The "H-Frame" Design of RoCC Pyrolytic Kilns, with Updates

This is the SECOND document (dated 4 August 2021). Further updates and/or new documents (including content from users) will be available at this website where there are already several documents and videos about the RoCC kiln technology (including pre-H-Frame information of archive value but not for fabrication).

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Website: www.woodgas.energy/resources

Four Sizes of RoCC Kilns (as of June 2021)

[Introductory slide; All of these are pre-H-Frame designs. They are discussed in other presentations.]

23-inch diameter (590 mm), (200 L or 55-gallon Barrel-size kiln) In Kenya, rear viewer (not in the normal operational position.)

32-inch (800 mm) Diameter x 48-inch (1220 mm) Length unit in India. Front view at right. Rear view below.

Below: 48 inch (122 cm diameter) x 60 inch length. In California, Feb 2020.

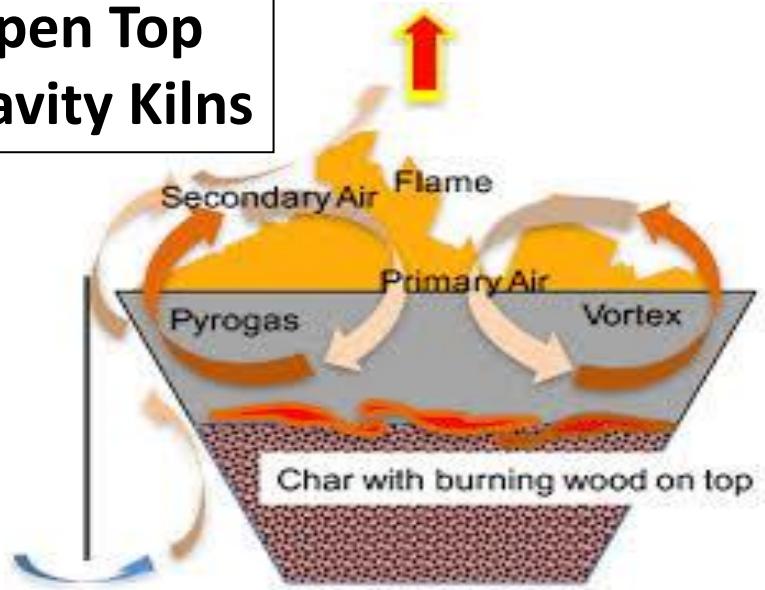
100 to 1000 kg/day biomass input

Above and below: 72-inch (6-ft, or 1.8 meter) RoCC kiln inside a 20-ft shipping container w/ mechanical rotation

Evolution of the RoCC kiln

- **Flame Cap** (aka Flame Curtain) pyrolysis technology is accomplished in cavities with closed bottoms and **open** tops.
- **"4C kilns"** were **covered** cavity kilns that were not rotatable. [~ 8 made between 2014 and 2019.]
- **Rotatable Covered Cavity (RoCC) kilns from 2019.**

Open Top Cavity Kilns

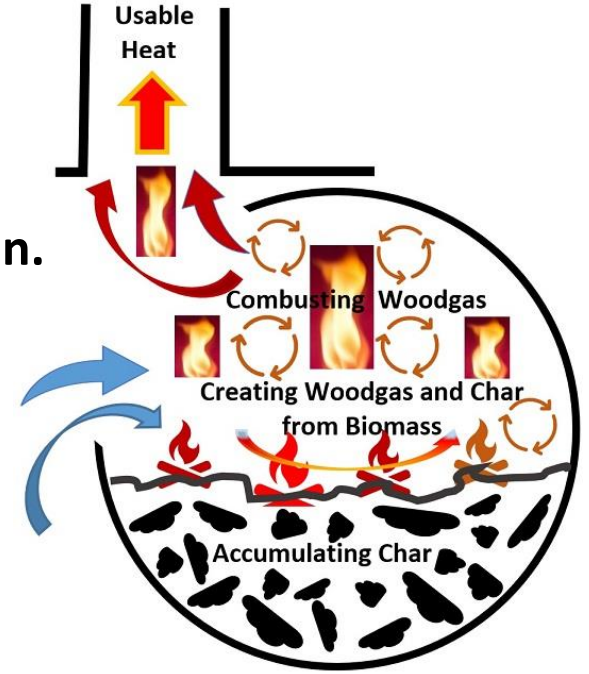


Shared Flame Cap Features

- Heat, flames and emissions rise away from the flame cap.
- Combustion of pyrolytic gases occurs with turbulence.
- Pyrolysis of biomass occurs because of the heat of the cap of flames.
- Char accumulates in the lower areas where oxygen cannot reach because of the cap of flames.

Advantages of RoCC:

- Flame is protected from wind & rain.
- Longer heat retention in the combusting gases.
- Created heat can be directed to uses via chimneys.
- Chimneys can assist with draft.
- Rotation mixes the char to assure that all the biomass is pyrolyzed.
- Rotation to easily empty the char.



Covered Cavity Kilns

Summary of Styles and Issues of RoCC Kilns

- **Sizes:**
  - **Smallest are in 200 L (55-gallon) barrels.**
  - **Largest thus far has 6-ft diameter x 7 ft length.**
- **Materials (all are metal):**
  - **barrels, tanks, corrugated culverts, scrap metal**
- **Styles of support for rotation:**
  - **On a rack with 4 or more casters / roller wheels holding the cylinder.**
  - **On rails underneath the cylinder.**
  - **On axle stubs, with variations named for the end-shape that supports the axle.**
    - **Oh-Frame (RoCC n' Roll design) – in the center of the wheel**
    - **X-Frame – at the cross of the X**
    - **H-Frame – on the center bar of the H --- This is the recommended design at this time.**
- **Optional features: Hood with chimneys; mechanized rotation; wheels for mobility; loading and unloading trays;**

Latest RoCC Kiln Innovation – "H-Frame"

- **Named for the "H" where the axle stub is supported.**
- **"H" design provided by Paul Wever in May 2021.**

Strong, easy to make, mobile, inexpensive, scalable, welded or bolted, versatile, ...

NOTE: There is an "X" formed by braces on the back side, but not at the ends. This is *not* an X-frame design. Shown here is the H-Frame design with the "H" at both ends.

Pieces to make an H-Frame RoCC kiln

Wheels are optional, ➔ removable and can be of various sizes for different terrain and height of clearance.

The cross-bar of the H has adjustable positions ➔➔➔

➔ ➔ Many options for the handles. The blue ones are recycled.

Materials list and explanations for ONE full H-Frame barrel RoCC™ kiln 2021-08-04

Notice: RoCC kiln technology (concept, plans, devices and usage) is patented (pending) by Paul S. Anderson, PhD,. Email him at psanders@ilstu.edu concerning options for use for financial gains, including how he can help you increase your income. Further information about RoCC kilns is available at www.woodgas.energy/resources .

Annotated list of materials: (Many variations are possible; **see included photos** and contact Dr. Anderson)

[The metric units are with slight roundings that are of no consequence.)

A. 1 x 1" square tube cut to lengths for "H" ends and long side pieces.

1. & 2. 8 of 40 " (100 cm) = 160 " = 26 ft 8 in. The vertical supports, two at each end, AND . The horizontal bars, two at each end.

3. 2 or 48 " (120 cm) = 96" = 8 ft The horizontal bars for the lengths of the bottom rectangle

4. 2 of 72" (180 cm) = 144" = 12 ft To form the "X" brace on the back side.

5. 2 of 10 " (25 cm) = 20" Each one becomes the **horizontal spacer-with-axle-sleeve** that spans the gap between the two vertical legs of the "H". Onto the spacer, the sleeves (C.2 below) for the axles will be welded (shown in previous slide). These 2 are separate pieces that is the last parts when assembling a kiln, with the axles of the barrel in place in the sleeves. Note: Do NOT WELD this cross piece into place because then the kiln cylinder cannot be removed unless the side braces (A.3 and A.4) are unbolted or cut loose if welded.

Note that threaded rod (Hardware I.2) or equivalent is used to hold each spacer (A.5) in place by passing through its hollow center and tightened with nuts on the outsides of the vertical supports A.1).

NOTE: **This size of H-Frame can support several different diameters of kiln.** The position of the horizontal spacer for a 55-gallon barrel (23-inch diameter) is 16 inches down from the top of the vertical supports. For a 36-inch diameter cylinder, the spacer with its axle stubs would be at the mid-point (20-inch mark) of the vertical legs.

B. Axle stubs for barrel

1. 2 of 1/8th inch steel plate 12 x 12 inches. These reinforce the thin end walls of the barrel
2. 2 of 1.25” OD pipe 8 inches long Each to be welded vertically in the center of one steel plate. The plates of the assembled (welded) stubs are to be welded to the ends of the barrel.

C. Sleeves made of 1.5-inch diameter pipe that fits over the 1.25” OD pipes of the axle stubs. MAKE SURE that there is comfortable, easy, free rotation of the axle in the sleeves. Wall thickness can be a problem. This is not a snug fit.

1. 2 of 5” long — To be welded onto the two horizontal spacers (A.5.)
2. 2 of 4” long — To be welded to the handles (D.1.)

