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WEGMANS TRAY LIFT ASSIST

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ABSTRACT

In any manufacturing environment, ergonomics and worker safety is always a constant concern. This project was undertaken at the behest of Wegmans Food Markets, Inc in response to what they felt was an ergonomic issue facing them in their bake shop. The main focus was to eliminate bending at the waste in a stacking operation. The device created from this specification was a self lowering platform that responded to weight being added to the working surface. This work surface locks into place once the lowest level has been reached so that the product can easily be rolled off. A release mechanism then is activated to raise the surface back to an acceptable height. This goal was accomplished through the use of springs as a return mechanism and air damper system, with the air damper being driven by compressed air to lock the platform in the lowest level, as well as providing an emergency release mechanism.

INTRODUCTION

The task specified by Wegmans for improvement was originally a basket stacking operation on the bread production line. As the task was presented to us, the operator stands at the end of a production line and receives full trays of bread, weighing up to 25 pounds, to be stacked on a dolly up to thirteen trays high. These stacks are the rolled out of the way and eventually sent to stores. The way the task is currently performed, the operator physically places the dolly on the ground and then individually stacks each tray. Wegmans felt that this activity offered an opportunity to improve the ergonomics of facility. The main area for improvement identified by Wegmans was to eliminate the bending over of the operator, and this became the focus of the problem and around which the solution was created.

However, after completion of the original design, it was found that the ergonomic benefits offered by this solution were not sufficient to justify the cost of the project. Further ergonomic analysis showed that the bending over in the task was not, in fact, the ergonomically detrimental part of the process. The ergonomically significant part of this was the placing of the trays at heights above the operator’s head. This discovery led to a new focus for this project, as well and a significant decrease in the allowable budget. The new focus of the project became a similar task in the cookie production line. However, requirements became less stringent as this was to be only a prototype device now. The task itself was very similar, however, the height of the final stack was lower. This meant that any ergonomic improvements would be more significant overall. The weights of the trays would also be lower. This meant that the initial design could be modified and simplified, rather than having to start from scratch.

PROCESS

The original requirements for this device were rather stringent. First and foremost, it had to achieve the goal of eliminating the bending over the task currently required. How this was to be accomplished was left rather open-ended. However, other requirements were more specific and had to be met. This included materials used, safety elements, cleaning specifications, allowable footprint, as well as other small details. The specifications drove many of the decisions made. Initially, a budget of $2500 was made available to use.

The first consideration was the method for achieving the goal of eliminating bending over. The solution decided on to rest the dolly and baskets on a platform or forks of some sort that would automatically lower as weight was added to the system. The goal was to keep the working surface at an ergonomically acceptable height of between 30 and 36 inches from the ground. Similar systems already exist and were investigated. However, none of these met the specifications required, as the dolly had to be wheeled off of the device without tipping over. Eventually a fork system was decided on.

Different ideas for the lowering mechanism were considered. They ranged from a basic spring and damper to a motor controlled unit. Originally, it was decided that a basic spring and damper unit would be used. However, this did not offer some of the features that were required for safety and convenience. Most notably, there would be no easy way to lower the device in an emergency as no easy way to lock it in the lowered position to enable the dolly to be rolled off. It was finally decided to use a compressed air piston to act as a damper. This allowed for an emergency lowering system and a way to easily lock the system in the lowered position and a way to raise it back up on demand.

Based upon this decision a detailed design was created and presented to the customer for approval. However, due to specifications required by Wegmans, the budget was exceeded. Materials such as stainless steel and Lexan plastic were to be needed, which drove the costs up to almost double the budget. This, coupled with ergonomic benefits that were not as impressive as expected led to a change in the scope of the project. The fundamental goal remained the same though: to eliminate bending over. The original design was modified and simplified. This, along with the ability to use less expensive materials, led to a significant drop in expense. The basic components of this project can be broken down into a few well defined subassemblies

Spring System

The final design chosen called for a system of two springs. These springs are responsible for lifting the forks to the start position and for providing the tension that lowers the forks slowly. The springs are mounted inside of two vertical steel tubes that are attached to the top of the frame of the device. They hang down and attach to the lift cart, which the forks are mounted to. These springs are encased fully inside the device to prevent against dangerous shrapnel flying out in the event of a catastrophic spring failure. The springs chosen for the final design were extra extending springs that can stretch further than a standard coil spring. They are an elastic like tube (similar to surgical tubing) encased in a cloth wrap. In testing, it was shown that these springs met the specifications set out and were successful.

