Sudan University of Science and Technology

College of Engineering

Department of Mechanical Engineering

(Production Department)

Design of a manual fodder baling machine

A project submitted in partial fulfillment for the Requirements of the Degree of B.Sc. (Honor) in Mechanical engineering (Production).

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قال تعالى:

((يَا أَيُّهَا النَّاسُ اتَّقُوا رَبَّكُمْ وَاخْشَوْا يَوْمًا لا يَجْزِي وَالِدٌ عَنْ وَلَدِهِ وَلا مَوْلُودٌ هُوَ جَازٍ عَنْ وَالِدِهِ شَيْئًا إِنَّ وَعْدَ اللَّهِ حَقٌّ فَلا تَغُرَّنَّكُمُ الْحَيَاةُ الدُّنْيَا وَلا يَغُرَّنَّكُمْ بِاللَّهِ الْغَرُورُ * إِنَّ اللَّهَ عِنْدَهُ عِلْمُ السَّاعَةِ وَيُنَزِّلُ الْغَيْثَ وَيَعْلَمُ مَا فِي الأَرْحَامِ وَمَا تَدْرِي نَفْسٌ مَاذَا تَكْسِبُ غَدًا وَمَا تَدْرِي نَفْسٌ بِأَيِّ أَرْضٍ تَمُوتُ إِنَّ اللَّهَ عَلِيمٌ خَبِيرٌ))[لقمان:33-34]

إهداء

الى كل من اضاء بعلمه عقل غيره أو هدى بالجواب الصحيح حيرة سائله فأظهر بسماحته تواضع العلماء وبرحابته سماحة العارفين.

اهداء للوالد والوالدة والاهل والاخوان وزملاء الدراسة.

اهداء لروح والدي بابكر عبدالمنعم.

شكر وعرفان

اشكر الله العلي القدير الذي انعم علينا بنعمة العقل والدين القائل في محكم التنزيل: "وفوق كل ذي علم عليم".

وقال رسول الله صلى الله عليه وسلم: "من صنع اليكم معروفا فكافئوه فان لم تجدوا ما تكافئونه به فادعوا له حتى تروا انكم كافأتموه".

وفاءً منا وتقديرا واعترافا منا بالجميل نتقدم بجزيل الشكر لأولئك المخلصين الذين لم يألو جهدا في مساعدتنا في البحث واخص بالذكر د. جعفر عبدالحميد على هذه الدراسة وصاحب الفضل في توجيهنا و مساعدتنا في هذا البحث.

واخيرا نتقدم بجزيل شكرنا الى كل من مدوا لنا يد العون والمساعدة في اخراج هذه الدراسة على اكمل وجه.

Abstract

Sudan is an agricultural country, and the need of balers is increasing because of the development in technology and green land expansion.

The project describes a detailed design of a manual fodder baling machine which uses wheat bran, how the machine works and a detailed cost of manufacturing the machine and compare it with import machine from outside.

It includes a practical test which describes the baling process on wheat bran.

ملخص البحث

السودان بلد زراعي والحاجة لآلات التكعيب في زيادة نسبة للتطور التكنولوجي و التوسع في الرقعة الزراعية.

المشروع يصف تصميم مفصل لماكينة تكعيب اعلاف يدوية تستخدم ردة القمح، كيفية عمل الماكينة و تفصيل لتكلفة الماكينة ومقارنته مع تكلفة استيراد ماكينة من الخارج.

يحتوي ايضا تجربة عملية توضح عملية تكعيب ردة القمح.

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Chapter 1

Introduction

1.1 Introduction

Agriculture is an important sector in the Sudanese economy. It contributed an annual average of 45 % to total GDP during the last ten years in addition to its employment of about 80% of the total labor force including agricultural-related activities (Siddig, 2009). Moreover, agriculture contributes to other activities such as transportation, agro-industries, and commerce, in the industrial, trade, and service sectors which account for a large share of the GDP.

The interest of national and international organizations by the use of agricultural technology in the production of agricultural good has grown as a result of the world trade liberalization, coupled with concerns over food security, high rates of population growth, the volatility of prices in global markets, and the use of limited and frequently degraded natural resources. The assessment of agriculture can provide insights about how efficiently the agricultural sector is using its endowments.

As a food crop, wheat ranks second to sorghum. Present annual consumption is around one million tons and estimated per capita consumption is 33 kg per annum. During the sixties, wheat production was confined to Northern Sudan where an area of 30,000 feddans was cultivated. Wheat has expanded over years to other parts of the country and its area reached 800,000 feddans during the early nineties. Recent changes in agricultural polices have resulted in a sharp decline in the area under wheat, whereby in the year 2000 this area was in the vicinity of only 200,000 feddans (Adil, 2012).

The wheat grain composed of a number of different tissues an outer branny husk (14–16% of the grain), the germ or embryo (2–3%), and the central endosperm (mainly starch: 81–84%) (Pomeranz 1988).

Nutritionally, bran fractions produced are rich in fiber, minerals, vitamin B6, thiamine, folate and vitamin E and some phytochemicals, in particular antioxidants such as phenolic compounds (Shewry 2009).

1.2 Problem Statement

Sudan is an agricultural country, and the need of balers is increasing because of the development in technology and green land expansion.

Balers are imported from foreign countries and make expensive costs and sometimes has shipping, loading and packaging issues.

1.3 Objectives

1. Design baling machine with quality and available materials.
2. Reduce manufacturing cost.

1.4 Research scope

The machine is manual drive and the baling material is wheat bran.

Chapter 2

Literature review and previous study

2.1 Bale types

1. Round bales
2. large square bales
3. small square bales

Round bales have the ability to shed water much better than square bales, which can allow round bales to be stored more easily in the field and for longer periods of time at a lower cost (Liu et al. 2013). Large square bales have a greater bulk density and are easier to transport and move than round bales. They also have higher field efficiency because square bales can be ejected from the baler without stopping during operation (Liu et al., 2013). Large square balers have a higher upfront cost than round balers, which makes purchasing them more difficult for smaller scale operations (Remoue, 2007). Storage of square bales is more difficult than round bales because they must be under a structure or out of the weather to decrease mass loss due to weathering.

Square bales can come in two forms, either large or small square bales. Small square bale technology was developed long before large square balers and is often used by smaller farmers in certain specialty areas, such as horse operations. Shinners et al. (1995) explains that one of the major differences between small square balers and larger square balers is the pre-compression chamber. Crop is fed into this chamber where it is compressed slightly until a relatively large amount of crop is accumulated. Once this has occurred, the crop flake is pushed from the pre-compression chamber into the main chamber and added to the main bale. Because of this difference, a higher bale density can be achieved with a large square baler, as compared to a small square baler.

The forces inside a large square baler can be extremely large, and previous studies have found that these forces often change depending on the crop type.

2.2. Baler types

Balers can be divided into 4 types:

1- Vertical baler.
2- Horizontal baler.
3- Tractor baler.
4- Simple manual baler.

2.2.1 Vertical baler

Figure (2.1) vertical baler (Photo: www.harrisequip.com)

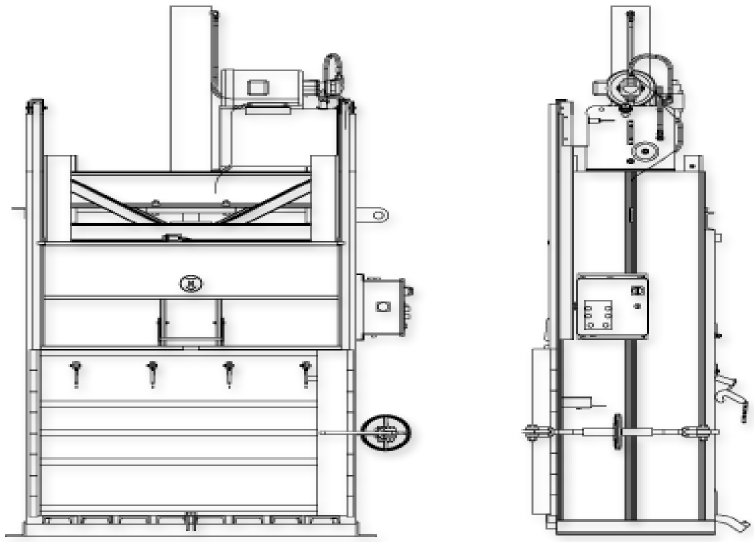

Figure (2.2) vertical baler drawing (Photo: www.harrisequip.com)

Figure (2.1) and figure (2.2) describes vertical baler shape and vertical baler views respectively.