D. Handles to be made of common materials that are not too heavy or expensive.

1. 2 of 24” to 30” long — These handles can be made of whatever is available.

E. Sliders over 1” sq tube, so probably is 1.25 or 1.5“ square tube (Check the wall thickness to be sure it fits). A useful substitute is 1.25” PERFORATED square tube (to reduce the number of holes to be drilled; See photos.) These are used to mount the wheels (see photos) and / or attach the side bars (A.3 and A.4.)

1. 6 of 6” long (or up to 9” long) One for each of 6 ends of the 1 x 1” square tube (A.3 & A.4).

F. For bolted frames that can be disassembled, special joiner pieces of rectangular tube through which 1 x 1 sq tube fits easily. Probably 1.5” by 3“ rectangular tube, but depends on what sizes are manufactured and available. [See photos on slide "One way to attach....."]

1. 4 of 1.5” wide — Can be an offcut or remnant in short pieces.

G. Drilling holes (for places that are not welded).

Most holes are to fit 5/16th inch bolts.

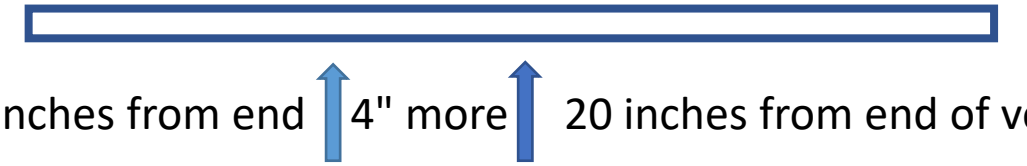
Exceptions are the holes for the “H” crosspiece (see next item) which need to allow the threaded rod or long bolt that holds the horizontal spacer-with-axle-sleeve.

H. Holes for the positions of the "H" cross pieces

in the 4 vertical pieces of 1" x 1” that measure 40 inches long, drill through opposite sides of the tube at (See photo in Slide "Adjustable height of.....")

1. 20 inches from the ends (that is, in the middle of the 40-inch length
2. Also holes at 16 inches from ONE end on each of the 4 pieces.

Diagram is NOT to scale; and the ends of the tubes are NOT closed.



I. Hardware:

1. Have available nuts and bolts of 3/8 inch diameter, bolts to be mainly 3 inches of threads.
2. Two pieces of 3/8th inch threaded rod, each being about 14 inches long, with nuts and washers as needed. Can be a long bolt or a solid rod that is threaded some at each end.

J. Wheels:

Some variations can be seen in the photo gallery that is appended.

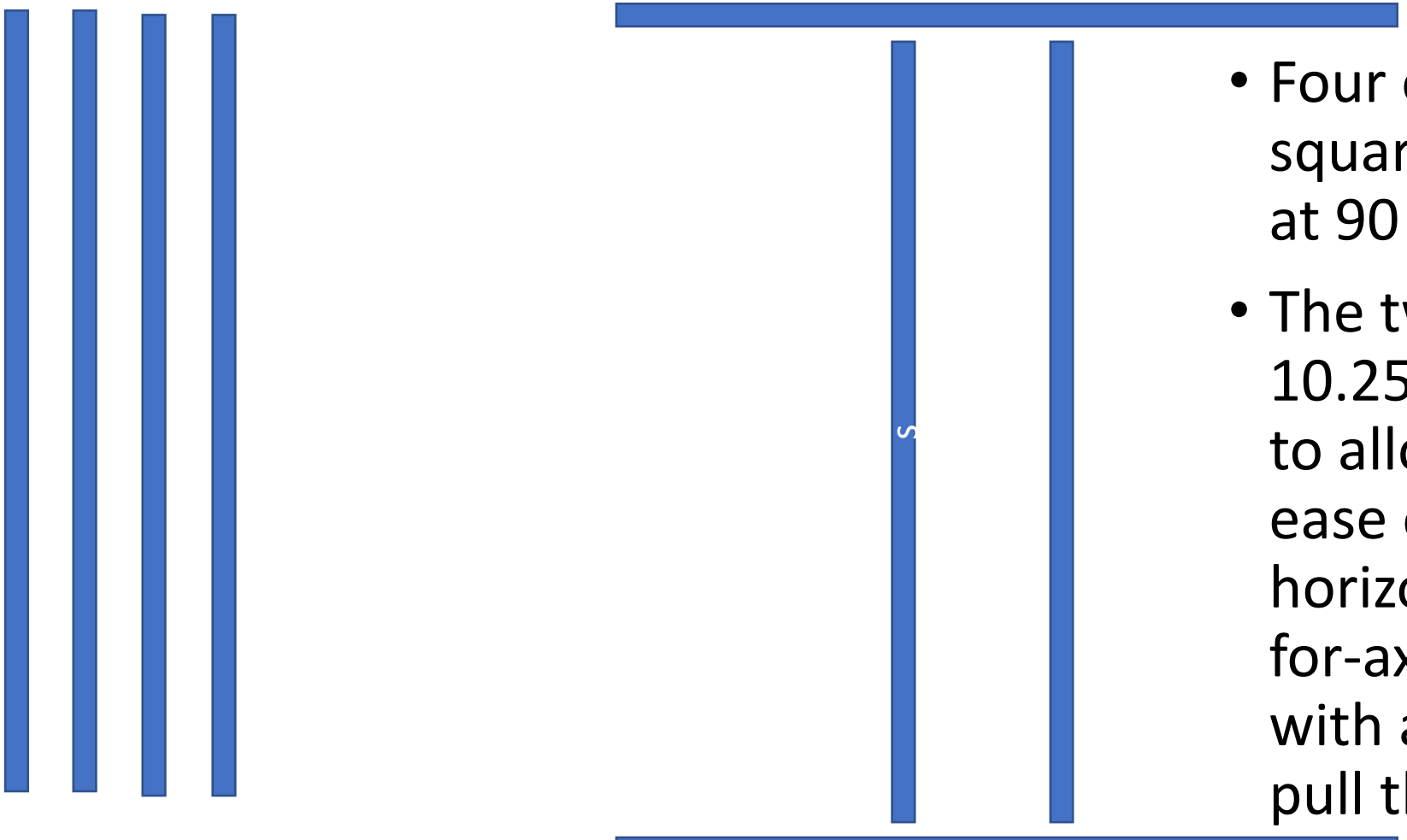
Adjustable height of the center of the H.

- The matching sets of holes allow for different diameters of cylinders to be used in the same H-Frame.
- The ability to remove the cross piece and sleeve allows for changing the kiln without disassembly of the frame (whether bolted or welded.)
- Note: For ease of assembly or changes, leave an extra quarter inch between the vertical bars; the bolt will pull the bars together tight to the cross piece.

Welded vs. Bolted

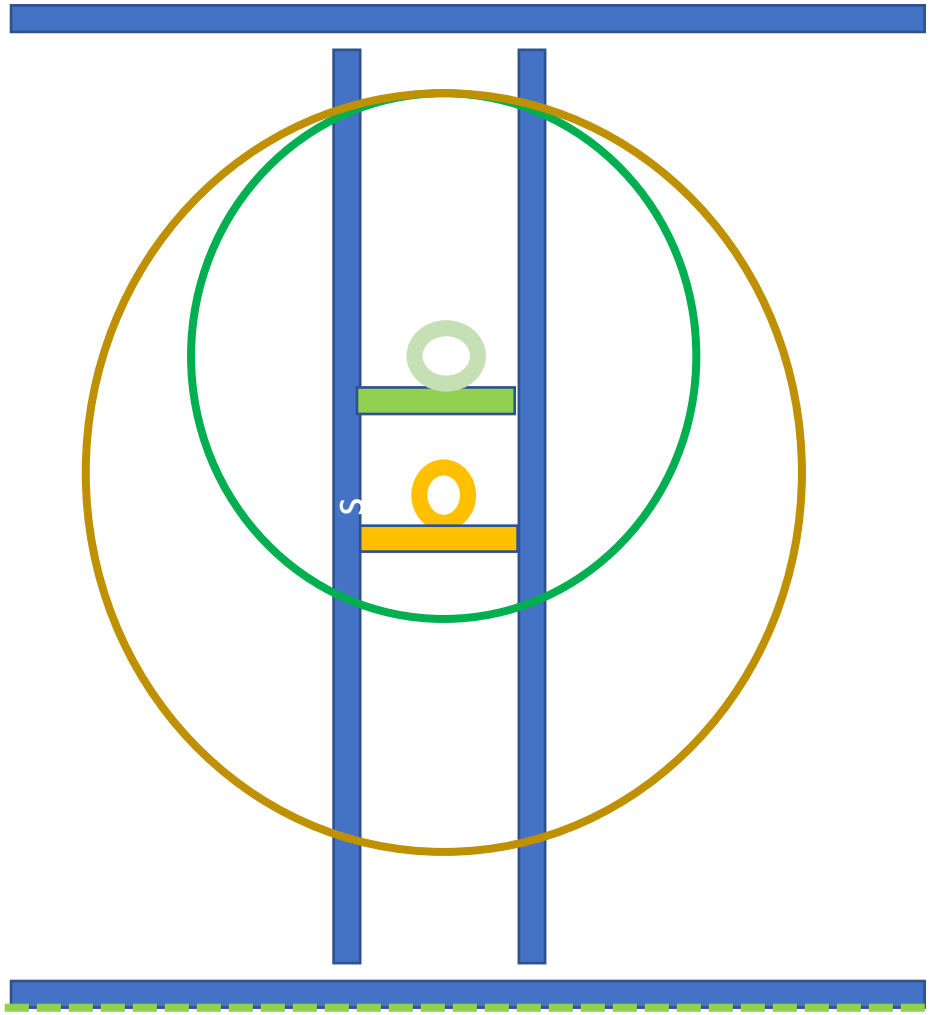
- Welding is faster, less costly, and stronger than bolts with nuts. So weld whenever possible if disassembly is not going to be needed.
- Bolts allow the RoCC kiln to be sufficiently disassembled for ease of shipping and less bulky transportation other than when in use in fields.
- The two H-shaped ends can be separated from the four side bars (two for the base and two for the side X braces) to become a very small volume.
- Bolting allows for changes in size, such as when making prototypes.
  - Change the height of the center of the H to accommodate larger diameters.
  - Change the lengths of the four side bars to accommodate longer cylinders.