Fig. 1: Springs and Air Piston Assembly

Damper System

The initial design called for the use of a basic air damper to counteract the force of the springs and provide smooth slow motion when the fork assembly returned to the raised position. Through research, however, it was found that no sort of damper existed that could accomplish this easily. It was also found that there was no easy way to lock a design like this in the lowered position and there was no practical way to implement an emergency release if the forks needed to be lowered unexpectedly.

After researching options available, it was decided to use an air piston instead of just a damper. This air piston was to act as both a damper and a mechanism to lower the fork assembly. The air piston had to be powerful enough to counteract the springs at full extension while still allowing for smooth travel and damping effect when the springs were allowed to pull the fork assembly back to the raised position. An air piston fitting these specifications was found and was used. This air piston was mounted directly to the top of the frame assembly in the center and the extension rod was attached to the lift cart.

The air pressure to the cylinder was regulated to about 35 psi. This gave enough force to lower the piston, and helped reduce built up pressure that would need to be purged later. The purging process would be much longer with higher pressure being allowed into the piston as our testing showed at 45psi. By reducing the pressure to 35 psi, we reduced time to return the forks to home position by 2 seconds (about 17 to 15 seconds).

Air System

The air system is run by compressed air line that is regulated down to 35 psi from 90 +/- 5 psi. During loading of the first five trays, the air system is open to the environment and unpressurized. This allows for the piston to act as a damper and take away bounce that the springs would induce. Once the fifth tray has been loaded, the cart will lower enough to activate a limit switch and the system becomes pressurized, lowering the forks the final two inches, and locking it in place to allow for the loading and removal of the remaining trays. There are two buttons on the side of the device that will also raise and lower the forks. The “Up” button, acts as a short circuit to the limit switch and releases air from the system until the fork raise back up to the point where the limit switch is no longer depressed. The “Down” button also short circuits the limit switch, filling the cylinder with pressurized air, lowering the forks. A needle valve is included in the design, but since the tubing is so small, it is kept full open to allow as much air as possible to escape. Air filter keeps contaminates and water out, and the blow off valve prevents major spikes from destroying parts of the air system. We chose quick disconnect tubing for faster and easier repairs, plus it is more versatile and cost effective, than solid lines.

Frame Assembly

The frame assembly is main structural component of this device. The original design called for a frame that fully encompassed the structure. All springs and pistons were to be completely enclosed. Along with this, the frame was to be made fully of 304 stainless steel square tubing. The overall dimensions of this frame were to be 24 inches deep by 30 inches wide by 87 inches tall.

Upon refocusing the project, the frame was redesigned to be much smaller and less bulky. The overall size diminished significantly, but the footprint expanded, as the specification changed from the device being bolted down to the need for a mobile platform. The material used also changed to basic steel. This helped bring the costs down. The final design for the frame encompassed the ability to mount the spring and air piston on the top and a location to mount the track system used for the movement of the fork cart, as well as extensions to provide stability for the finished device.

The frame itself was to be built out of square steel tube with welded construction. Fabrication work was performed by the Wegmans maintenance shop based off of drawings supplied by our team.

Fig. 2: Frame Assembly

Fork Cart Assembly

Initially, the design of the forks was complicated by a need to make them removable for easy storage. However, this idea was decided as unnecessary when the project was refocused on the idea of a proof of concept. The final design was a very simple assembly. It consisted of a square assembly, to which the wheels for the track system as well as mounting points for the springs and air piston were attached, and the forks themselves. The forks have vertical tips on them to prevent the dolly and trays from sliding off the end while in the forks are raised. These two parts were welded together and gussets were used to strengthen the forks. This assembly was also fabricated by Wegmans maintenance for square steel tubing attached with welds.

