Recent Research in Science and Technology 2023, 15(S1): S18-S23
Special issue on 3rd International Conference on Sustainable materials, Manufacturing and Renewable Technologies (i-SMaRT 2023)
doi: 10.25081/rrst.2023.15.8460
https://updatepublishing.com/journal/index.php/rrst

Research Article

ISSN: 2076-5061

Development and prototyping of an innovative design for automatic paper bag making machine

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ABSTRACT

The Plastic Waste Management Amendment Rules, 2021, already prohibit the manufacture, import, stocking, distribution, sale, and use of plastic carry bags having a thickness of less than 75 microns. They also provide for a ban on plastic carry bags with a thickness of less than 120 microns as of December 31, 2022. So, there is an increasing demand for paper bags. The already existing paper bag-making machines are expensive and consume 25-50 square meters for their operation. A machine whose initial cost is less, which does not require large space consumption and operates with simple technologies, can be used for small-scale production. This will help the manufacturer earn money through the small-scale production of paper bags. The demand for paper bags is continuously increasing, so this project aims to develop an economical and easily fabricable machine with simple methods that promote the use of paper bags instead of plastic carry bags and helps reduce the impact on the environment.

KEYWORDS: Paper bag, Paper bag making machine, Waste management rule, Environmental impact

Received: June 16, 2023
Revised: September 19, 2023
Accepted: September 20, 2023
Published: November 07, 2023

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INTRODUCTION

Paper carry bags are a common type of packaging used by businesses like dry cleaners, bakeries, grocers, stationers, sweet sellers, and textile and clothing retailers. The establishment of shopping centers and retail establishments in rural, semi-urban, and metropolitan regions has increased the demand for paper bags. Paper has an additional advantage in packing because of its biodegradability and natural origin (Borude *et al.*, 2019). Plastic has serious environmental problems; hence, it must be replaced. Despite the fact that there are machines for creating paper bags, they are large, bulky, and not entirely automatic, necessitating human participation. Additionally, the price of these machines is prohibitive for small businesses. There is a high demand for paper bags because of the public's growing awareness of the environmental risks posed by plastic bags and the governments' bans on them in India and other countries. The paper has a wider application for the goal of this machine because of its biodegradability and natural origin (Lall & Ghosh, 2015; Kumar *et al.*, 2019).

One must always be one step ahead when it comes to considering all options before purchasing a machine in today's world when technological corporations are sufficiently unpredictable to entirely surge up or turn down within months. The Bag Making Machines: Types and Benefits guide will go over all of the various features and benefits of bag making machines. Before dipping your toe into the packaging industry, you should think about these sorts of bag-making machines and their benefits to ensure your success. The need for paper bag manufacturing equipment is just as high as it is for non-woven bags manufacturing equipment. The 'One Step Forward' rule states that as the world is constantly moving towards combating pollution by utilizing more paper and less plastic, paper bag production equipment will never be rejected in business. It is advised to use plastic bags, paper bags, and biodegradable plastic bags alternately on different occasions because the viability of reusing plastic grocery bags varies in different countries or under different circumstances. For packing liquids and soft items, plastic and biodegradable bags are the best options. Paper bags can be used for food packing or as shopping bags for clothing because they have a flat surface. Ultimately, there are a number of recommendations for reducing the pollution caused by plastic bags, including the creation of new degradable bag technologies or as shopping bags for clothing because they have a flat surface. Ultimately, there are a number of recommendations for reducing the pollution caused by plastic bags, including the creation of new degradable bag technologies (Li *et al.*, 2022). The automation of the paper bag-making machine can be made by simple electric connections using electrical actuators. The

actuation of the belt arrangement and rotation of rollers can be controlled by a microcontroller and Arduino programming operation, which can be used as a substitute for DPDT switches (More *et al.*, 2022). The two primary categories of actuators are active and passive actuators. The active actuators require a source of electric energy to operate. In contrast, passive actuators don't need a power supply because they run on renewable energy sources like thermal expansion material and stored spring energy. Circular, rotary, oscillatory (seismic), and rectilinear motions are among those that are necessary. According to their motion, degrees of freedom (DOF), and excitation sources for particular functional motion, electric actuators are classified (Redekar *et al.*, 2022).