Create the two end pieces ("H" without central piece)



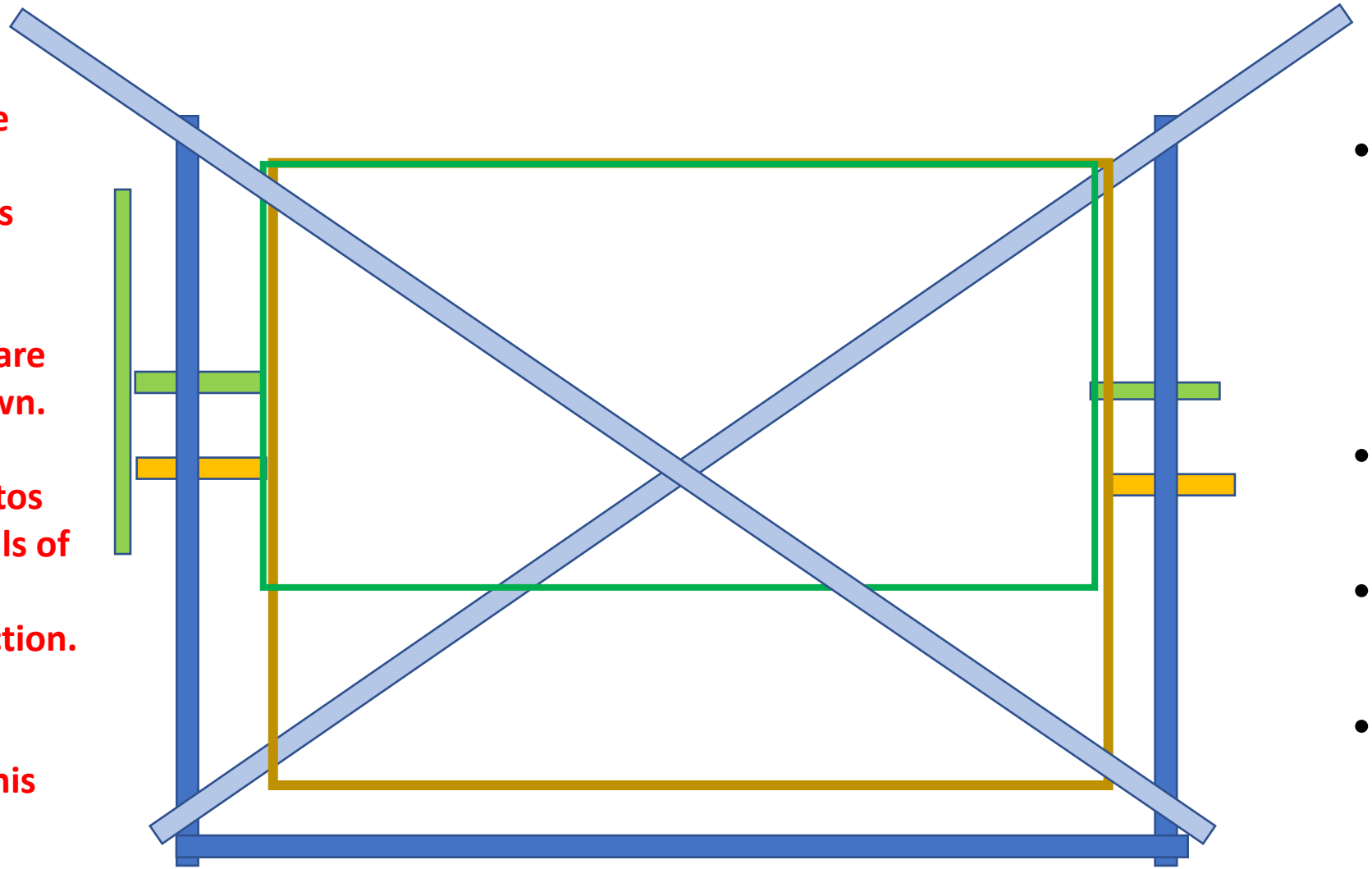
- Four equal pieces of 1" x 1" square tubes 40 " long joined at 90 deg right angles.
- The two vertical bars are 10.25" apart (inside to inside) to allow 0.25" spare for the ease of placement of the 10" horizontal spacer-with-sleeve-for-axle (A.5) to be secured with a bolt or threaded bar to pull the verticals together.

Showing two versions (green and orange) of the horizontal spacer in the "H" design and the corresponding sizes of kiln cylinders



- Not drawn to measured scale, only approximate.
- The proportions are about right, so change the scale to make much larger units with stronger bars such as "I" beams for 8-ft diameter RoCC kilns.

Side view showing two versions (green and orange) of two sizes of kiln cylinders that can fit in the same H-Frame.



Only one handle (green) is shown.

Wheels are not shown.

See photos for details of actual construction.

Welding makes this easy!

- Not drawn to measured scale, only approximate.
- The proportions are about right, so change the scale to make larger units with stronger bars.
- Length can be much greater than shown.
- There can be many small variations.
- Shown is the "side-X" or "back-X" brace. This is <u>not</u> an X-Frame RoCC.

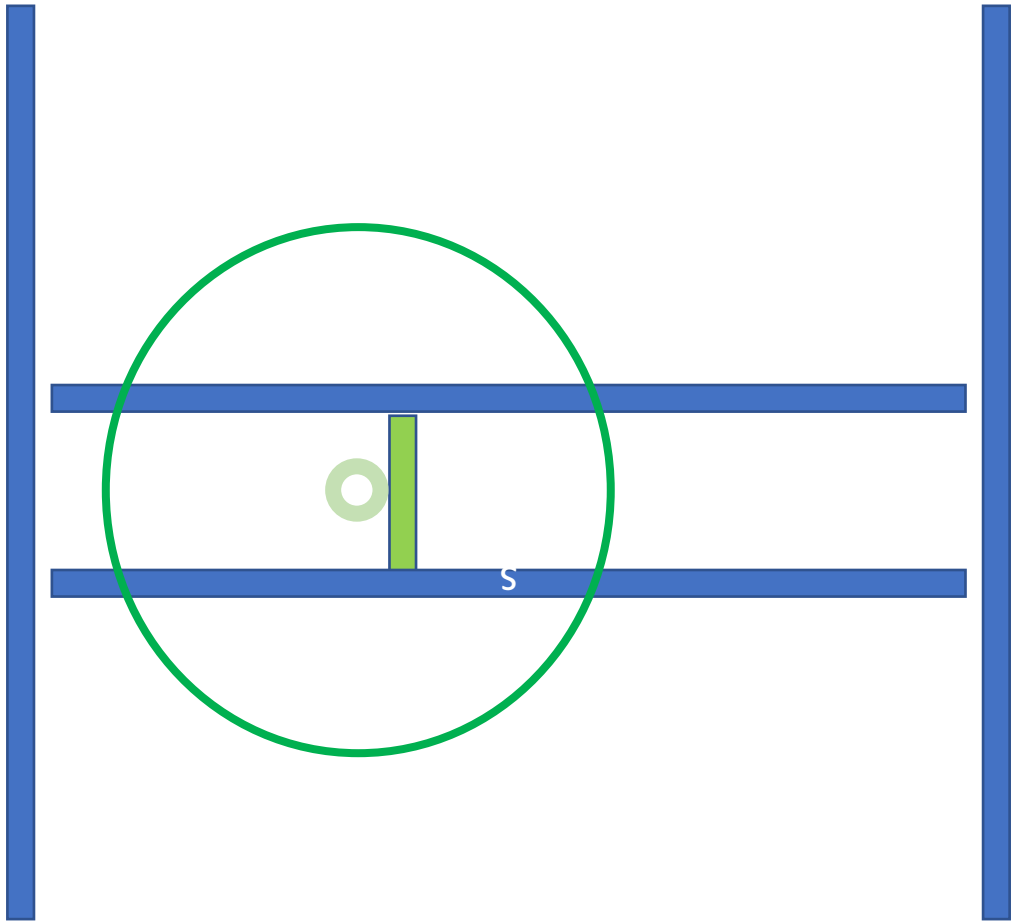
Q: What is the big difference between these two H-Frame RoCC kilns on the left?