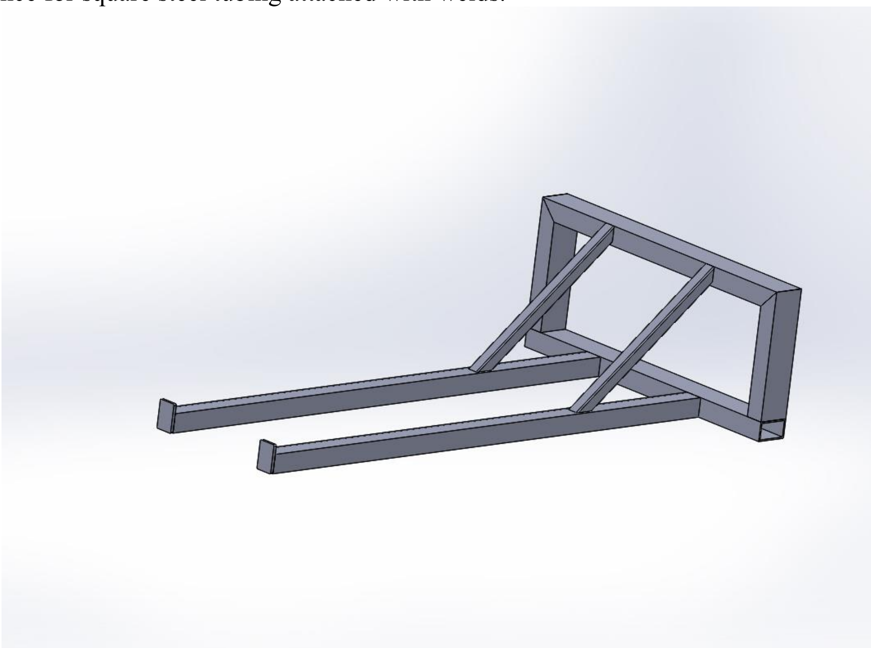

Fig. 3: Fork Assembly

Track Assembly

The track assembly is one of the more important pieces of the device. The track is what allows the vertical movement of the fork assembly, while still keeping the forks level. The design for the track system stayed constant through the entire process, with only the material changing from stainless steel to basic hardened steel. The final track decided on was a basic V-groove track and wheel system. The wheels were mounted to the sides of the fork cart assembly. Four wheels were used, two on each side, for a balance of forces while keeping the forks parallel to the ground. The track was mounted to the inside of the frame assembly. The wheels ride in the track and have minimal play. This gave the smooth motion and minimal play desired in the final product.

Fig. 4: Wheels and Tracks

Safety Considerations

Throughout this project, safety has always been a primary concern. Many considerations and design features were targeted towards keeping the operator safe at all times. First of all among these safety considerations is the cladding of the whole device. The whole frame is covered in a plastic shielding. This is to keep all moving components and pinch points out of access to the operators. Secondly, the springs were clad in steel to prevent dangerous shrapnel from escape in the event of catastrophic failure. Next, an emergency release button was implemented that will lower the device to the ground if it is needed. The damper system also provides a safety aspect as it prevents injury from the device raising at a rapid speed. The device to lock the forks to the ground was also implemented with safety in mind. This was to prevent the device from upending full stacks of trays while they were being removed from the forks. Along with this, the forks have a hard stop to keep them from being lowered too far and crushing an operator's feet.

RESULTS AND DISCUSSION

Fig. 5: Finished product

The final design, shown above in Fig. x, accomplished the goal that was initially set out. The device successfully eliminated the bending over from the stacking task. The device kept the working surface at an average height of roughly 36 inches. This was the upper limit of the goal height. However this is still a substantial improvement in ergonomics over bending over to place the trays close to the ground. Through use of the NIOSH lifting equation, it was found that the ergonomic improvement of the whole process was roughly 15% for the operators in the task. This shows that the device accomplished its goal.

Other design considerations were also met. Upon the redesign, it was determined that the device needed to present itself in a smaller form factor. This was accomplished with the device being small enough to be moved by hand and placed unobtrusively in a corner when not in use. This met the design criteria. The lowered budget was also met, with overall costs coming to be under $2000. The safety considerations were also met, with all major safety concerns addressed.

The one major design flaw encountered was in the air system. The air system did work as designed. It was capable of lowering the forks as well as lock them at the lowered level. This part was a success. The one failure in this system came from the rates of movement. The movement of the forks, both up and down, was slower than desired by a fairly large margin. This was caused by air tubing that was too small for the amount of air that needed to be moved at any given time.

CONCLUSIONS AND RECOMMENDATIONS

This project was designed to be a proof of concept for the lift assist device. In this, it was successful. It was shown that the spring and air damper system could be effectively used to regulate the height of a work surface and improve the ergonomics in the stacking task presented. However, there were definite areas that could be improved.

Among the improvements possible, most notably would be using a larger diameter tubing for the air system. This would address the issue of the slow movement of the forks. The next improvement of the design would be a redesign of the track system. The current track system has a lot of lateral play. This could be rectified be a redesigned track system. The last major change was purely cosmetic. The HDPE plastic used as a covering could be improved on to make the final design cleaner and smoother looking. Overall, however, this device accomplishes the goal set out for.

ACKNOWLEDGMENTS – USE STYLE “ACKNOWLEDGMENTS CLAUSE TITLE”

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