The emerging demand for paper bags will increase the number of production units. If such a production unit can afford paper bag-making machines that need very little space for working and may have simple actuating technologies, it will encourage more people to focus on this business as a career. Such movements will help more people get rid of unemployment.

Environmental Impacts

The graph shows the percentage of Delhi's 100 merchants who use plastic carry bags. Out of 100 vendors, almost 99% sell produce and fruit in plastic bags, while 95% sell meat and fish (Borude *et al.*, 2019). Thus, the area of application for plastic bags is clearly shown in Figure 1. Therefore, the project aims to lessen the use of plastic bags in these areas, if only slightly. The studies show the market potential of paper bags in various areas of daily life. 99% of fruit sellers use plastic carry bags, which have serious impacts on the environment. Substitution of paper bags over plastic carry bags in major sections of daily life will help reduce environmental impacts. The paper bags can easily be employed in the above-shown sectors if they are easily available. The availability can ease if production increases. So, the project can make a paper bag-making machine that operates with simple technology and runs at a lower cost. It helps the vendors meet the requirement for the paper bag themselves.

A great technique to reduce waste and encourage sustainability is the local recycling of waste paper to create production raw materials. Recycling used paper aids in resource conservation, energy efficiency, and the reduction of greenhouse gas emissions related to the manufacture of new paper. The waste paper needs to be sorted and converted into pulp in order to be used as a raw material for production. After that, the pulp can be utilized to create fresh paper goods, including tissue paper, newspapers, and cardboard. The recycled paper can be used to produce paper bags, which helps reduce the usage of plastic carry bags.

CONSTRUCTION AND WORKING

Design

The main steps in the paper bag making process can be divided into paper feeding, tube forming, gusseting, tube bottom folding, and final paper bag bottom folding. The proposed design has the functionality to perform the process up to the tube-bottom folding technique (Figure 2).

The square bottom of the paper bag can be made by the above-shown design structure, which performs the same operation as in the already existing machines. The arrangement of splines on the path of the tube-bottom folded paper bag will result in the folding of the final square-shaped paper bag bottom. The design consists of rollers, conveyors, and supporting motors to guide the paper through the structure to create the paper bag (Figure 3).

The various operation regions of the machine are shown in Figure 4. The first operation comes with the feeding of paper input to the machine. Here the input paper is of dimension for the final paper bag and given along with glue on one side. Tube forming is the process of creating a tube-shaped structure with paper input to create a hollow space for goods to occupy. The folding sheet, along with the rectangular box, is responsible for the tube-forming process. Gusseting is the process of creating