2.2.1.1 Vertical baler features

- Heavy Duty Construction – Built with heavy-duty steel to handle repeated use.
- Easy Operation – Simple one-touch mechanical operation and straight forward manual tying system.
- Easy Unloading – Manual unlock and mechanical assist make easy work of unloading.

Table (2.1) vertical baler different models (Table: www.harrisequip.com)

Model Name		V5-HD-10	V5-HD-15	V5-SLP	V5-XHD	VNF-5	V6-15	VS-6M	VDC-1
Bale Size, in baler	Length: in.(mm)	60 (1524)	60 (1524)	60 (1524)	60 (1524)	60 (1524)	72 (1829)	72 (1829)	Crushed
	Width: in.(mm)	30 (762)	30 (762)	30 (762)	30 (762)	30 (762)	30 (762)	42 (1067)	Drum Height
	Height: in.(mm)	48 (1219)	48 (1,219)	33 (838)	48 (1219)	48 (1219)	48 (1219)	48 (1219)	6 - 8 (152-203)
Bale Weight (OCC)	(lb)	900-1000	900-1100	600-700	1100-1450	1300-1600	1000-1275	900-1300	Varies with
	(kg)	(408-454)	(386-499)	(272-318)	(612-680)	(590-725)	(408-578)	(408-590)	Drum
Cycle Time	No Load (sec)	50	50	29	71	45	50	50	58
Motor Horsepower		10	15	10	15	15	15	15	15
Hydraulic Pressure (Max)	(psi)	1,800	2,000	1,800	2,000	3,000	2,000	2,000	2,000
	(BAR)	(124)	(138)	(124)	(138)	(206)	(138)	(138)	(138)
Platen Force Maximum	(lb)	50,900	56,550	56,550	76,969	145,770	56,500	51,000	69,200
	(kg)	(23,088)	(25,650)	(25,650)	(34,912)	(66,120)	(25,650)	(23,133)	(31,388)
Main Cylinder	Bore: in.(mm)	6 (152)	6 (152)	6 (152)	7 (178)	8 (203)	6 (152)	6 (152)	7 (177)
	Stroke: in.(mm)	48 (1219)	48 (1219)	27 (686)	48 (1219)	54 (1372)	48 (1219)	48 (1219)	36 (914)
Hydraulic Pump Capacity	gpm(lpm)	11 (41)	12 (45.4)	12 (45.4)	12 (45.4)	28.5/7.5 (108/28)	12 (45.4)	15 (56)	12 (45.4)
Oil Reservoir Capacity	gal(L)	18 (68.1)	18 (68.1)	12 (45.4)	18 (68.1)	44 (166.6)	18 (68.1)	18 (68)	18 (68)
Feed Opening	Width: in.(mm)	60 (1524)	60 (1524)	60 (1524)	60 (1524)	60 (1524)	72 (1829)	72 (1829)	46 (1,168)
	Height: in.(mm)	27 (686)	27 (686)	19.5 (495)	24 (610)	27 (686)	25 (635)	32 (813)	29.5 (749)
Shipping Weight	(lb)	4,300	4,300	3,860	6,500	9,750	5,500	6,500	4,500
	(kg)	(1,950)	(1,950)	(1,751)	(2,948)	(4423)	(2,495)	(2,948)	(2,041)

2.2.2 Horizontal baler

Figure (2.3) horizontal baler (Photo: www.harrisequip.com)

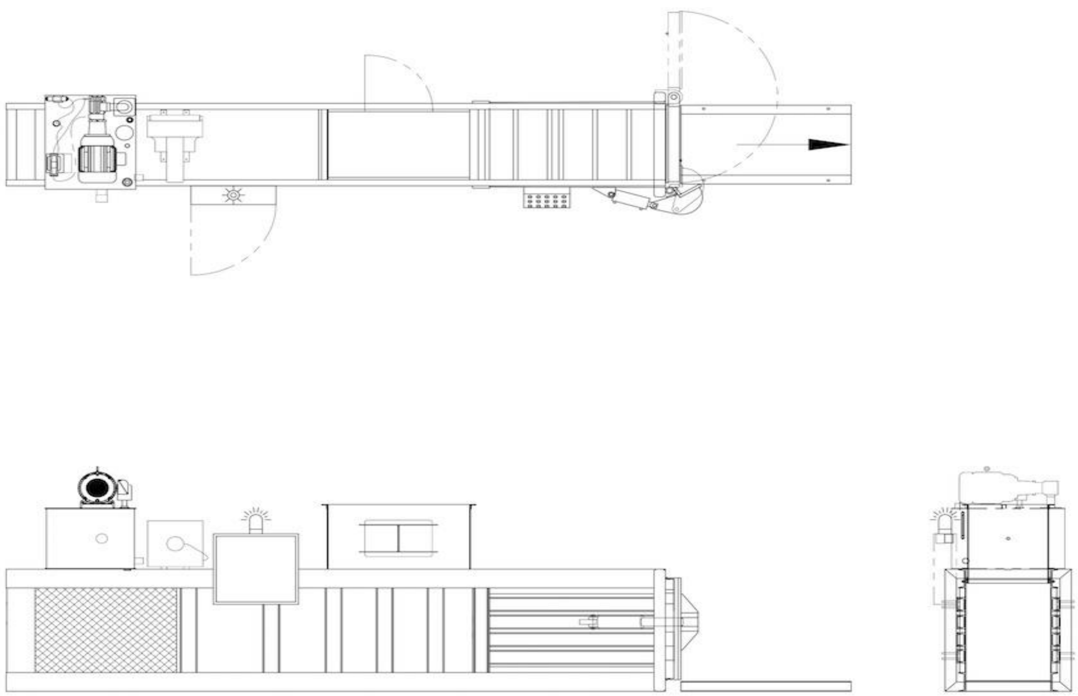

Figure (2.4) horizontal baler drawings (Photo: www.harrisequip.com)

Figure (2.3) and figure (2.4) describes horizontal baler shape and horizontal baler views respectively.

2.2.2.1 Horizontal baler features

- Replaceable Wear Components.
- TEFC High Efficiency Motor.
- AR400 Abrasion Resistant Alloy Steel Shear Blades.
- Adjustable Shear Bar.
- Automatic Cycle.
- Meets or Exceeds All Current ANSI Z 245.5 Safety Standards.

Table (2.2) horizontal baler different models (Table: www.harrisequip.com)

Model	CD-632	CD-721 UBC	CD-736	CD-751	CD-862
HYDRAULIC					
Main Cylinder	6" Bore 152 mm	7" Bore 178 mm	7" Bore 178 mm	7" Bore 178 mm	8" Bore 203 mm
System Pressure	3000 PSI 207 Bar	4500 PSI 310 Bar	3000 PSI 207 Bar	3000 PSI 207 Bar	3000 PSI 207 Bar
Total Force Metric Ton	84,780 LB 38 t	173,090 LB 87 t	115,400 LB 52 t	115,400 LB 52 t	150,720 68 t
Ram Face Pressure	78 PSI 5.4 Bar	144 PSI 9.9 Bar	93 PSI 6.4	65 PSI 4.5 Bar	85 PSI 5.9 Bar
Door Cylinder	3.25" Bore 82 mm	5" Bore 127 mm	3.25" Bore 82 mm	4" Bore 102 mm	4" Bore 102 mm
ELECTRICAL					
Main Motor	20 HP 15 kW	20 HP 15 kW	20 HP 15 kW	30 HP 22 kW	50 HP 37 kW
STRUCTURAL					
Length Overall	220 in 5.6 meter	204 in 5.2 meter	242 in 6.2 meter	276 in 7 meter	290 in 7.4 meter
Width Overall	34.5 in .87 meter	48 in 1.2 meter	34.5 in .87 meter	68 in 1.7 meter	55 in 1.4 meter
Charge Hopper Height	72.5 in 1.84 meter	60 in 1.5 meter	83 in 2.1 meter	90 in 2.3 meter	90 in 2.3 meter
Hopper Opening	28 in W x 50 in L 711 mm W x 1270 mm L	38 in W x 30 in L 965 mm W x 762 mm	28 in W x 50 in L 711 mm W x 1270 mm	40 in W x 50 in L 1016 mm W x 1270 mm	40 in W x 60 in L 1016 mm W x 1524 mm
PERFORMANCE					
Bale Size Expanded	30 in (762 mm) Wide x 36 in (914 mm) High x 60 in (1524 mm) Long	40 in (1016 mm) Wide x 29 in (736 mm) High x 48 in (1219 mm) Long	30 in (762 mm) Wide x 43 in (1092 mm) High x 60 in (1524 mm) Long	42 in (1067 mm) Wide x 42 in (1067 mm) High x 72 in (1828 mm) Long	42 in (1067 mm) Wide x 42 in (1067 mm) High x 72 in (1828 mm) Long
Bale Weight	Up to 1100 LB OCC 499 KG OCC	Up to 700 LB UBC 318 KG UBC	Up to 1300 LB OCC 590 KG OCC	Up to 1700 LB OCC 771 KG OCC	Up to 2000 LB OCC OCC 907 KG OCC
	Additional models available.				

