DESIGN, AND CONSTRUCTION OF A PORTABLE ARTIFICIAL INSEMINATION CHUTE

by

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ABSTRACT

This senior project report discusses the design, construction, and evaluation of a portable artificial insemination chute for the use of the Cal Poly Beef Department. The design was based on the suggested modifications from operators of several other chutes currently in use.

The main areas considered for the design were: Ergonomics, cattle safety, factors effecting maximum breeding conception rates, and Portability.

The breeding chute proved superior over traditional chutes in a variety of ways. Improvement occurred in the areas of consideration as follows, user operation was simplified, animal stress was decreased, and maximum breeding efficiency was obtained.
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INTRODUCTION

Artificial Insemination (AI) has been a growing method for breeding cattle in both the beef and dairy industry in the last decade, and with new technology and studies it continues to grow rapidly. Improving conception rates and time efficiency are areas always looked at for improvement by ranchers and breeding technicians. Having a convenient and quick flowing breeding facility is ideal and always sought after. A facility such as this allows breeders to work quickly, efficiently, as well as improves conception rates due to less stress on the animal, breeder, and proper functioning equipment.

With a great demand for a convenient breeding facility there has been a design put together by Larges Farms inc. in Nebraska where they are manufacturing and selling the portable AI barns. These portable AI barns are ideal for breeding cattle, but due to the costs, production is so low that the market is unaware of the product. This portable AI barn is a trailer on axles that pivot using hydraulics, allowing transportation to different locations and then dropping to the ground to stabilize for use. By interviewing different ranches that have the breeding chutes, it is found that this method is very efficient and has improved many aspects of artificial insemination. The time to set up the facility has decreased, and reduced stress on the cattle. The AI barn is very ergonomic and can be operated by one person. The breeding equipment can be stored in a little office space inside the shed where the lighting and temperature can be controlled, this allows for less light exposure time to the semen which decreases conception rates.

The Cal Poly Animal Science Department has been using artificial insemination as a method to breed their cows for many years. This takes place in an artificial insemination project in which the students are supervised by the professors, as they set up the facility and breed the cows. The enterprise has been using the same method and facility for many years but have many problems with the procedure because Cal Poly’s beef herd is disbursed amongst several locations The facility needs to be taken apart for transportation and set up at another location to breed more cows. Another problem is that the breeding chutes used are not sturdy, they move while cows are moved into them and some have broken due to the pressure of the cattle. The pipes that are in the chutes currently used are too far apart allowing the cows to stick there heads through and push the chute. In attempt to fix this problem as well as keeping out of the wet and cold weather conditions during the breeding period of November to February the chutes have to be covered with a canvas tarp.

In attempt to effectively improve the conception rates and time efficiency of Cal Poly Beef Unit’s breeding facility. The design will be modeled from the breeding trailer made by Larges Farms inc. with modifications of design and use of some different materials that will improve the original design.
LITURATURE REVIEW

AI is a reproductive technology in which semen is collected from males and then used in fresh or frozen form to breed the females. The process in cattle consists of bringing the cow into estrous also known as estrous synchronization, either by allowing it to occur naturally or by inducing estrous by injecting hormones. Once in estrous the breeding technician will then insert a loaded breeding gun through the cervix of the cow depositing the semen at the junction of the cervix and uterus illustrated in Figure 1. The semen will then travel through the uterine horns to the ovum resulting in conception.

![Figure 1. Insemination Process (Selk, G. 1990. Artificial Insemination in Beef Cattle. F-3164)](image)

AI allows cow calf producers to use bulls possessing superior genetics. Depending on the needs and goals of an individual’s breeding program, AI is an economically feasible means of increasing productivity throughout a wide range of traits. In the beef cattle business this means of reproduction is increasing nationwide. In order to initiate a breeding program such as AI, a sound management program is a necessity. Some factors that need to be considered by management when implementing an AI program are: proper semen handling, a low stress well designed breeding facility, and a time efficient process. By considering these factors the producers can receive optimal conception rates as well as save on labor costs.