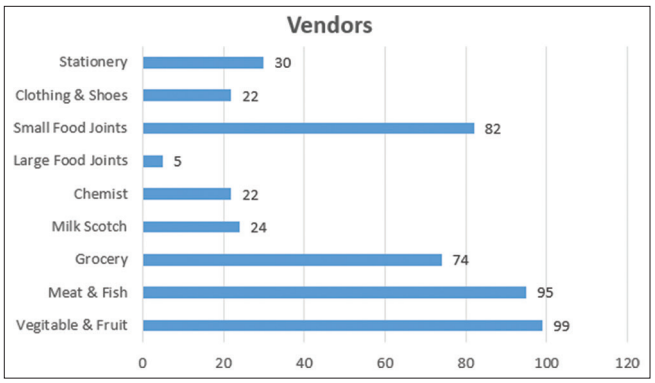

Figure 1: Percentage usage of plastics

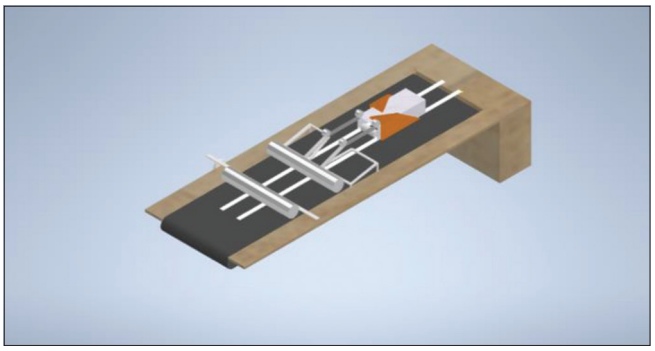

Figure 2: Automatic Paper Bag Making Machine

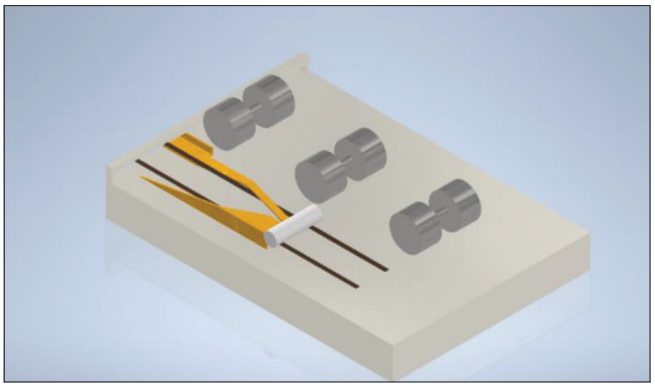

Figure 3: Square bottom folding machine

folds on the side of a paper bag, which allows the paper bag to occupy less volume during storage and provide a large space for material occupation. Tube bottom folding is the process of folding the gusseted paper at the bottom prior to the final paper bag bottom folding.

Construction

The structure is made to manufacture paper bags with a length of 20 cm, a width of 15 cm, and a height of 10 cm. The gusseting is 5 cm. The input paper measures 20 cm in length and 54 cm in width. The paper input is given glue on one side and allowed to move forward for box forming and further paper bag operation (Figure 5). The paper is allowed to move below the guideways.

Tube forming

Tube forming is the process of creating a box-shaped structure with input paper to form a hollow rectangular structure (Figures 6 & 7). In this design, it is made to happen by using a rectangular box of the size of the tube to be made and folding sheets that are placed offset from each other for efficient folding of the paper input to form the tube.

The paper moving below the guideways is allowed to enter between the two folded sheets, which are placed on both sides. The folding sheets on both sides allow the paper to fold on both sides, making a rectangular box as the center, and the tube-forming process is carried out this way.

Gusseting

Gusseting is the process of creating folds on the sides of the paper bag, which allows the paper bag to occupy a low volume during storage and expand during usage time to provide more space for goods (Figures 8 & 9).

The structure for the gusseting operation is shown here. Here the bend, guideways, and gusseting sheet are responsible for gusseting. The amount of gusseting given is 5 cm, which is set by the gusseting sheets. As the tube-formed paper moves forward through the bend, it allows air to enter between the gusseting sheets. The exit paper after the gusseting sheets, followed by a