2.2.3 Tractor baler

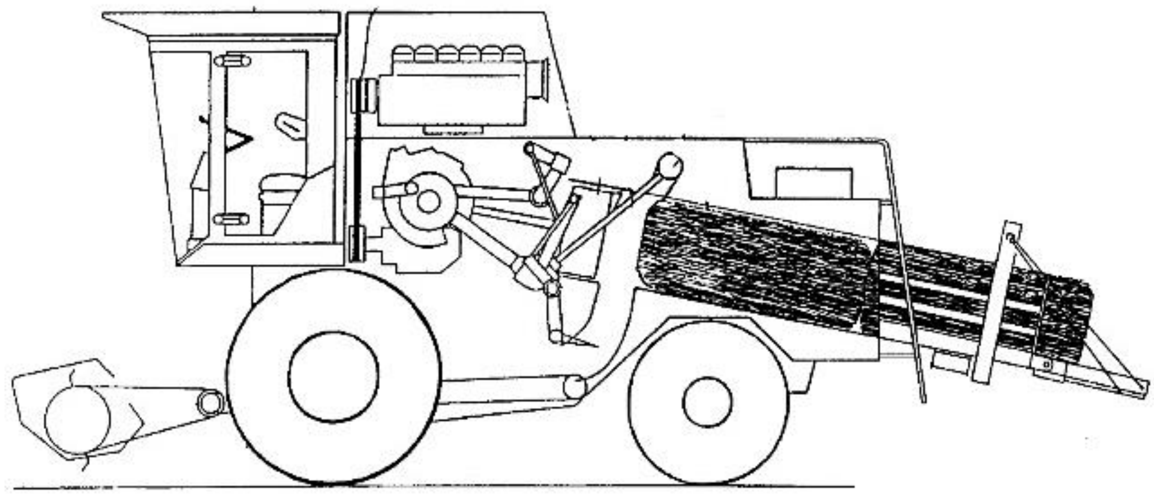

Figure (2.5) tractor baler (Wilhelm 1998)

Figure (2.5) describes a tractor baler having a conveyor device mounted beside the machine, such that the feed is transversal rather than longitudinal. Thus, the harvested crop is picked up beside the machine, fed transverse to the direction of travel into the processing device, in which case the inlet of the processing device is on the side of the machine. The resulting width of the machine complicates the maneuverability thereof and there is a danger that the harvested crop lying on the field may be run over by the wheels of the machine.

2.2.4 Simple manual baler

Figure (2.6) simple manual baler (Yuri)

Figure (2.6) describes a simple vertical baler has a manual wheel driver and a set of gears to change the direction from circular to vertical to move a plunger that work as a piston along a funnel ends in the bale chamber.

2.2.4.1 Frame

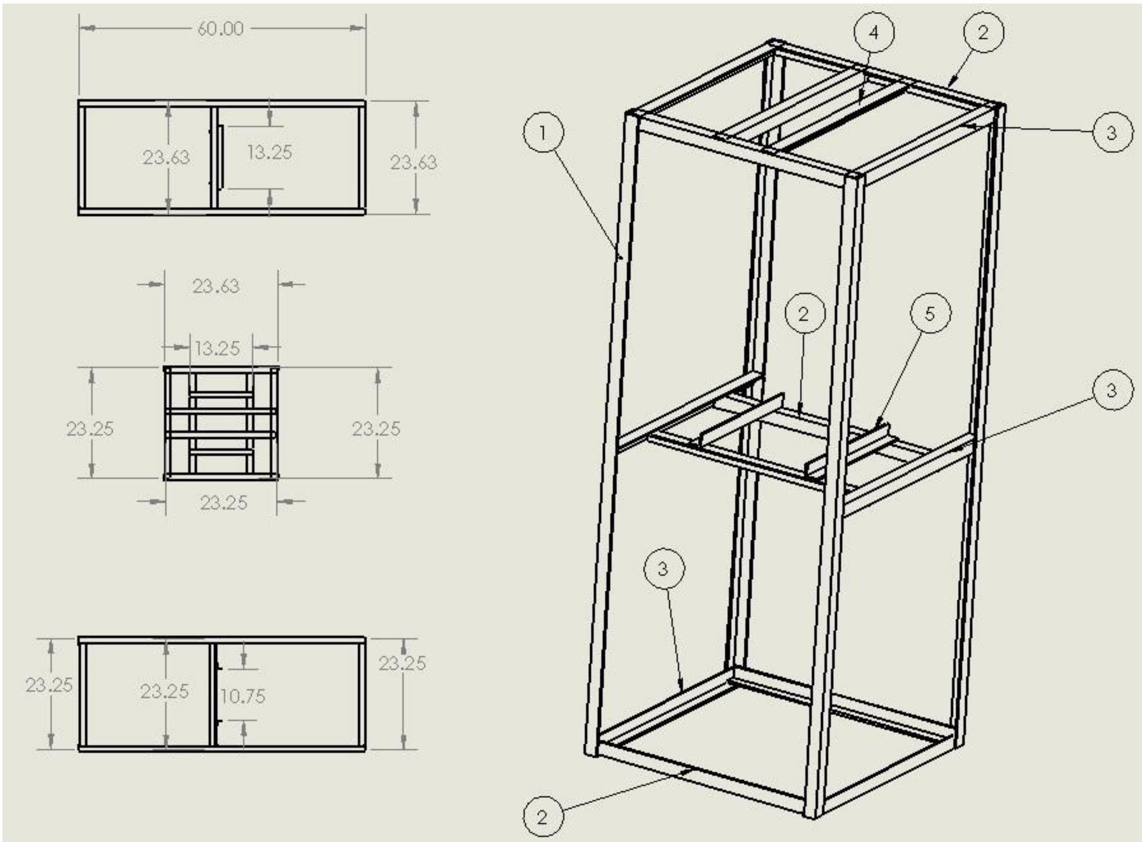

Figure (2.7) frame

For the frame used angle iron stock that was 3/16” thick by 1 1/4” wide. The four posts [#1 in figure 2.7] are 5’ tall. The cross braces [#’s 2 and 3] are 23 and 5/8” and 21.5” respectively. The #2 cross braces were notched on both ends to mesh with the posts, and were then welded in place so that they created a flat plate on the ends of the posts. The #3 braces were then butted against these welds, and all pieces were welded in place. We now essentially had a box to work with that could stand alone.

The two braces for the gear assembly [# 4 in figure 2.7] were cut to 23 and 5/8” and were notched like the previous cross braces to mesh and provide a flat plate on top of the frame and so that there are two flat sides facing each other on the . Before welding these in it is important to check the alignment of the rack with these braces, as they will need to be centered so that the rack doesn't drift from side to side. They should be welded symmetrically at about the center line of the top of the baler, and should be far enough apart to fit the gear box assembly and allow the middle pair of roller bearings to sit on one side. For more details on this portion of the design read the "Gear Assembly" section.