A: Same kiln and frame, but the frame is rotated 90 degrees onto its side.

This changes the height of the portal from the ground for loading different types of biomass.

Both positions can have wheels for moving through fields.

Rotated 90º on its side places the kiln closer to the ground surface, which can be useful for loading some types of biomass .



Photos of H-Frame RoCC kiln

(14 June 2021)

This unit can be dismantled with only a wrench and screwdriver so that it can fit easily inside of the vehicle shown in this photo.

Photos of barrel-size RoCC H-Frame kiln
End and side views

- d

One way to attach the sloping tubes of the side-X (also called back-X) to the vertical H-frames.

Direct welding is easier but does not allow disassembly for transport.

Photos of wheel attachments on barrel-size H-Frame RoCC kilns (showing perforated sliders, Material item E.)

The Barrel

1. Typically 23 inches in diameter and 33 in. long. Verify any variations such as the number and size of “bungholes” (which will require metal plugs/caps) or a removeable lid with clamp ring. Verify the position of the welded seam of the cylinder. That seam is to be within the metal that will be cut out to create the portal.

2. The large bunghole is recommended to be positioned at the bottom of the side of the barrel when the barrel is in the “A” position. (Visible in some of the images.) It is there so that it can be opened if needed to insert something into the “bottom” area of the char accumulation.

(Continued)

SAFTY FIRST: Read all of the instructions, and then only do the tasks for which you have competence and tools. Lack of experience can hurt or kill. Use protective glasses and gloves, etc. During fabrication and also during use, always consider that any part could be sharp or blistering hot. This document has only basic instructions. Common sense is not common. BE CAREFUL.

Figure 3: Portal cut into the side of the kiln barrel.

3. Clearly mark the outline of the portal that is to be cut out. Be sure to leave intact (not cut) about 1 to 2 inches of the cylinder closest to the two ends of the barrel so that the barrel is not weakened. The line of the welded seam can be used as the upper edge of the portal (when in the A position), keeping the seam in the area to be cut away. The height of the portal is typically 13 inches as measured on the curved surface of the cylinder. Measure that distance and then mark the lower edge of the portal. The resulting portal will have an opening about 12 inches in height when measured straight across the opening.

4. Cut out the metal in the area of the portal. Typical tools could be an angle grinder with a cutting wheel for metal, or a hand-held jigsaw with a metal cutting blade, or experienced metal workers might use a laser / plasma cutter. Be sure to smooth off the burrs and sharp edges.

5. The work on the barrel is completed until later to attach the two axle stubs either by welding or by drilling holes for bolts and nuts.

Appendix A: Album of Photos

Double Length H-Frame RoCC Kiln in Kenya July 2021

A triple length barrel H-Frame RoCC kiln has been build and used in Mexico. (Awaiting photographs)

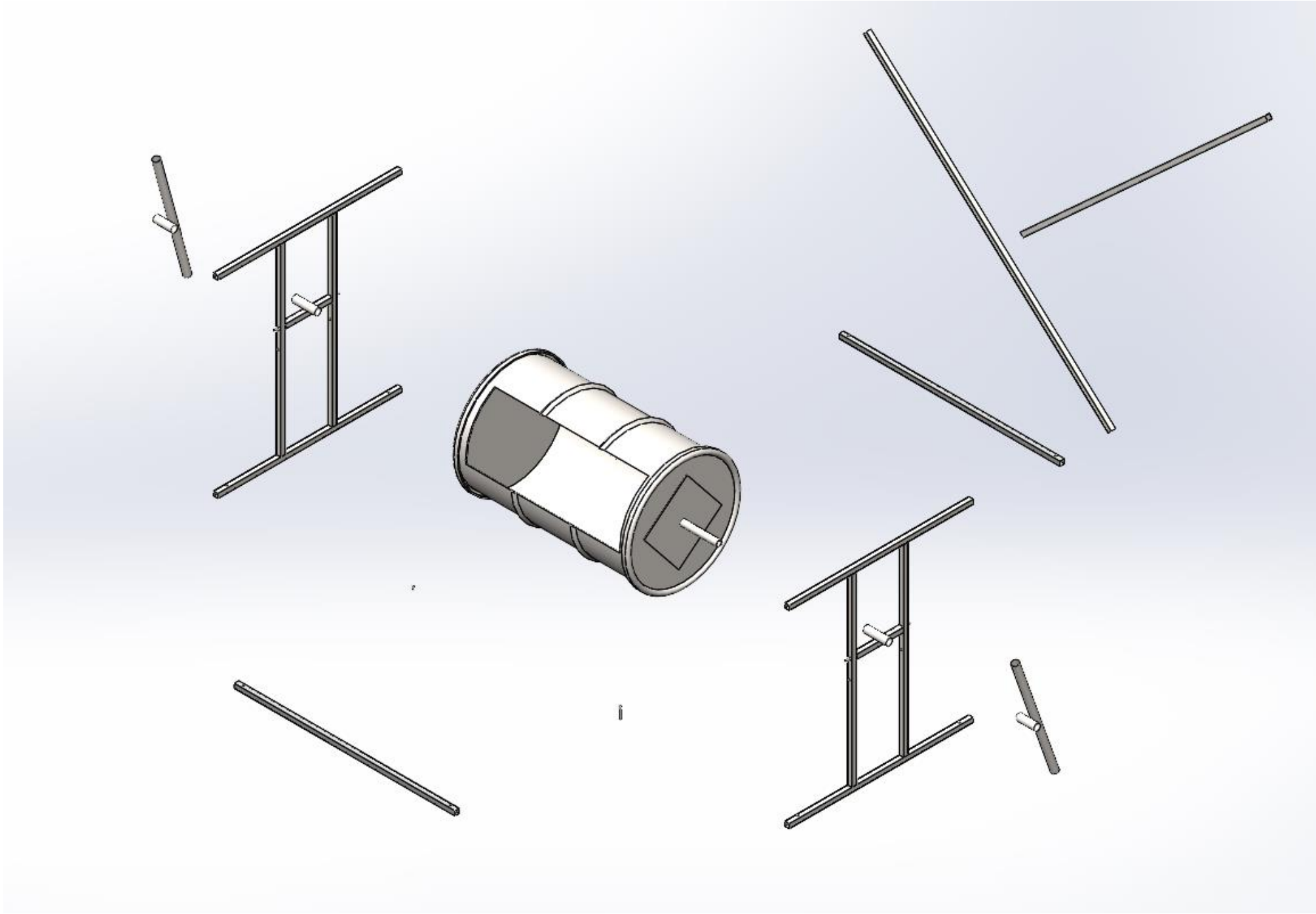
Learning experience: The X-frame (X is at the ends) that is NOT recommended. But shows great wheels!!

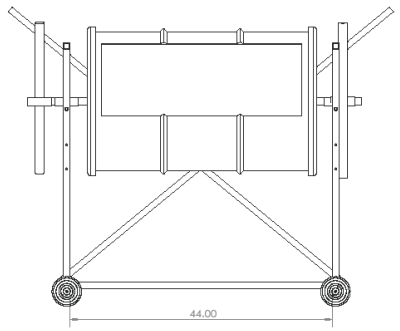
- No need for the central pipe through the barrel nor the upper long-side bar.

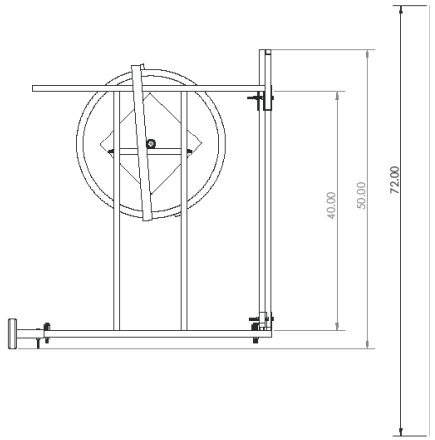
Appendix B: Technical Drawings of H-Frame RoCC Kilns of 200 Liter Barrel Size

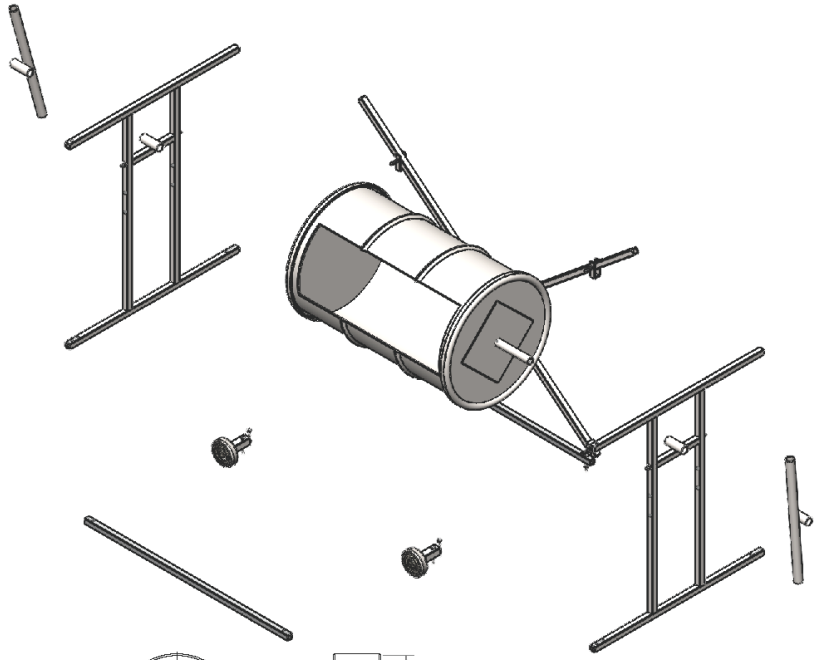
- We thank Sai Karthik Mysore Mouliswar (a 2021 Masters Degree graduate in Mechanical Engineering at Arizona State University) for his fine assistance as a volunteer for preparing these materials.