The proper handling and thawing of frozen semen poses an economic effect as well as an effect on conception rates. One of the most frequent chances for semen damage is during the transport from semen tank to cow. An ideal procedure for the best conception rate is to immediately transfer the semen straw from the frozen semen tank to the thawing...
device which contains water at a temperature of 95 to 98 degrees for a minimum of 40 seconds. Secondly the straw needs to be loaded rapidly into the breeding gun and then the cow needs to be inseminated within minutes after the semen is thawed. The process needs to be done in a sheltered, heated area keeping the semen warm and away from contact to light.

It is essential in an intensive breeding program that special care is given in handling and stress management. Rough, stressful handling of cattle during AI can raise body temperature which depresses secretion of hormones needed for conception. Stress on the breeding technicians can also reduce conception rates. Stressed technicians can be hard on the cattle as well as not perform to their ability. Some strops that can be taken to reduce stress handling:

1. Make sure facilities are designed as well as possible to smooth the movement of cattle.
2. Keep things as quiet as possible.
3. If time permits, move the cattle through the working facility for acclimation purposes. (Dr. Steve Blezinger 2000).

Cows should be contained in dark boxed for AI (Parson and Helphinstine, 1969; Swan, 1975). This process will also improve conception rates. It is recommended that AI chutes not be the same chute used for branding, dehorning, or injections. Cows can be easily restrained for AI or pregnancy testing in a dark box chute that has no head gate or squeeze. A dark box has solid sides, top and front. A cow in the dark box is inside a quiet, snug, dark enclosure and is restrained from behind. The effectiveness of a dark box type restraint is due to a combination of factors such as blocking the view of an escape route and preventing the animal from seeing people that are inside the flight zone Figure 2. Darkness, however, has a strong calming effect. Even the wildest cattle remain much calmer in a dark box. Small light leaks can sometimes cause animals to become agitated.

Figure 2. Example of flight zone Grandin, T. Cattle Behavior During Handling and Corral Design for Ranches. Beef Cattle Handbook. BCH-9003)
One design of breeding chute used is shown in Figure 3. This design can be built either in the lead-up to the squeeze chute or after the squeeze chute but would have to be set up every time before breeding and then removed after breeding. This design does not provide much safety to the technician while behind the cow. It also poses a problem because it does not allow for the breeding to be conducted in a timely manner. In order for the cattle to flow through the chute all of the technicians must start and finish breeding at the same time. If there is a problem with one cow the other technicians have to stop, and wait until all of the cows can be pushed through the chute in order to load another set of cows. Another problem this design poses is, there is not an area to store and handle the semen safely and out of the light.

Figure 3. Straight load breeding chute. (Canada Plan Service. 1984. Plan 1818)

The Herringbone AI chute shown in Figure 4 is similar to that of the Cal Poly Animal Science Department. The chute allows the number of cow positions to be selected by management. This design is recommended for larger sized herds. Having an inadequate area for semen handling and storage this facility has to be set up for AI, and when the AI process is complete it needs to be removed. Because of being removable these AI chutes, difficult to secure, shift just with cattle moving in and out of the chutes making it unsafe for the cattle as well as those handling the cattle. This system is also difficult to operate without at least three people present.
Finally the squeeze chute with the palpation cage (shown in Figure 5), is the least preferable means for a breeding facility. Allowing the animal to see its surroundings as well as being caught by a head gate and being squeezed causes a high amount of stress to the animal resulting in low conception rates. This method also allows only one cow to be bred at a time which slows the process down dramatically. Breeding in this chute is less safe because when caught cows can sometimes pull their heads out of the head catch, back up and the breeding technician can be caught between the cow and the back gate of the palpation cage.
When designing and choosing the proper AI chute one needs to consider the amount of time needed to set up and prepare for running the cows through to AI as well as removing and storing the chutes. This will reduce the amount of labor needed during the ranches breeding season. The durability of the structure is also important. The Chute should not be allowed to move while in use, and should be strong enough to handle the weight and abuse from the cattle, keeping both the cattle and the handlers safe.