The last portion of the frame seen above in the middle of the assembly {#'s 2, 3, and 5] is meant to provide a frame to hold the funnel in place. Items 2 and 3 are cut in the same way as their counterparts on the top and bottom of the frame, except that the #3 pieces are welded in from the side to fit the width of the funnel. They should be welded 10 and 3/4" apart (assuming you use funnel material dimensioned the same as ours) and should be symmetric about the center line. This whole portion of the frame should be welded roughly halfway up from the bottom. This location does not need to be precise, as it is just a brace for the frame. The two #5 pieces are not welded to the frame, but are instead fastened to the outside of the funnel and are made of aluminum angle stock. The dimensions do not matter, the stock just needs to be wide enough to accept a fastener without difficulty. These #3 pieces are roughly 12" long. Not pictured above is a piece of angle iron stock that is welded to the funnel carriage at a location where it will butt against the aluminum stock that is fastened to the funnel so as to provide a stop to ensure the correct horizontal location of the funnel. This can be a rough dimension as well.

2.2.4.2 Funnel

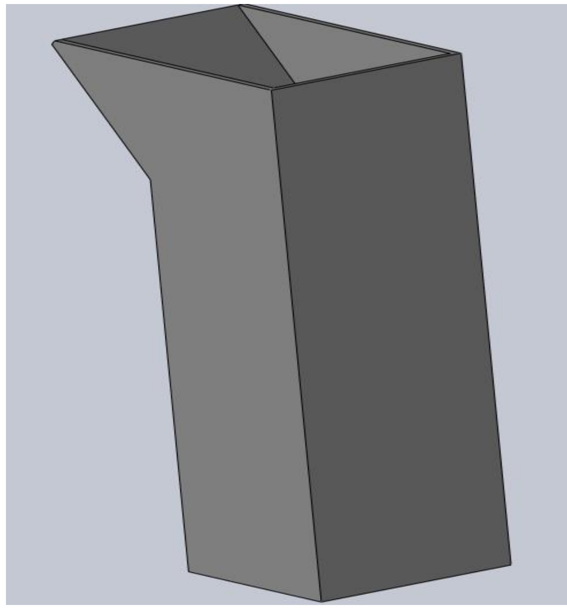

Figure (2.8) the funnel

The funnel is constructed of 3/8” thick high density polyethylene sheet material and sections of aluminum angle stock connected with self-tapping fasteners. The funnel measures 30” tall with an inside width of 10” square. The front face of the funnel extends outward at a 45º and reaches 6” down from the top of the funnel. The bottom of the angled front face marks the height at which the hops should be filled in order to create a 5lb bale. Several 6” lengths of aluminum angle stock were cut to act as a framework for the polyethylene boards. Self-tapping screws were used as fasteners to fix the polyethylene to the aluminum strips. The screws were countersunk on the inside of the funnel and were screwed from the inside out into the aluminum. The two pieces of aluminum referenced in the Frame section were fastened to the funnel at a height that allowed the funnel to sit flush with the form box. This height was determined after constructing the form box and setting the funnel on top of it.

2.2.4.3 Gear assembly

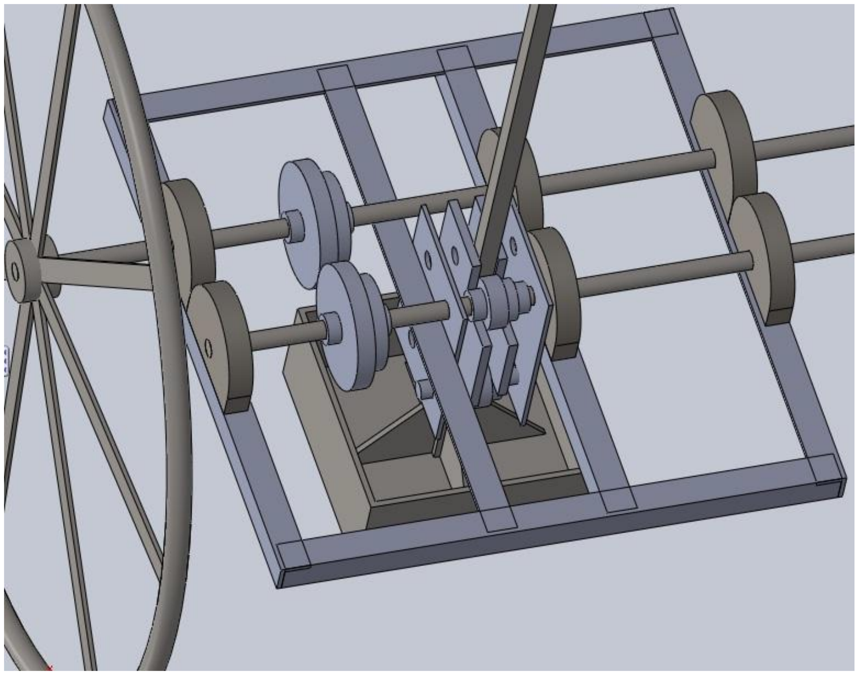

Figure (2.9) gear assembly

The gear assembly consists of two (2) 2.125” gears, two (2) 5.125” gears, and two (2) 1.5” high density polyethylene rollers. All gears are made of steel and have a pitch of 16, and are keyed with a 3/32” deep by 3/16” wide keyway. The gear assembly, shown above, transmits the force applied on the crank wheel to the rack and thereby to the plunger. The crank wheel is fixed to a keyed input shaft, which is fixed by three cast iron mounted bearings and also holds the first input gear. The shaft is 30” long and has a diameter of ¾”. It is fully keyed with a 3/16” by 3/32" keyway. The input gear has a diameter of 5.125”, a 20º pressure angle, a pitch of 16, and a face width of ¾”. The force from the input gear is transferred to a second 5.125” gear with the same specifications held by the transmission shaft. This shaft transmits the force to a 2.125” gear, also with a pitch of 16, a 20º pressure angle, and a ¾” face width, which in turn transmits the force to the rack. A second 2.125” gear is located directly below the first on a rolling shaft in order to provide bracing for the rack. The shaft is held in the gear box by press-fit high density polyethylene spacers that fit snugly on the roller shafts. These spacers and the gears and rollers are sandwiched by two high density polyethylene boards made from the same material as the funnel. These boards are then held in place by two steel plates that are welded to the cross braces. The cross braces are angle iron of the same dimensions as the frame and are welded to the frame. All gears are held in place on the shafts by keyways with key stock, and two collars with set screws for each gear. The mounted bearings also have set screws to hold the shafts in place. It is important that the gear ratio supplied to the hops from the crank wheel to the rack be at least 15:1, if the necessary force is to be applied.

2.2.4.4 Plunger

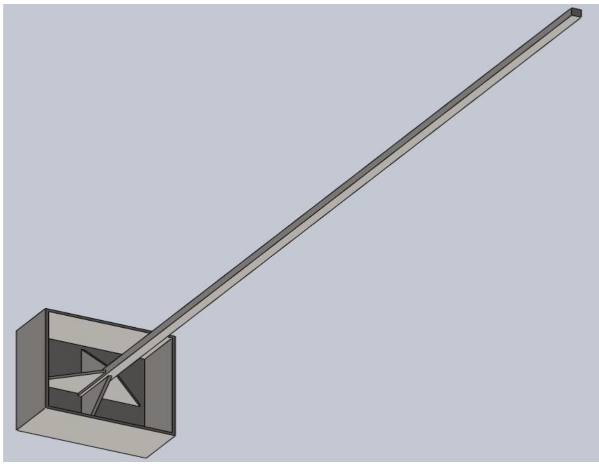

Figure (2.10) the plunger

Seen in figure 2.10 is the plunger component. It consists of a flat plate base made of ¼" thick steel with guide plates welded onto the top of the plate to prevent it from becoming misaligned with the funnel and form box. Welded onto the plate is our rack, which receives the power input and delivers it to the hops. The rack is 5' tall and has pitch of 16 with a 20º pressure angle and is a ¾" square. The rack is braced by four angled pieces of plate steel, which are welded to both the rack and the plunger plate. Several small holes have been drilled into the plate and small pieces of thin rubber have been epoxied over them to act as one-way air valves.