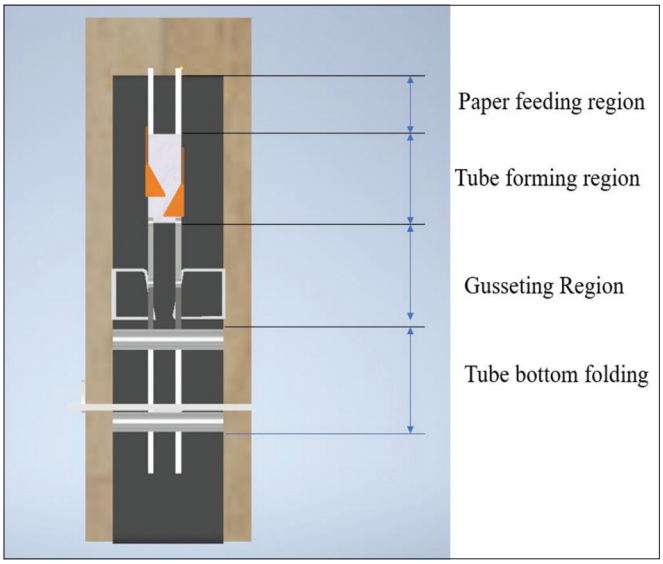

Figure 4: Region of operation

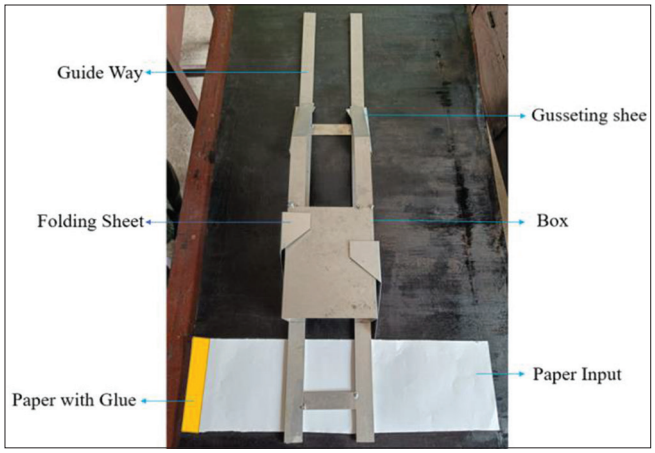

Figure 5: Structure

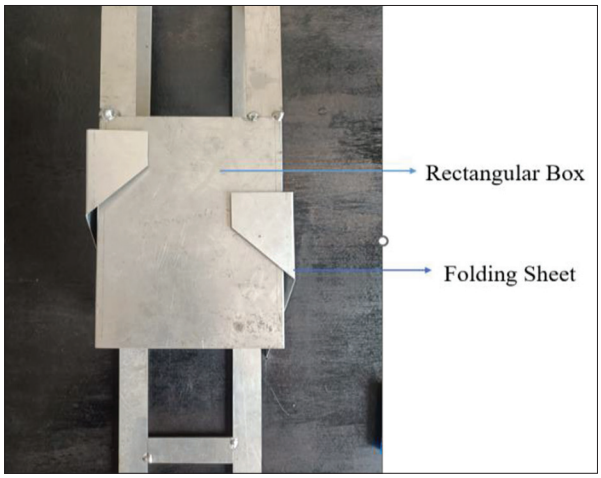

Figure 6: Tube forming region

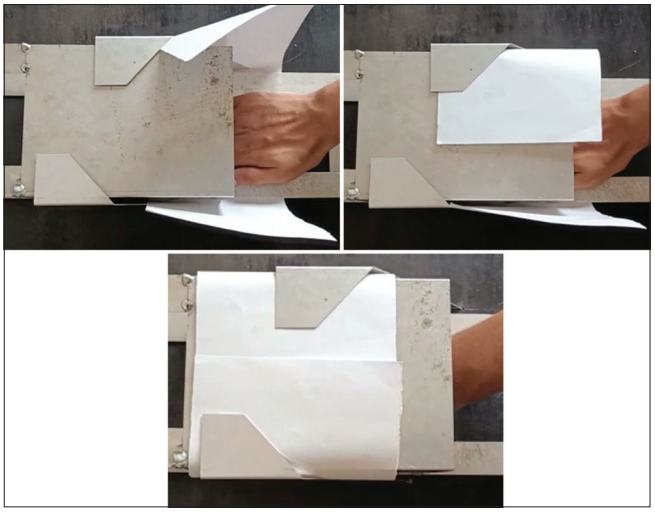

Figure 7: Tube forming process

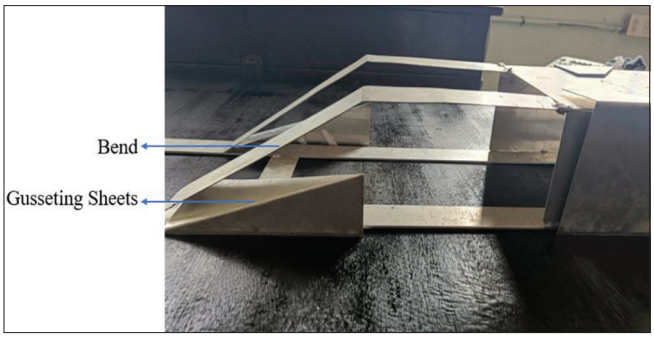

Figure 8: Gusseting region

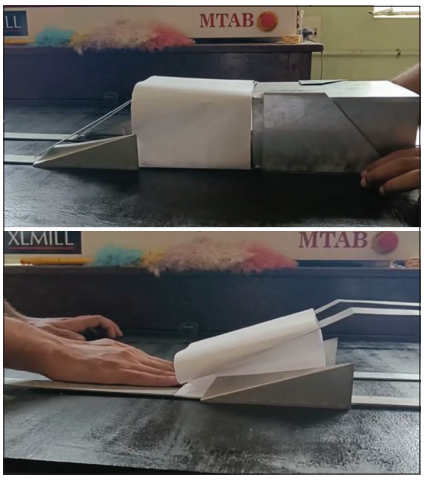

Figure 9: Gusseting process

press roller, will give the gusseted paper tube. The dimensions of the gusset can be altered by the dimensions of the gusseting sheets, which are fixed at the end of the bend.