For ranches that have a disbursed herd such as Cal Poly where the beef herd is spread out amongst five different locations, the most feasible means for an AI cute is to design it to be portable. It is not economically feasible to build a breeding facility at each location. It also uses up to much space to have a breeding facility at each location. If the breeding chute is towable by another vehicle it can be delivered to the area and set up quite rapidly. A breeding chute like this can be built on a trailer frame and covered to create the dark box recommended for AI chutes. It can also have a space for storage of semen and equipment keeping everything close and convenient to the breeding technician.

In order to build a breeding chute that is towed the design must follow the State regulations and specifications for trailers that the trailer resides in. California regulations state (California Department of Motor Vehicles. 2003. Recreational Vehicles and Trailers. http://www.dmv.ca.gov):

1. Every hitch or coupling device used as a means of attaching the tow and towing vehicles shall be properly and securely mounted and be structurally adequate for the weight drawn. The mounting of the hitch or coupling device on the towing and towed vehicle shall include sufficient reinforcement or bracing of the frame to provide sufficient strength and rigidity to prevent undue distortion of the frame.

2. The drawbar, tongue, or other connection between the towing and towed vehicles shall be securely attached and structurally adequate for the weight drawn.

3. No person shall operate any motor vehicle having three or more wheels, any trailer, or semi trailer unless equipped with fenders, covers, or devices, including flaps or splash aprons, or unless the body of the vehicle or attachments thereto afford adequate protection to effectively minimize the spray or splash of water or mud to the rear of the vehicle and all such equipment or such body or attachments thereto shall be at least as wide as the tire tread.

4. Every vehicle shall be equipped with at least one reflector so maintained as to be plainly visible at night from all distances within 350 to 100 feet from the vehicle when directly in front of the lawful upper headlamp beams.

5. Whenever any motor vehicle is towing a trailer coach or a camp trailer the combination of vehicles shall be equipped with lamp-type turn signal system.

6. Every motor vehicle which is not in combination with any other vehicle and every vehicle at the end of a combination of vehicles shall at all times be equipped with stop lamps, tail lamps, and turn signals mounted at the rear.
7. The width of the trailer shall not exceed 108 inches.

8. The trailer hitch must have safety guide chains at all times of operation.

There are many areas that must be considered when designing a breeding chute. These areas should seek to improve conception rates, decrease labor, consider ergonomics, and follow state codes and regulations.
Procedures and Methods

Factors taken into consideration while designing the breeding chute were strength, durability, portability, safety, and ease of construction. The material used must be strong enough to handle the abuse from transportation of the trailer, and cattle handling. The dimensions of the trailer are 16’ Lx70”Wx85.5”H. this allows for the trailer to breed two cows, have sufficient space for storage and supplies, while reaching legal requirements to drive on California highways. The trailer will have divider gates and can’t backs to increase safety, and decrease stress while moving cattle through it.

Design Procedure

Main Frame. The artificial insemination chute must be able to handle rough terrain, abuse from processing cattle in and out of it therefore the 16’x 7’ bottom part of the main frame would be built with 3”x3” square tubing with a ¼” thickness. 1 ½” square tubing and angle iron with a 3/16” thickness will be used for the 7’ high outer walls and center partition with adequate spacing to hang siding this is shown in Figure 6.

Axles and Hydraulic system. Given the raw material ordered and the weight of the material per linear foot shown in Table 1. The total weight that the axles and hydraulic system would have to account for was calculated at 3500 pounds. Therefore as shown in appendix B the axles will be made of 2-8 Hole, 4500 lb Straight Spindle Stub Axle Assemblies with 8 lug wheels. As for the hydraulic system it will consist of 2-2” bore, 8” stroke hydraulic tie rod end cylinders, and 1- Haldex 12 Volt DC Power Unit with 3/8” hydraulic hose. The power supply for the hydraulic power unit consists of one 12 volt automotive battery.
Table 1. Weight of material.