2.2.4.5 Forming box

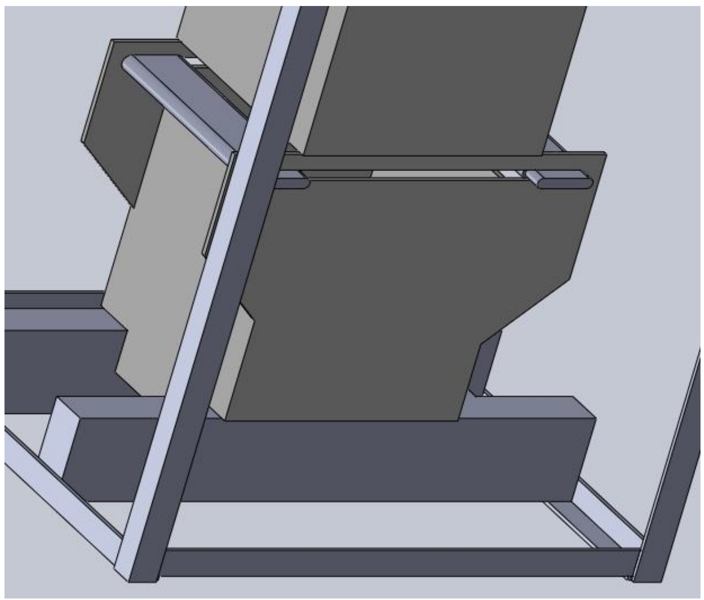

Figure (2.11) the form box

The bale shaper box is constructed of the same material as the funnel, but instead of being braced by aluminum angle stock it is braced by steel to provide a stronger skeleton. The box is 12.75" tall, with a 10" inner footprint. The base of the box is a 10.75" square piece of plate steel with a ¼" thickness. Two of the sides opposite each other are not fixed into the box but instead are held in place by small pieces of angle iron welded to the base plate on the inside of the box. This design feature allows the pieces to be removed easily which makes removing the bale very smooth

2.2.4.6 Crank wheel

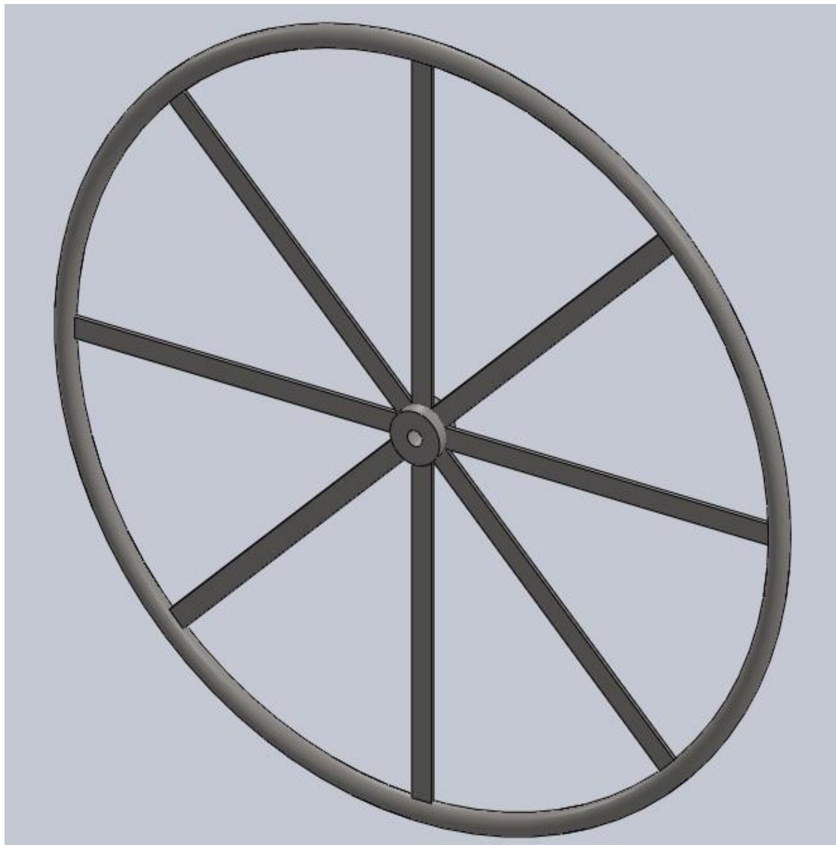

Figure (2.12) the crank wheel

The crank wheel was machined with 3/4” round steel stock. It was rolled to a diameter of 36”. There are 8 -3/4” spokes that connect the outer wheel to an inner hub. The hub has an outer diameter of 2.5” and is bored to fit the 3/4” shaft. The hub has a 2” face width and has a keyway measuring 3/32” deep by 3/16” wide. We considered many options for the crank wheel and settled on this one simply because we had the budget for it and we could have it machined easily by a local shop (Clews Machining, LLC). We had also considered the crank wheel from a hand powered grain mill, the crank wheel from a boat lift, and many other options. The wheel cost us $350 so it is certainly not the most economical choice.

2.3 Force produced by human

Four hand wheels were used in the study The hand wheels were assigned Large (40.6 cm), Medium (22.9 cm), Small (20.3 cm), and Small-Handled (crank-type handle on wheel, 17.8 cm) designations (beginning with the largest and moving counterclockwise).

A biomechanical testing machine designed by LIDO™ (Loredan Biomedical, 1992) was used to define optimum design parameters for a variety of wheel turning tasks. The apparatus consisted of a dynamometer, an analog-to-digital converter (A/D), and a computer.

These results are found:

Table (2.3) Mean and standard deviation for the four wheels (Myers 1972)

Handwheel Size (cm)	*M* (Nm)	*SD* (Nm)
40.6	61.8584	22.0995
22.9	34.8929	11.3182
20.3	25.5338	8.9239
17.8	24.4613	9.5882

Chapter 3

Methodology

3.1 Design assumptions

The machine which we are designing is a manual fodder baling machine that constructed of the following:

3.1.1 Frame

The frame we used is same to the previous design, angle iron stock that is 3/16" thick by 11/4" wide. It is sufficiently strong enough for the load demands that we calculated (see Appendix A).

Figure (3.1) frame

3.1.2 Funnel

The funnel is also same to the previous funnel in dimension but different in material which was constructed of 95.25 mm thick Perspex sheet material and sections of aluminum angle stock connected with self-tapping fasteners (see Appendix A).

Figure (3.2) funnel

3.1.3 Gear assembly

The gear assembly is different from the previous design which consists of two large gears and one small gear and 3 rollers to guide the direction of the plunger.

The small gear has a module of 2, 25 teeth, 20º pressure angle and 19.05 mm face width.

The two large gears has a module of 2, 63 teeth, 20º pressure angle and 19.05 mm face width.

The shaft diameter is 25 mm.

All gears and rollers are made of stainless steel.

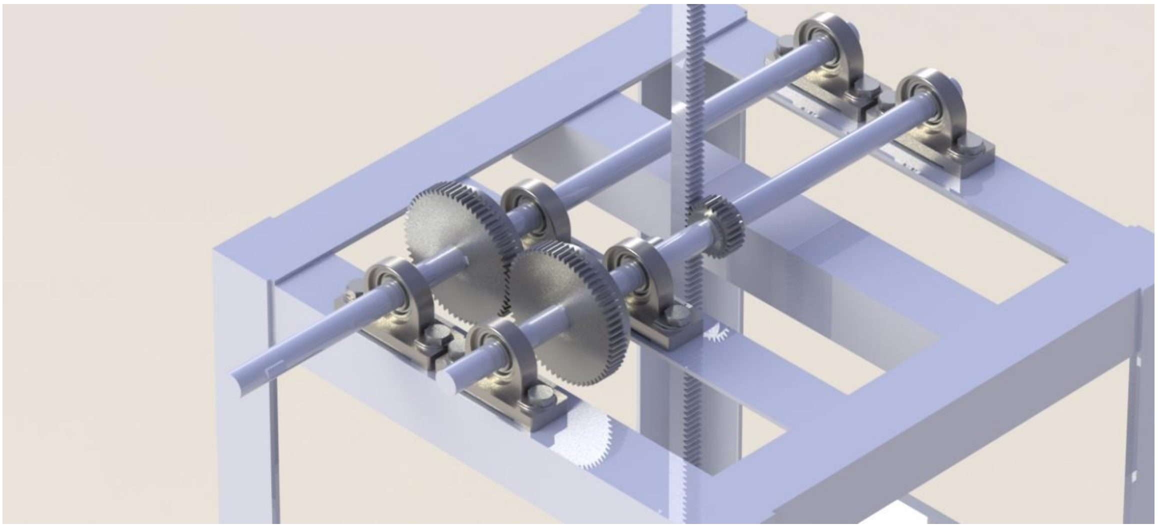

Figure (3.3) gear assembly

3.1.4 Plunger

It's same as the previous design which consists of a flat plate base made of 6.35 mm thick steel fastened to a rack (see Appendix A).