At the end of the bend, the press roller can be placed to press the gusseted paper flat and push the paper in between the rollers and the base for forward movement. The gusset made here is 5 cm (Figure 10).

Tube bottom folding

It is the second-last step in the paper bag manufacturing process. In this process, the bottom of the tube is folded. The tube-bottom folded paper is then finally folded to get the paper bag. The bottom of the tube is folded by a hook-like structure arranged on a cam that moves up and down as per the cam rotation, and hooking followed by simultaneous pressing by the roller will give the bottom folded tube.

A supporting member is given before the hooking member according to the length at which it should be folded. The folding happens with respect to that supporting member. As the forward- moving gusseted paper is hooked by the structure and followed by the press roller, it will give a tube-bottom folded paper bag.

In Figure 11, the upper tip of the gusseted paper comes into contact with the hook; it hooks the upper surface edge of the

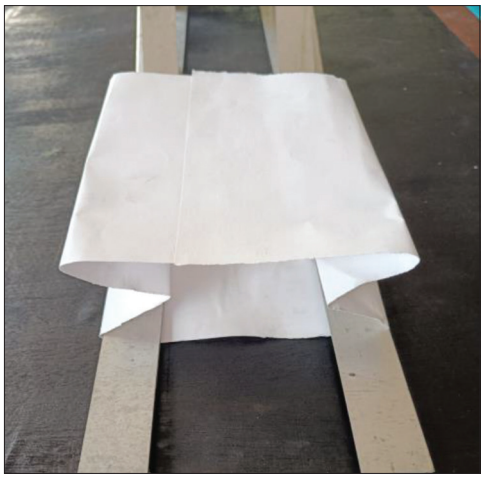

Figure 10: Gusseted Paper

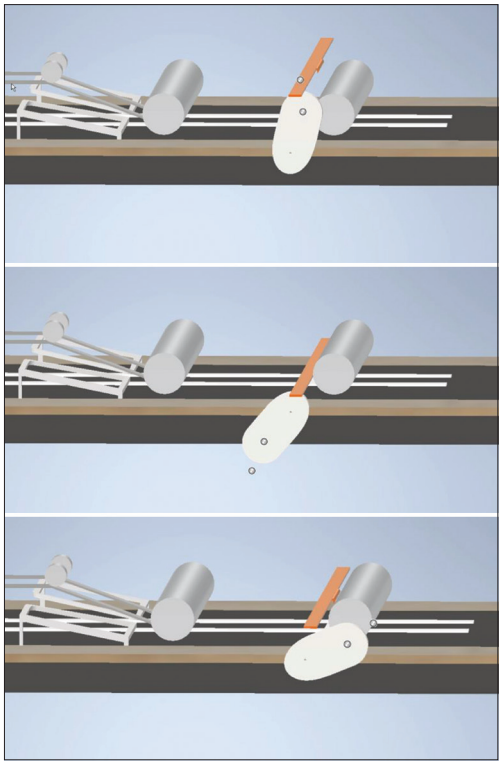

Figure 11: Tube forming process

paper and causes one surface of the paper to move up at a distance of 5 cm. The hooking followed by the press roller gives the tube a folded bottom. One surface will always be beneath the two guideways, and the other face is free to be lifted by the hook.

Paper bag bottom folding

The bottom folding of the paper bag happens as in the already existing paper bag making machines. As the tube-bottom folded paper moves in between the guideways, the folding happens by the splines arranged as shown in the design. The spline arrangements are capable of lifting the bottom sides to be

folded and making them fold into a square bottom. The folding happens as the paper unit is in continuous forward movement. The folding, followed by a pick-up roller at the end, will give flat, square-bottomed folded paper bags (Figure 12).