<table>
<thead>
<tr>
<th>Size of material</th>
<th>Type</th>
<th>lb/linear ft</th>
<th>Amount of material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5&quot;x1.5&quot;x3/16&quot;</td>
<td>angle iron</td>
<td>1.81</td>
<td>160 Ln/ft</td>
<td>288</td>
</tr>
<tr>
<td>2&quot;x2&quot;x3/16&quot;</td>
<td>angle iron</td>
<td>2.41</td>
<td>280 Ln/ft</td>
<td>672</td>
</tr>
<tr>
<td>1.5&quot;x1.5&quot;x3/16&quot;</td>
<td>square tubing</td>
<td>3.35</td>
<td>340 Ln/ft</td>
<td>1139</td>
</tr>
<tr>
<td>3&quot;x3&quot;x1/4&quot;</td>
<td>tubing</td>
<td>8.81</td>
<td>100 Ln/ft</td>
<td>881</td>
</tr>
<tr>
<td>2&quot;x3/16&quot;</td>
<td>hot roll</td>
<td>1.38</td>
<td>20 Ln/ft</td>
<td>28</td>
</tr>
<tr>
<td>26ga. sheet metal</td>
<td></td>
<td>0.906</td>
<td>564.0 sq ft</td>
<td>508</td>
</tr>
<tr>
<td><strong>TOTAL WEIGHT</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>3,516 lbs</strong></td>
</tr>
</tbody>
</table>

**Dark box.** Since the dark box is where the cattle is restrained and bred it had to be designed with material that can with stand the weight and struggle of cattle. The sides are tapered from wide at the top to narrow at the bottom to conform with the body of cattle. This will allow cattle to fit comfortably with little movement. The dark box is constructed with 2"x2"x3/16" angle iron as the frame and sided with ¾" plywood on both sides and the top. In the rear of the dark boxes are “cant backs” that fall from vertical to horizontal position once the cattle are in the dark box to keep them from backing up. The cant back are constructed of 2”x2” square tubing.

**Gates.** The gates on the trailer will be constructed of 1 1/2” angle iron and ¾” plywood. The hinges will be welded on and pinned by 5”x1/2” bolts. The latches will be spring loaded that pull a ½” pin out of a hole when a lever is pushed to open the gate. When swung closed the levers will self lock into place.

**Construction Procedure**

**Main Frame.** For the construction of the main frame a 220V arc welder using 7018 rod was used to weld the steel together for a deep penetrating weld. The 3” square tubing was cut to form a 7ft by 16ft trailer frame with a 4ft tongue as shown in the designs in appendix A. once the bottom frame was completed the 1 ½ in square tubing uprights were welded in place making sure they are straight using a level. Using the up rights as welding points the horizontals were welded in all the way around at 12in., and 58in. from the bottom with 1 1/2in. angle iron. And along the top edge with 2in. angle iron.
**Axles and Hydraulic system.** Since the axle system is designed as a lever arm to raise and lower the trailer to the ground as shown in Figure 7. It had to be made from 3ft pieces of 2in. by 6in. square tubing. Holes were cut all the way through on both sides of the square tubing so that it can fit the 3in. axles on one side and on the other a 1/4in. thick pipe with an inside diameter of 2 1/2in. A piece of 3in by 8in. flat plate 1/4in. thick has a hole cut in the center just big enough to fit a 5in. long 2 1/2in. rod in it and then welded. The flat plate and rod was then welded so that when the lever arm is placed onto the rod the axle at the other end is at the center of the trailer. On the pivot side of the lever arm a mounting bracket for the hydraulic cylinder was welded on with a 1in. hole for the retaining pin. Once the axle and lever arms are assembled the hydraulic cylinders, hoses and power unit was assembled using the factory instructions.

![Figure 7. Axle system](image)

**Dark box.** The frame of the dark boxes were made by cutting a pie shaped piece out of one side of the angle iron 10in. from the end that will be the bottom and bending and welding it into place to form the taper so the space in between each side of the dark box begins at 33in. at the top and 20 ½ in. at the bottom. This was done on twelve pieces so that we could have three on each side of the two dark boxes with the flat sides of the angle iron facing each other to allow placement of the plywood. A better picture can be made by looking at the design of the front section of the trailer in appendix A. Once the frame is done the complete trailer was primed and painted then the plywood was cut and screwed into the frame in the dark box and ally ways.