3.1.5 Forming box

The bale shaper box was constructed of the same material as the funnel, but instead of being braced by aluminum angle stock it is braced by steel to provide a stronger skeleton (see Appendix A).

3.1.6 Crank wheel

The wheel was machined with 20mm round steel stock, it is rolled to a diameter of 782 mm (see Appendix A).

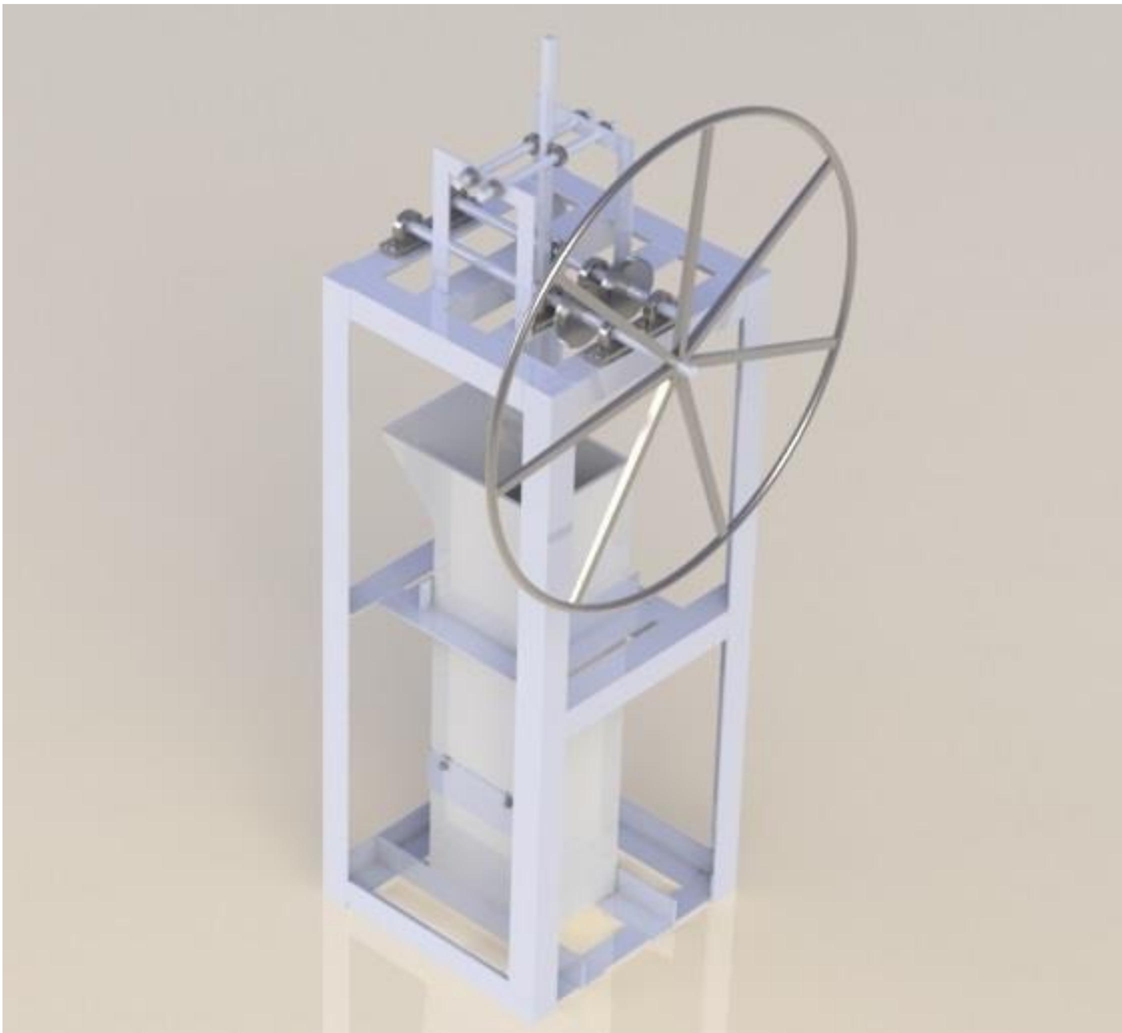

Figure (3.4) final assembly

3.2 Material of baling

The previous machine used Hops as the material of baling but in our design we are using wheat bran.

3.3 Software used

In our design we are using SolidWorks software for design and simulation.

For the frame we draw the section and use extrude tool to make the 3D shape for each component of the frame with respect to the dimension.

For the funnel we draw the side view of the funnel and extrudes it to have a solid 3D shape, then uses shell tool to hollow the solid shape and have the final shape of the funnel.

The gear assembly is taken from design library with the desirable dimensions for the gears and bearings.

The plunger consist of two component, the plunger box and the rack.

For the plunger box we made a cube with the suitable dimensions and shell it to have the box, the rack is founded in the SolidWorks toolbox.

The forming box is a cube that is shelled.

For the crank wheel we made a circle with the diameter of the shaft with respect to the key hole and another circle around it to be the center of the wheel, then draw a small circle with the width of the wheel which is away from the center by the diameter of the wheel and use revolve tool to an axis from the center to shape the wheel.

Chapter 4

Design analysis And Theories

4.1 Design theories

Our machine movement is based on power transmission between gears and shafts, where the power transmit from the crank wheel to the large gear (driver) which connected to the other large gear (driven) which it convert the power to the small gear by the shaft between them.

The small gear is connected to a rack which convert the movement from circular to vertical movement which drive the plunger up and down.

The force affected by the person who drive the wheel determined by the test from chapter 2:

From the result we found that the force produced by the driver =

$$F = T/R \text{ ……… } (1)$$

Where:

F: The force produced by the driver.

T: the torque produced.

R: wheel radius.

From the previous test the wheel radius is 40.6 cm and the maximum torque is 61.8584 so:

F = 61.8584/0.406

F = 152.3606 N

Our wheel is 78.2 cm radius

The maximum torque produced = 152.3606*0.782 = 119.146 Nm

4.2 Practical test for baling process

For proving the capability of the wheat bran to be baled a test has been done with the following:

4.2.1 The compressor

The compressor is a hydraulic compressor with a maximum capacity of 15 ton (See Appendix B).

4.2.2 Forming box

The forming box was made of four wood plates assembled with nails.

It is 80 cm height and 32*29 cm dimensions (See Appendix B).

4.2.3 Compressing process

The compressing process was done with a fully forming box of wheat bran and compressed to a height of 39 cm, the piston was kept at that position for two minutes and driven back (See Appendix B).

4.2.4 Watch reading

The watch arrow pointed at 23 kg/cm2 (See Appendix B).

4.2.5 Final bale shape

The bale dimension is 32*29*39 cm (See Appendix B).

4.3 Calculations

The force applied by the piston = watch read*Area*gravity

23*0.29*0.32*9.81 = 20.94 N

Pressure:

$$P = F/A \quad \ldots\ldots\ldots\ (2)$$

A = area of the forming box

P = 20.94/0.32*0.29 = 225.65 Pa.

The mass of the bale was found 13 kg and (0.32*0.29*0.39) =0.0362 m^3volume

So the density of the bale=

$$\rho = \frac{M}{V} \ldots\ldots\ldots..(3)$$

Where ρ = Density

M = mass

V = volume

ρ = 13/0.0362 = 359.195 kg/m^3

The density of the bran before baling was =

13/0.32*0.29*0.8 = 175.11 kg/m^3

4.3 Machine cost

Table (4.1) machine component cost

Component	**Quantity**	**Price, SDG**
Iron angle	16.5 m	320 per meter=**5280**
Pinion	1	**250**
Gear	2	2*400=**800**
Plunger	1	**700**
Shaft (0.025 dia)	2	2*250=**500**
Shaft (0.02 dia)	2	2*220=**440**
Perspex	2 m^2	750 per m^2=**1500**
Bearing	9	9*20=**180**
Bearing block	6	6*100=**600**
Wheel	1	**750**
Assembly features		**200**
Total cost		**11200 SDG**

Cost of vertical baler at (www.alibaba.com) shopping website is around 5,000-1,000 US$ + the shipping and custom cost it can reach 15,000 $.