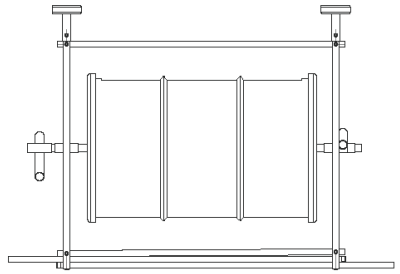
- Digital copies and other file formats for engineering are available. Contact Paul Anderson at psanders@ilstu.edu

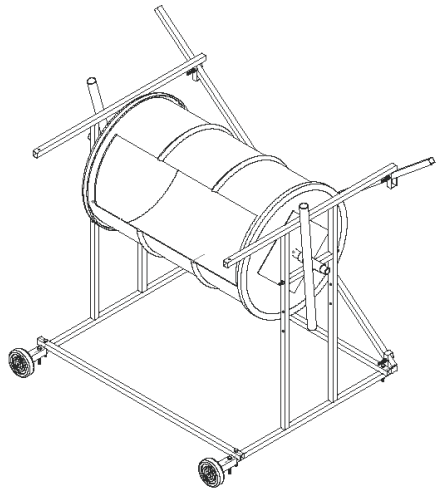


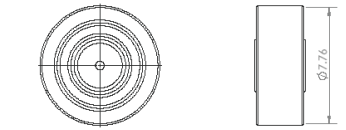


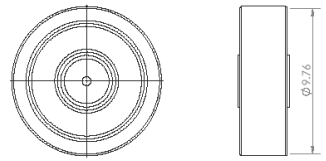


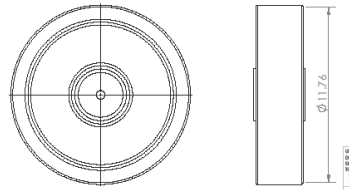












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2	1BRK005		2
3	1BRKA1		1
4	1BRKA3		2
5	1BRK013		10
6	1BRK014		10
7	1BRK017		4
8	1BRK004		2
9	1BRK018		2

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION:

Prepared by: Sai Karthik M M, ASU

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APP'D			
MFG			
Q.A			

MATERIAL:

WEIGHT:

TITLE: BioChar Project

DWG NO. H-frame Rocc Kiln

A1

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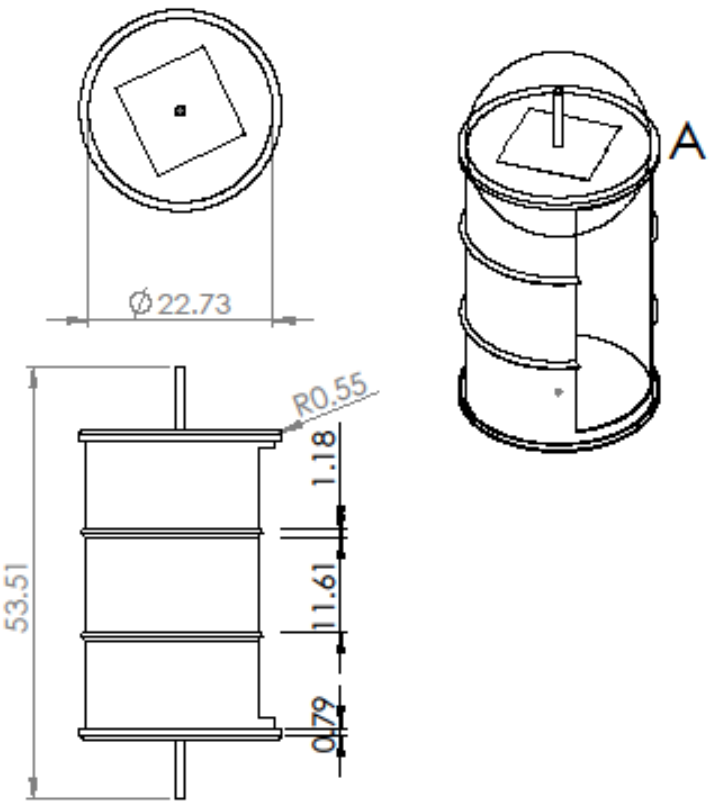
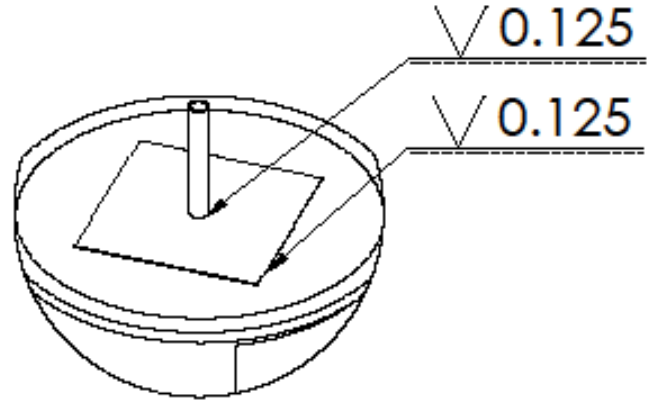
SHEET 1 OF 1





DETAIL A
SCALE 1 : 10

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			CHECKED			
			ENG APPR.			
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			Q.A.			
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS:			
		MATERIAL	Prepared by: Sai Karthik M M, ASU			SIZE A | DWG. NO. BARREL ASSEMBLY | REV
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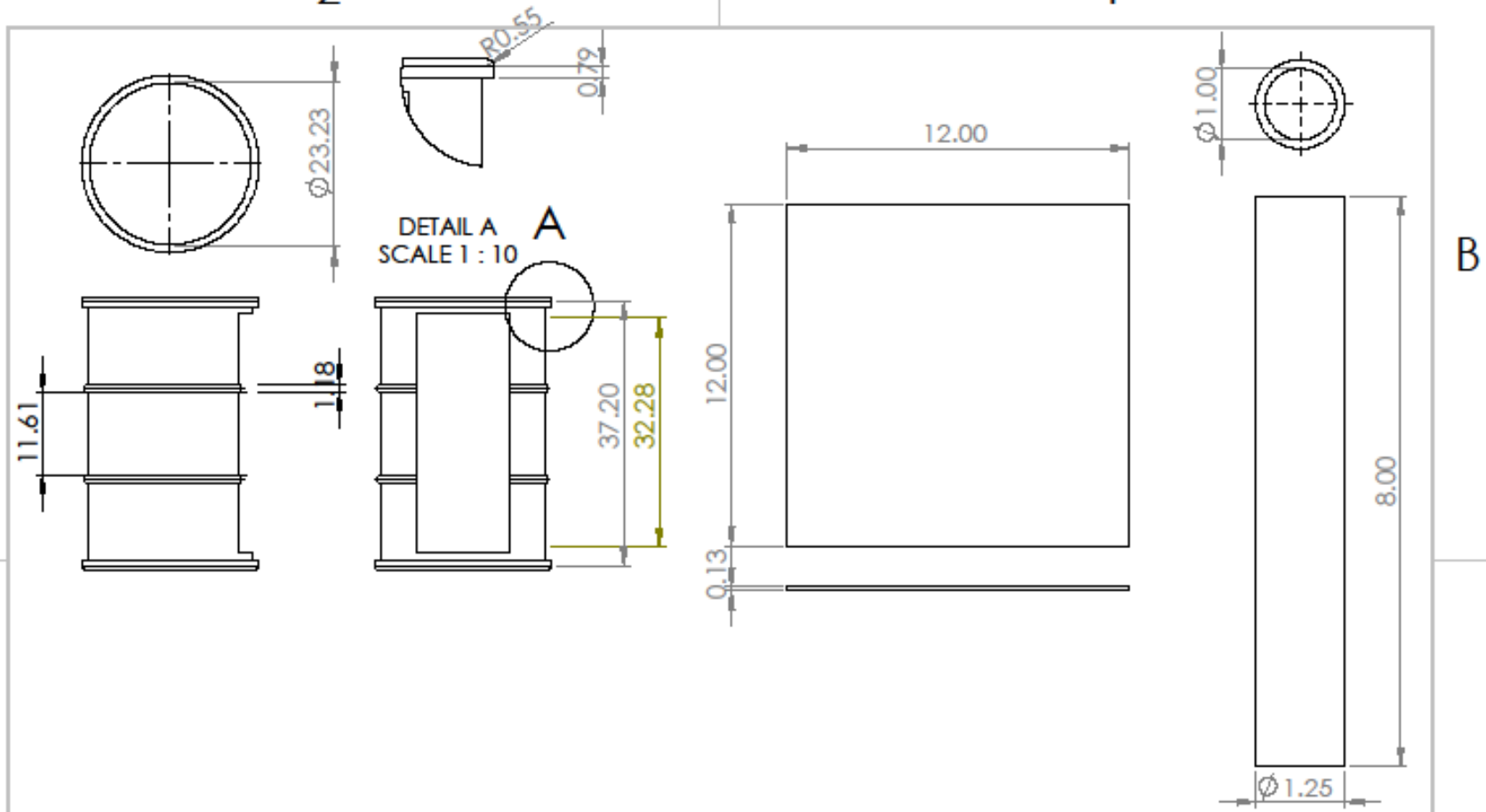