TUBE FORMING AUTOMATION

The tube-forming process can be automated by the combination of free-rotating rollers and belt-powered roller arrangements (Figures 13, 14 & 15). On the bottom platform, four free, rotating rollers are provided. Above the free-rotating rollers, rollers that are connected by a belt arrangement are provided. The above roller is powered by the DC motor with a reduction gear in order to get the torque to push the paper around the rectangular box to create a tube. The roller arrangement is provided on the bottom of the rectangular box.

The arrangement of rollers with motors drives the other rollers by the arrangement of belts. A DC motor with a reduction gear is coupled to the shaft, which contains a roller.

RESULTS

A commercial design for an automatic paper bag machine is developed. The developed structure is capable of performing the operations in paper bag making machines such as tube forming, gusseting, and tube bottom folding. The final paper bag bottom folding happens the same as in conventional or already existing paper bag making machines. The structure is made of aluminum sheets of thickness 0.7 mm joined by the tig welding technique. Box forming is automated by using free-rotating rollers, belt-powered rollers, a DC motor with a reduction gear, and a welded structure. The structure is made to make the paper bag with a height of 15 cm, a width of 15 cm, a thickness of 10 cm, and a gusseting of 5 cm.

The combined length of the newly designed model is 3.03 meters, which is lower than the conventional models, which have a length of 5 meters and above. The maximum width is 0.9 meters, which is also less than the conventional one. So, the space requirement for the operation is less. The simple techniques for operation also reduce the complexity of manufacturing and operation. As it can operate with simple technologies, the total cost is also lower.

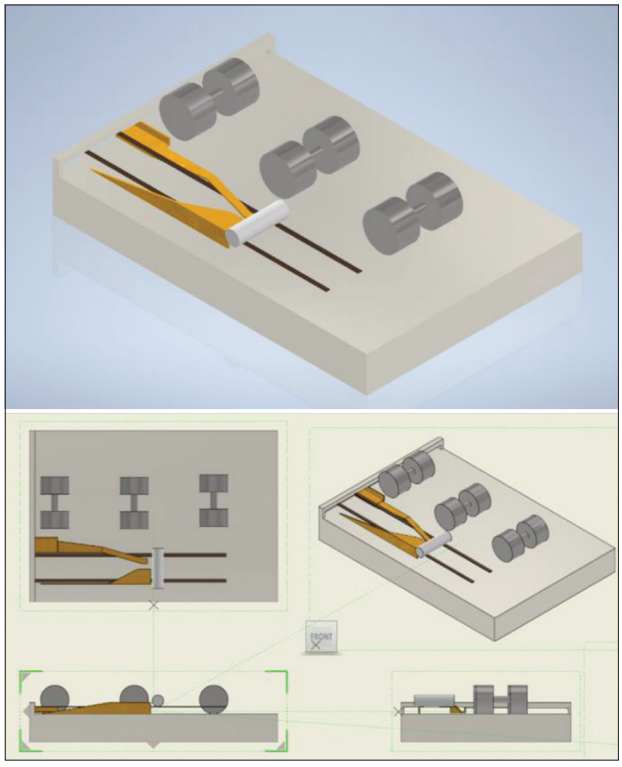

Figure 12: Paper bag bottom folding process

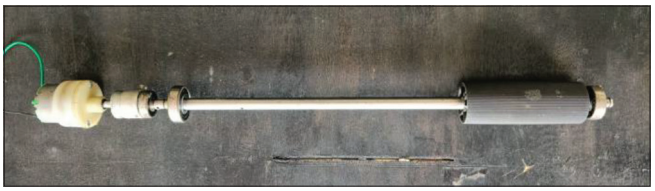

Figure 13: Drive roller

Figure 14: Free rotating roller on the bottom

Figure 15: Belt powered roller arrangement

CONCLUSIONS

A developed design is capable of producing paper bags with simple techniques. The box-forming process can be automated by using rectangular boxes and folding sheet arrangements. The developed machine has less space consumption, is cost-effective, and uses simple techniques when compared with already existing techniques.

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