Chapter 5

Conclusion and Recommendation

5.1 Conclusion

The project has detailed and describe the design and cost estimation for the manual fodder baling machine and compare that cost with the cost of importing a machine from outside the country, and there was a high reduction in the cost.

The capability of the machine and wheat bran compression was tested and it can be possible to use.

5.2 Recommendation

For the future work of the machine we recommend for the following:

1- Drive the machine with an electrical motor with microcontroller to control compression start and finish and delay time to shape the bale.
2- The compressor would be hydraulic with a pressure meter.

5.3 References

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6.0 APPENDIX

6.1 APPENDIX A

CAD Drawings of machine parts

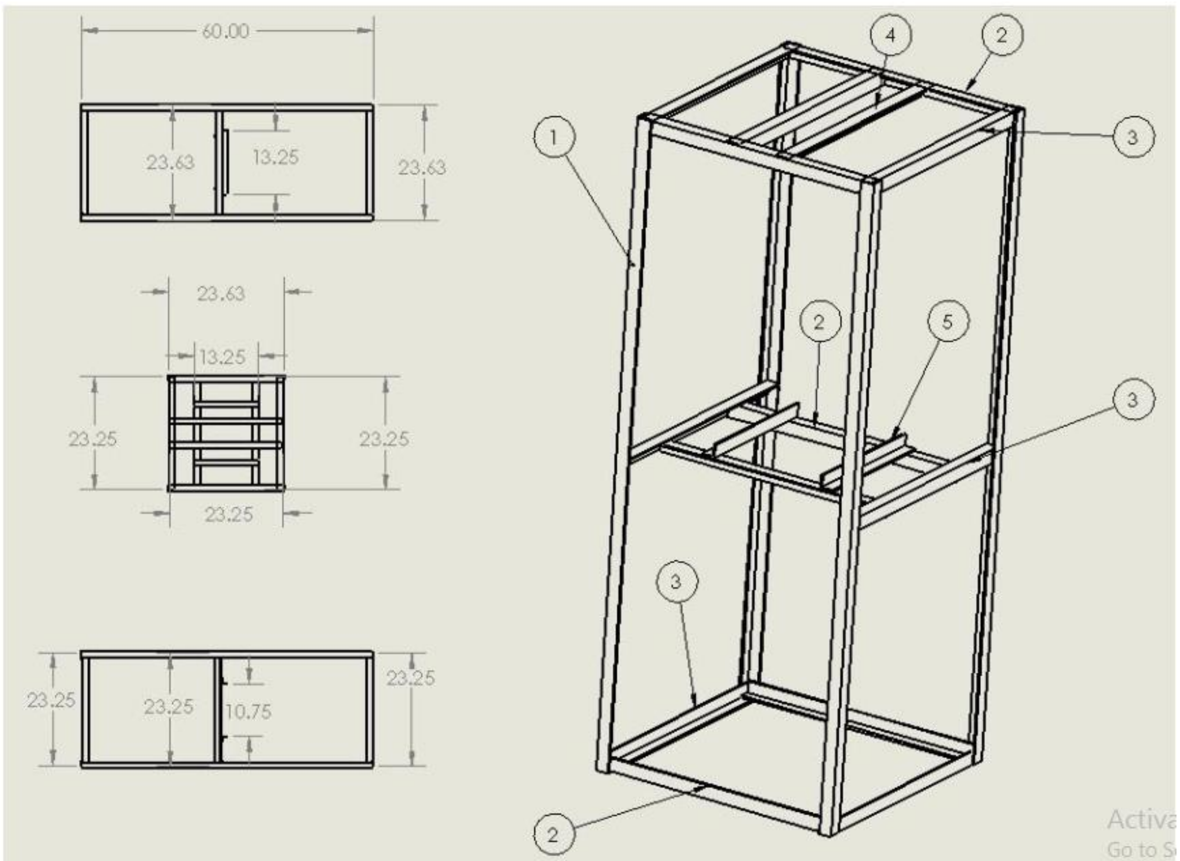

Figure (6.1) Frame dimensions

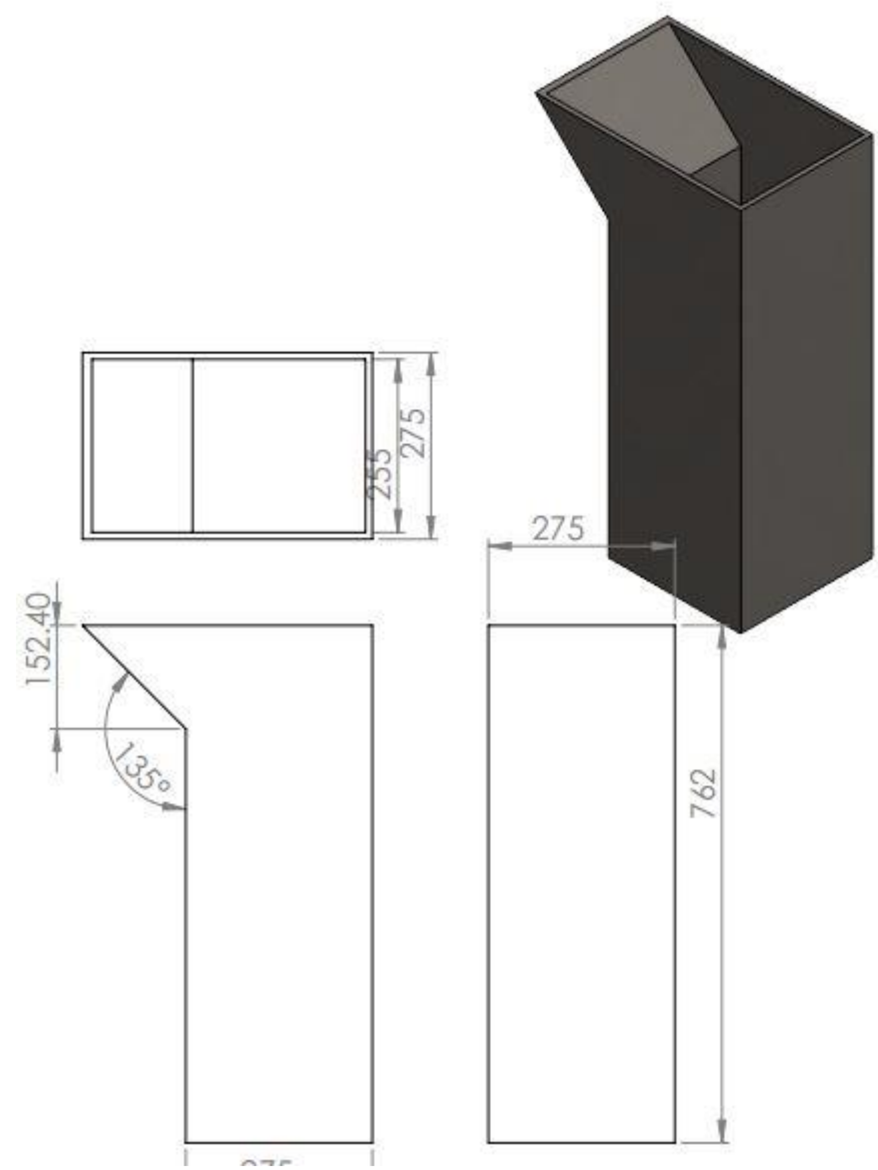

Figure (6.2) Funnel dimensions

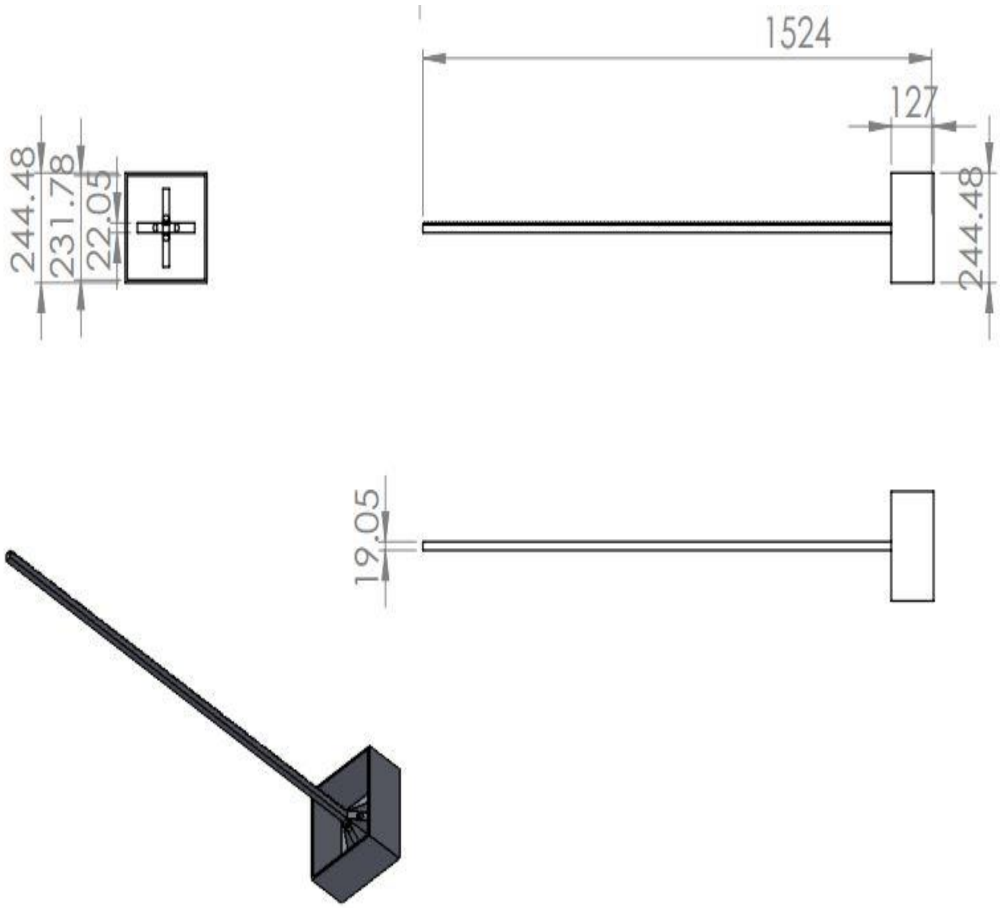

Figure (6.3) Plunger dimensions

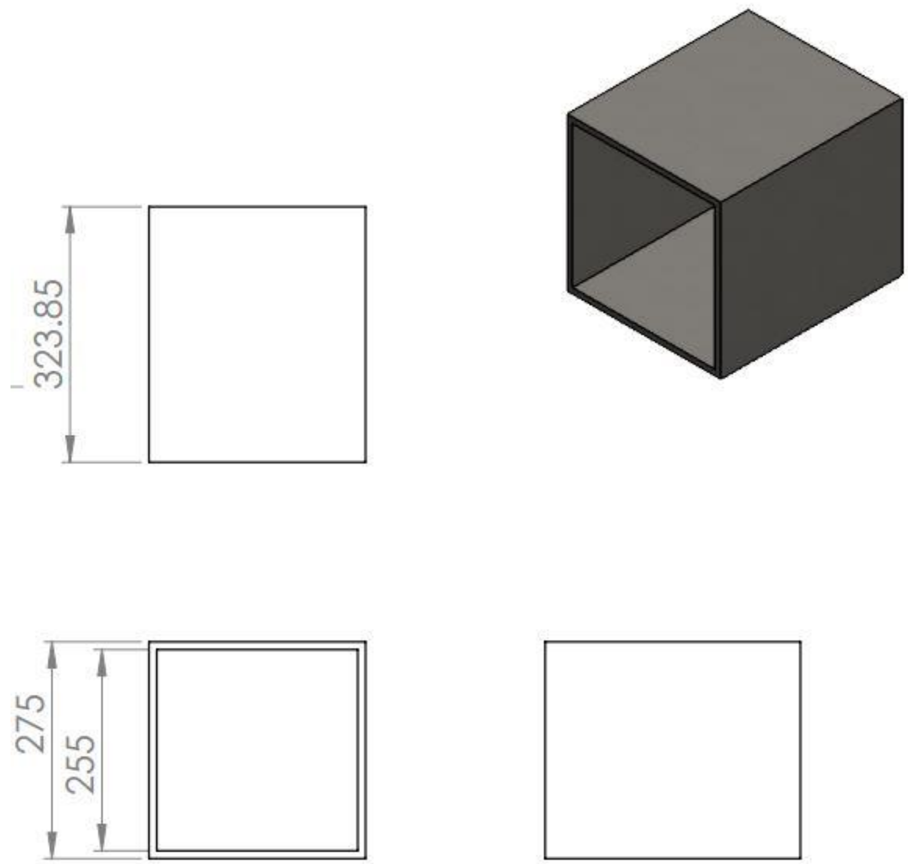

Figure (6.4) Forming box dimensions

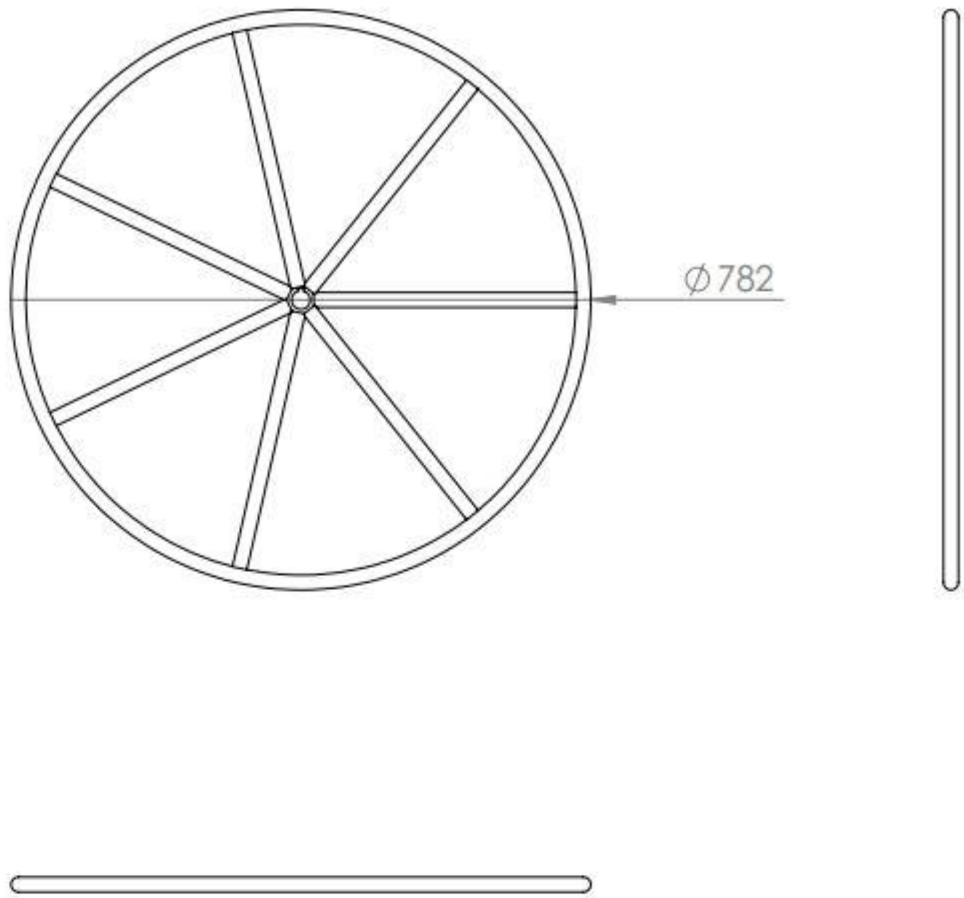

Figure (6.5) Crank wheel

6.2 APPENDIX B

Practical test of baling process

Figure (6.6) Compressor

Figure (6.7) Forming box

Figure (6.8) Compressing process

Figure (6.9) Compressor watch reading

Figure (6.10) Final bale