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			CHECKED		
			ENG APPR.		
			MFG APPR.		
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		MATERIAL	COMMENTS: Prepared by: Sai Karthik M M, ASU		
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TITLE:
H - frame RoCC Kiln

SIZE	DWG. NO.	REV
A	BARREL	

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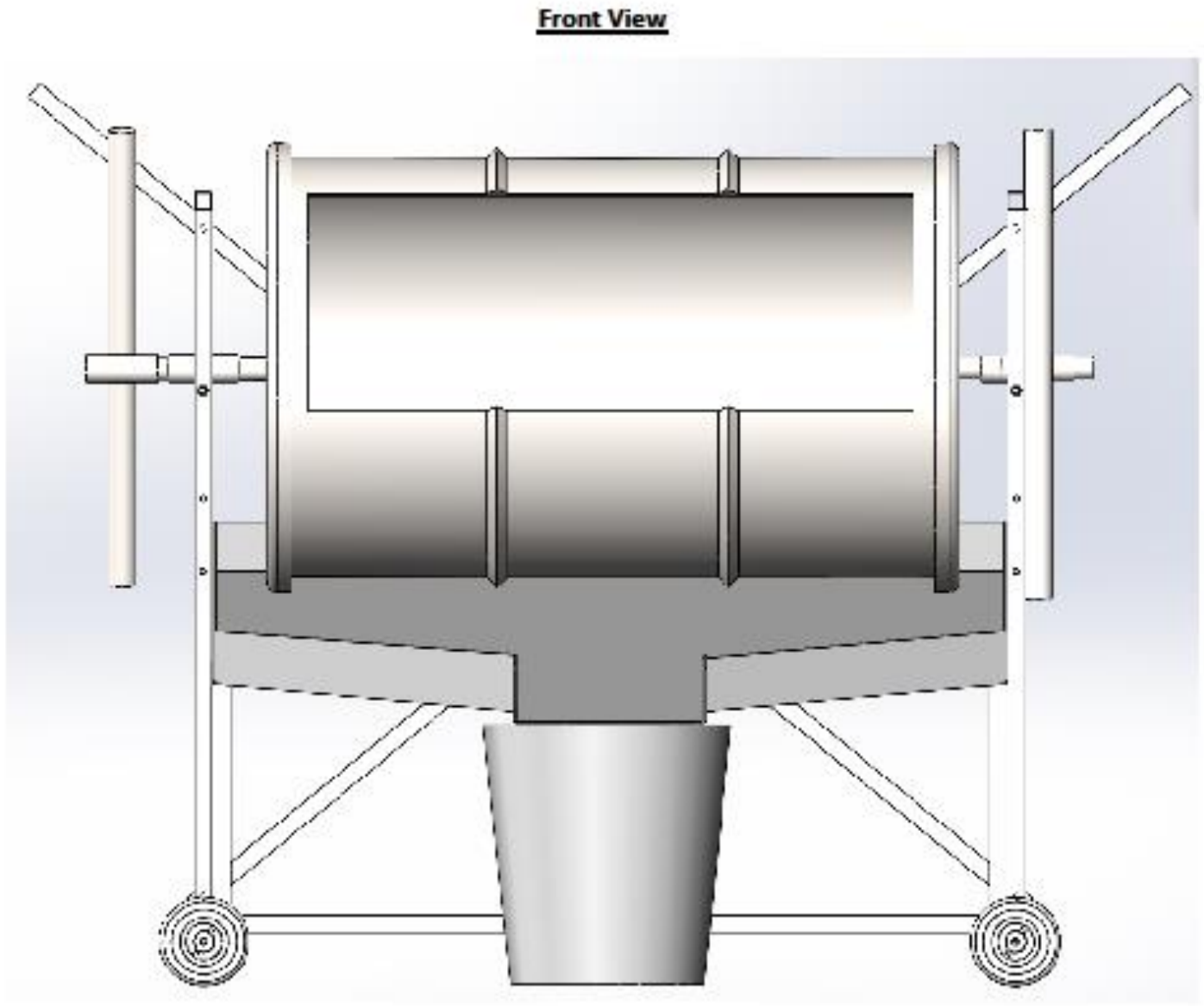
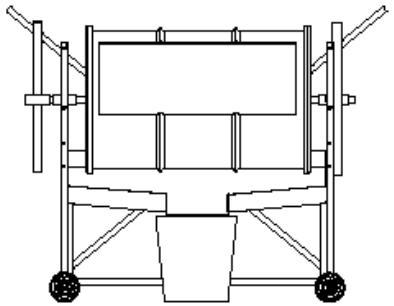
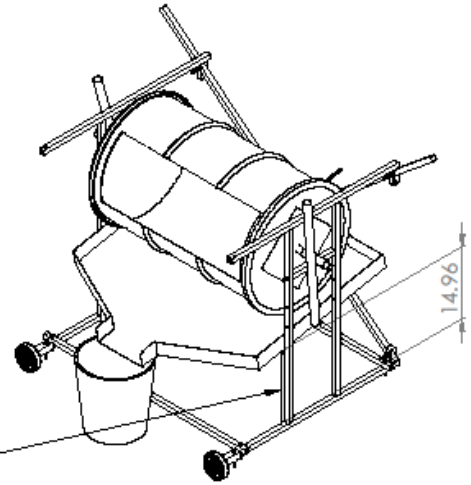
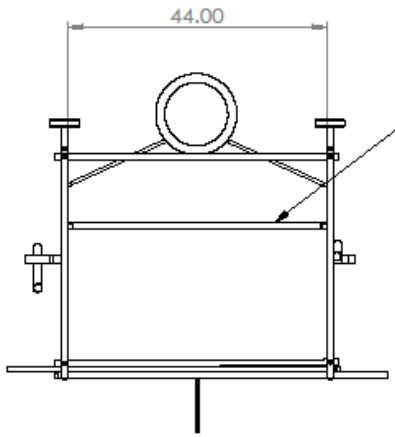


Front view of a RoCC barrel-size H-frame kiln with a discharge tray and collection bucket

Notes: The barrel is higher in the H so that there is extra height for slope of the tray. The handle on the right side should be further out. The wheels can be much larger.







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7	1BRK017		4
8	1BRK004		2
9	1BRK018		2
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11	1BRK021		1
12	1BRK012		1
13	1BRK022		1

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
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DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APP'V'D			
MFG			
Q.A			

TITLE:

H-frame Rocc Kiln with tray and binSLDASM

MATERIAL:

DWG NO.

