill system, in addition to the melting units, helps operators maintain and run the equipment efficiently. It also eliminates the problem of missing beads while the boxes are sealed, as it minimizes contamination during the melting process. The melt-on-demand technology used in the new generation of these machines helps to reduce foreign particle introduction and charr built up in the melting section of the unit. It also helps maintain a constant supply of hot melt adhesive to the unit without even running the unit dry and causing significant damage to other machine components. The new system improves the safety feature previously missing from the older style unit as the operators are not exposed to high-temperature molten directly when trying to refill the unit. It reduces the possibility of accidents due to the splashing of the hot molten glue on the operator during refilling. The use of self-cleaning nozzles reduces the downtime due to nozzle blockage as any charr that enters the nozzle area is broken down into smaller pieces due to the integrated needle mechanism, thus eliminating the downtime and need to replace or clean nozzles. Overall, with these two new features, companies have a higher probability of getting less recall on products and customer complaints about the boxes being opened before they even reach the consumers.

This new technological advancement of using the feeder tank and self-cleaning nozzle can be integrated with automation and the use of sensors, warning features, etc., to alert personnel on the production floor when the hotmelt adhesive reaches a certain level in the feeder tank, eliminating the need for someone to keep track of refilling them. More research can be done into deploying automatic shut-off features to cut off supply in case

of any disruption in the production line due to failure related to other parts of the production machines. One of the areas that can be explored is further advancements in the design and hose that is used for transferring the molten adhesive from the melter unit to the applicator over long distances to eliminate temperature drop issues and reduce the solidification of the molten adhesive [1-10].

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