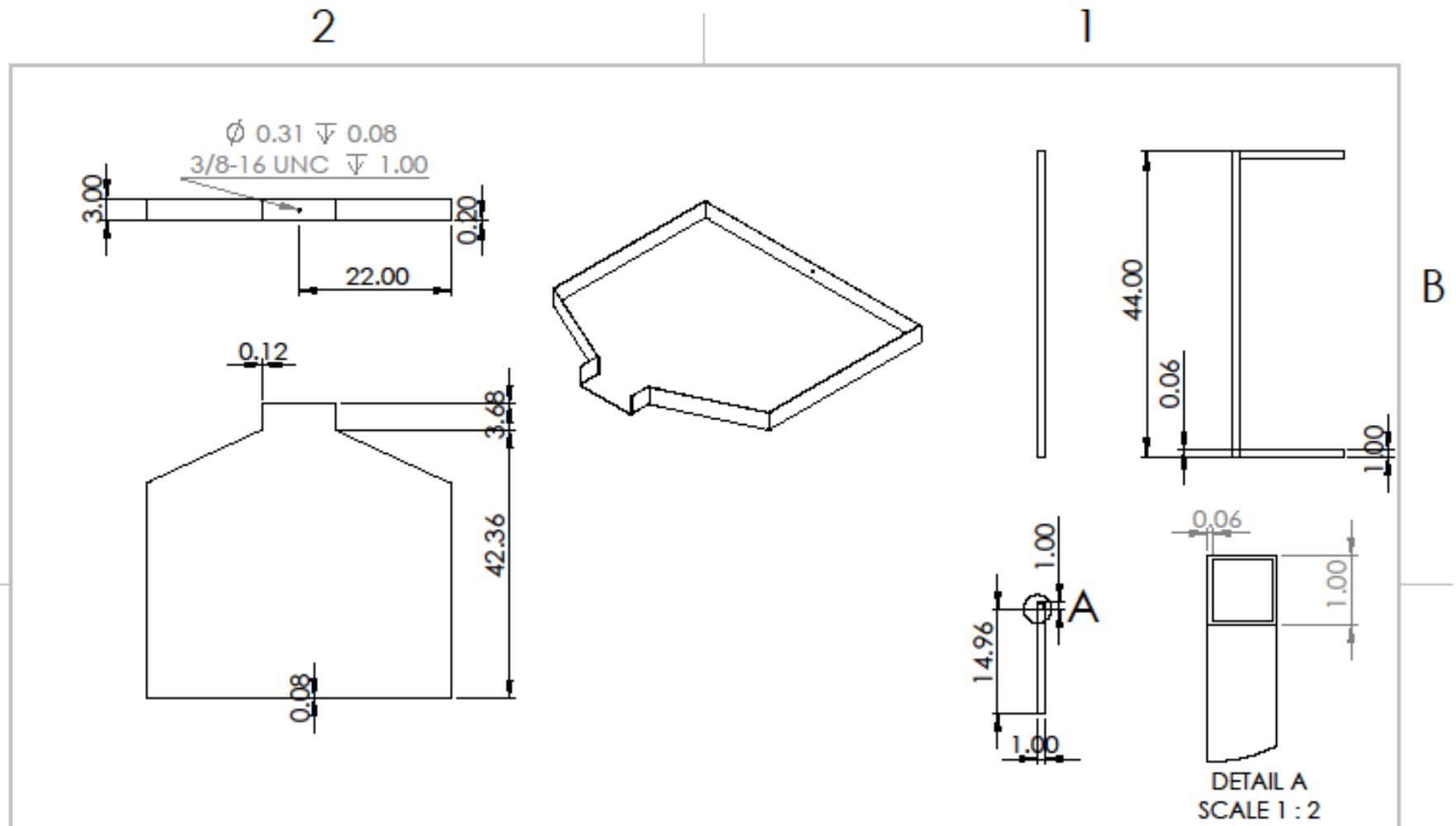
A3

WEIGHT:

SCALE:1:50

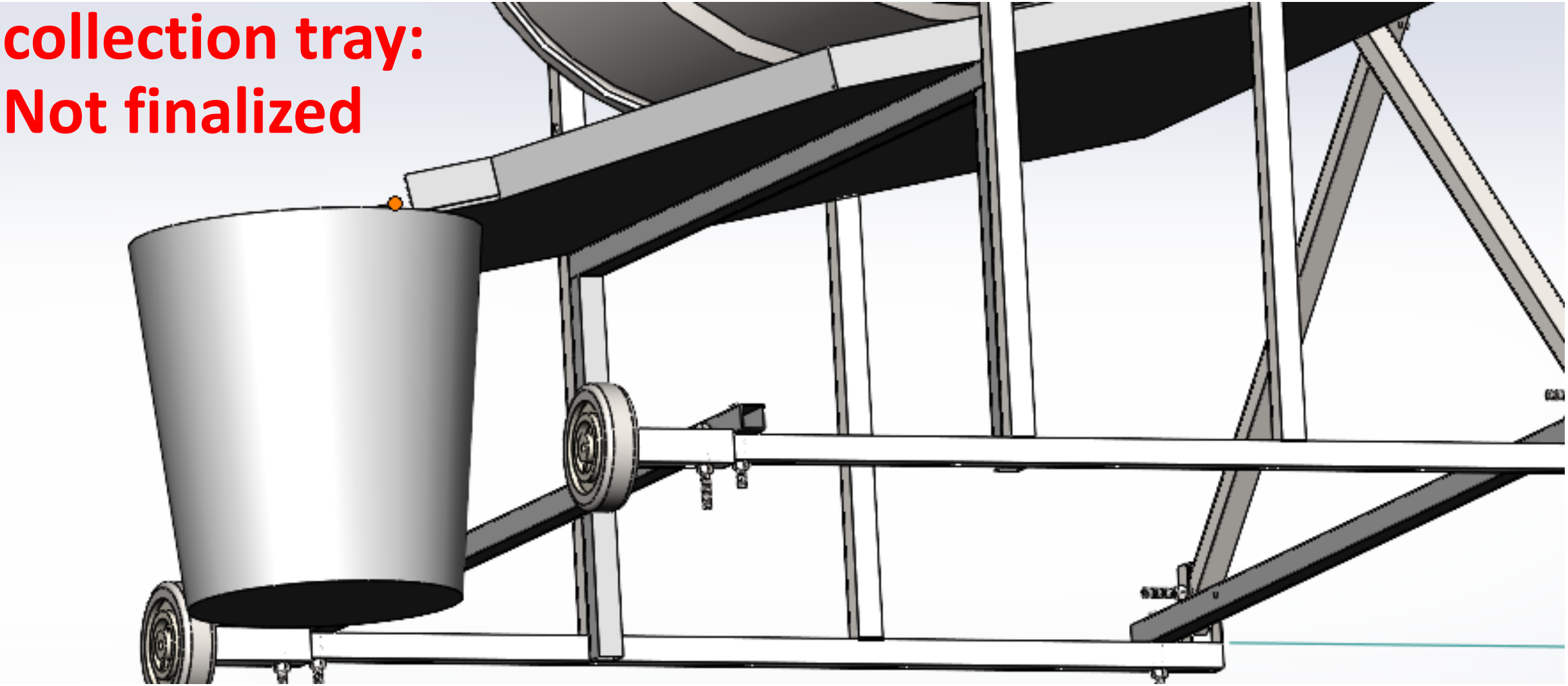
SHEET 1 OF 1

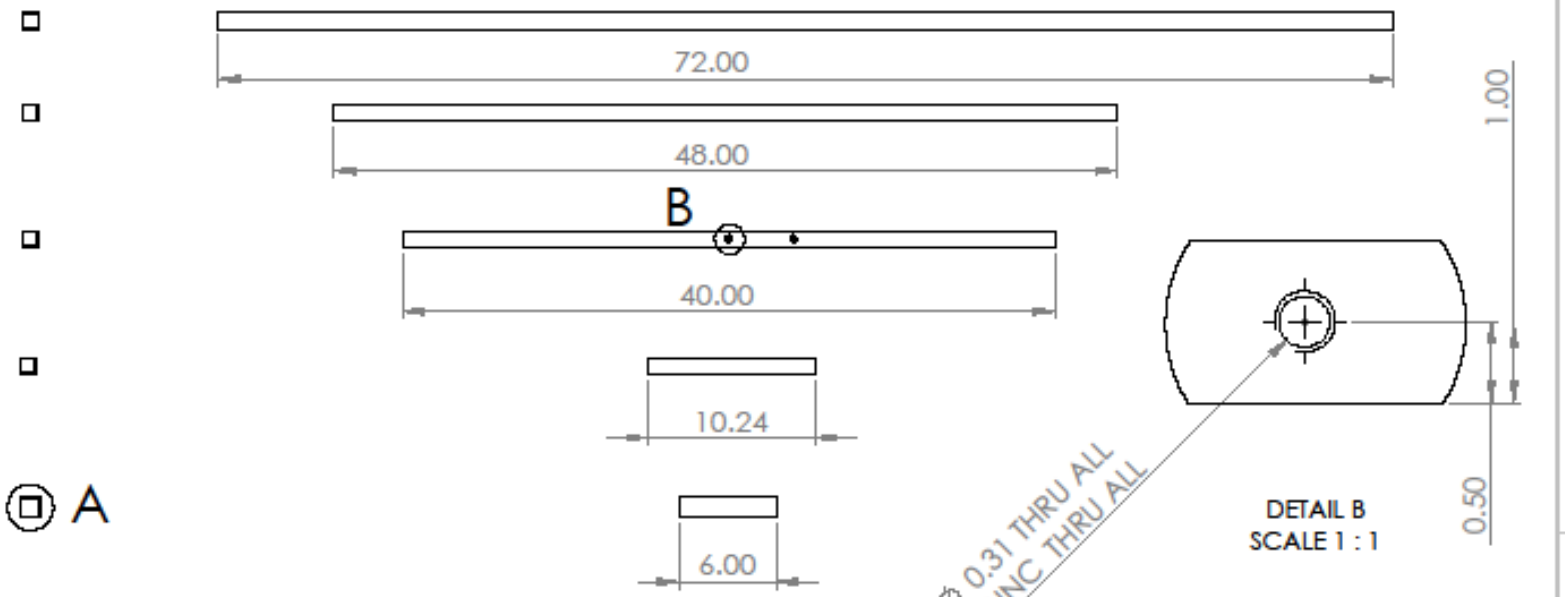
The biochar discharge and collection tray: Not finalized

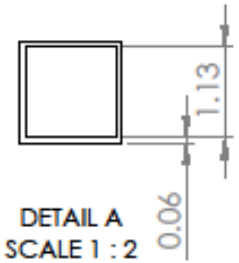


The biochar discharge and collection tray: Not finalized

Larger wheels would further elevate the frame to have greater slope or taller buckets.







DETAIL A
SCALE 1 : 2

SL.NO	QTY&NAME
1	2*72 inch pipe
2	2*48 inch pipe
3	8*40 inch pipe
4	2*10 inch pipe
5	6*6 inch pipe

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

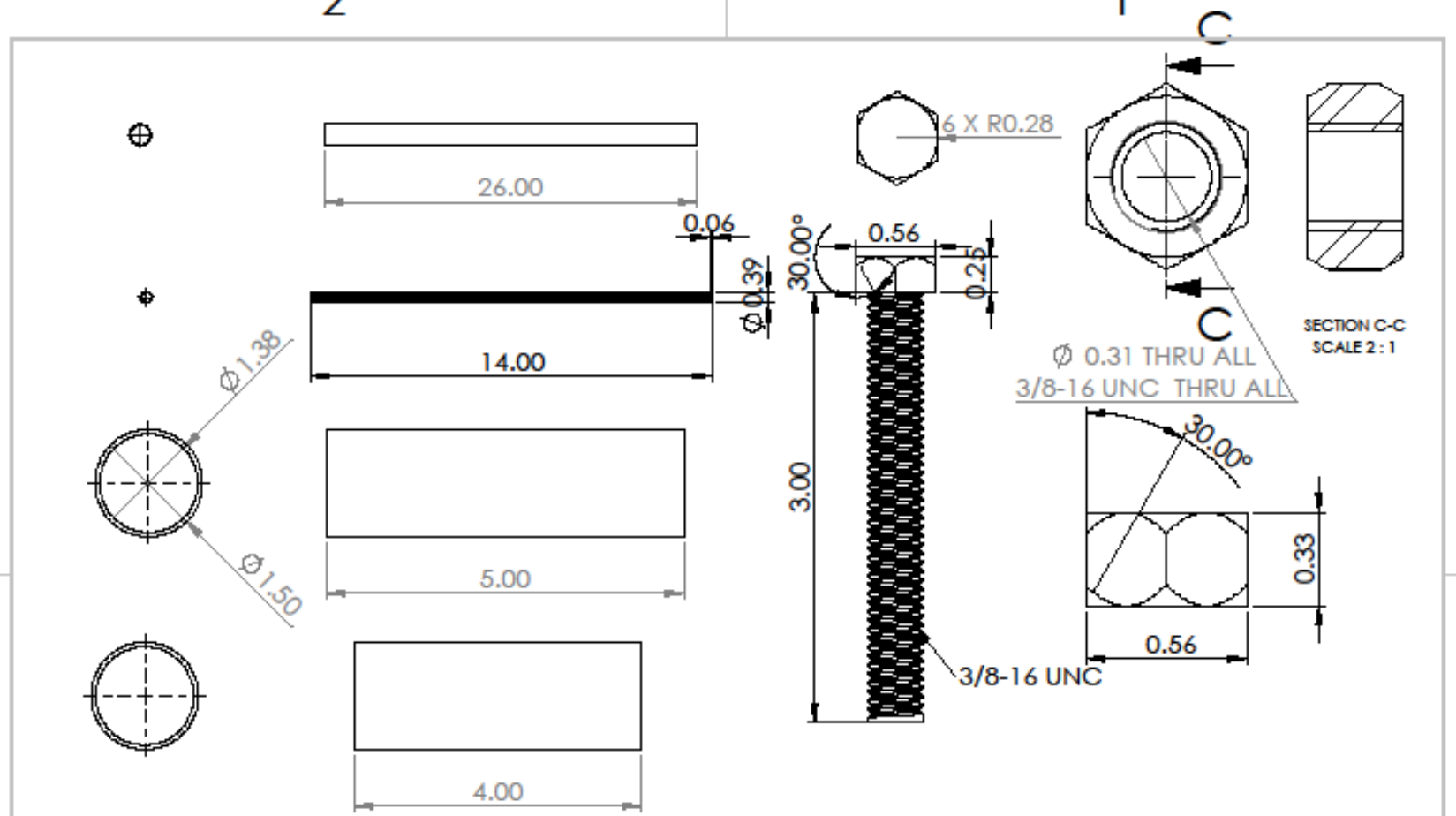
	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

Bio Char Project

TITLE:
H-frame Square tubes

SIZE A | DWG. NO. | REV

SCALE: 1:20 | SHEET 1 OF 1



SL.NO	QTY&NAME
1	2"26 inch handle
2	2"3/8 inch threaded rod
3	2"5 inch sleeve
4	2"4 inch sleeve
5	3/8 inch dia bolt
6	3/8 inch dia nut

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

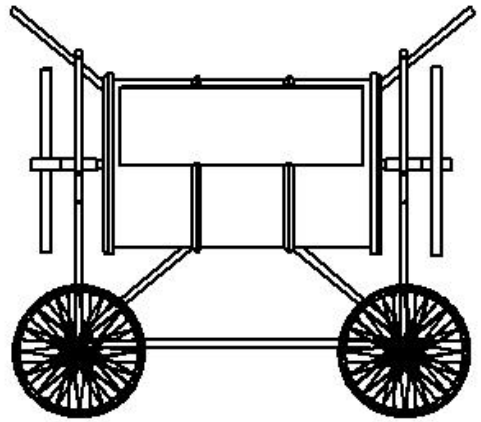
COMMENTS:
Prepared by:
Sai Karthik M M, ASU

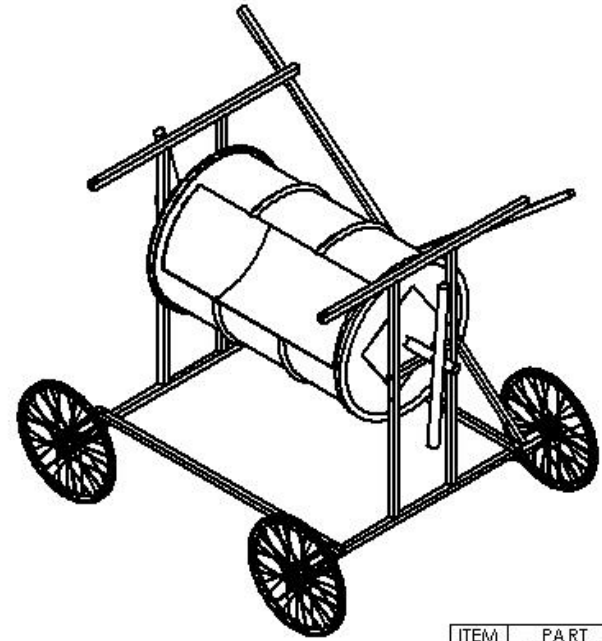
BioChar Project

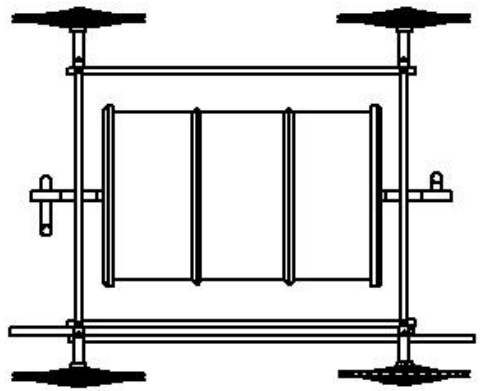
TITLE:
H- Frame pipes

SIZE A | DWG. NO. | REV

SCALE: 1:10 | SHEET 1 OF 1







ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1BRKA2		2
2	1BRK005		2
3	1BRKA1		1
4	1BRKA3		2
5	1BRK013		8
6	1BRK014		8
7	1BRK019		4
8	1BRK004		2

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

Prepared by: Sai Karthik M M

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APP'D			
MFG			
Q.A			

MATERIAL:

WEIGHT:

TITLE:

BioChar Project

DWG NO.

H-frame Rocc Kiln Bike wheel

A3

SCALE:1:50

SHEET 1 OF 1

More information will be coming

- Further items and more details will be available about
  - Types of wheels and their attachment
  - Biomass loading shelf
  - Improved biochar extraction chute
  - Comments on usage, including diverse types of biomass
  - Cost and time to build (Under US$100 in Kenya in one day for barrel size.)
- Major items will be available via www.woodgas.energy/resources
- Initial users are encouraged to share their experiences and enhancements.
- Open discussions and announcements are on the "Biochar Crusaders" WhatsApp group in India and also on the biochar email group. Subscribe at: main@Biochar.groups.io

Patents and Business Prospects

- The RoCC kiln invention has international patent pending status with likely coverage until 2040. This protects your interests as well as those of the inventor who wants you to be successful.
- When there is financial gain based on the RoCC kiln production or use or other activities such as gained carbon credits, some appropriate share should come to the inventor.
- Therefore, there are at this time (08/2021) no up-front fees to become involved with RoCC kilns and to receive expert assistance.
- All options are open for business arrangements to be made so that the RoCC technology can become the basis of businesses for biochar, energy, climate benefits, and more.
- You are encouraged to become informed about how you or your geographic area or field of activities could benefit with RoCC kilns.

Conclusion:

- You are encouraged to make a barrel-size H-frame RoCC kiln.
- See other documents at the website about user experiences, methods for use, and possible opportunities.

www.woodgas.energy/resources

- Contact Paul S. Anderson for assistance and to tell of your progress and for information about possible carbon financing for CO2 removal via biochar sequestration:
  - Email: psanders@ilstu.edu
  - Mobile and Whatsapp number: +1 309-531-4434