**Gates.** The gates were constructed of 1 1/2in angle iron as the frame, then filled in with plywood. And hung into place. Once in place the latches were constructed and set in place as shown in figure 8.
Siding and roofing. After the gates are hung and the interior of the trailer is painted the pre-cut and pre-painted siding is then set into place and screwed in using self tapping metal screws provided by the manufacturer of the siding.

**Evaluation Procedure**

Upon completion of the portable breeding chute it was hauled over to a location where cattle would be bred. It was then place in position, lowered to the ground and cattle were ran through and bred in it. A record of the time it took to set up in man hours, number of cows bred per hour and the amount of time it took to break down and depart in man hours were recorded and compared with those of previous years when cows were artificially inseminated in the old breeding facility.
RESULTS

Once construction and evaluation was completed as seen in Figure 9, we found that the new breeding chute is efficient in more than one area. The steel construction with plywood interior walls allows the chute to be sturdy and withstand the abuse of cows reaching weights of 1500 lbs. Using thin sheet metal exterior siding allows it to be lightweight for easier towing and maneuvering. The hydraulic wheels used on this trailer allows the chute to be portable for transportation but fixed by retracting the hydraulic rams which raises the pivoting axles off the ground when in use to artificially inseminate cows. When cattle are in the chute the front doors are closed creating a dark area that causes the cows to calm themselves putting less stress on both cattle and breeding technician which improve conception rates.

Figure 9. Completed Breeding chute in place and lowered for use.

During the evaluation I found that the trailer can be used and operated by one person but for maximum efficiency the trailer should be used with two people. Using two people backing the trailer to the cattle lead up and lowering it to the ground preparing it for use took 10 minutes. An average of 30 cows an hour can be ran into and artificially inseminated. When finished it takes 5 minutes to lower wheels to the ground and towed away. As shown in Table 2. These results have been compared to the previous artificial insemination facility used showing a drastic improvement in efficiency.
Table 2. Time comparison chart

<table>
<thead>
<tr>
<th></th>
<th>Old Facility</th>
<th>Portable AI Trailer</th>
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</thead>
<tbody>
<tr>
<td><strong>Time used to set up</strong></td>
<td>8 hrs</td>
<td>10 min</td>
</tr>
<tr>
<td><strong># of cows bred/hr</strong></td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td><strong>Time spent to remove</strong></td>
<td>6hrs</td>
<td>5 min</td>
</tr>
</tbody>
</table>
Constructing this breeding chute in the small shop that was provided by the Cal Poly Animal Science Department and not having an assistant, made it difficult to build slowing the construction process. For example not having the correct tools and equipment for a project of this size, made welding the axle spindles onto the pivoting arms as well as pivot point to the trailer frame difficult. This does not allow us to obtain a tight fitting pivot point and square angles to prevent bad wear on tires and stress to the trailer frame. In a crooked axle as shown in figure 10.

![Figure 10. Loose axle with a slight tilt](image)

The breeding chute is fully enclosed and creates the dark box needed to relax the cow while in the chute. The butt bar shown in figure 11 that is lowered behind the cow once the cow is in the chute also helps in preventing excessive movement and kicking that can harm the cow as well as injuring the AI technician. This greatly increases the safety and ergonomics of the breeding facility.
The cost of constructing this chute is $5238.39 as compared to the cost of $2537.13 to build the 3cow herringbone system that was previously used at Cal Poly. Cal Poly has 300 cows and 100 hfrs that are artificially inseminated once a year, all of which are divided in groups of 100 head in four different locations. The money saved in time and man power using the hydraulic chute while breeding 100 head of cows at a time as described in the analysis below will justify building the new breeding chute that costs $2701.26 more to construct will reach it’s breakeven point in 6.14 years.

Three Cow Herringbone:

- Cost to set up for breeding: 8man hrs x $8/hr = $64
- Cost to breed 100 head of cows: 100 cows x $7.50/cow = $750
- Cost to remove breeding chute: 6man hrs x $8/hr = $48
- Total cost per breeding: $64 + $750 + $48 = $862

Portable Hydraulic Breeding Chute:

- Cost to set up for breeding: 0.167man hrs x $8/hr = $1.34
- Cost to breed 100 head of cows: 100 cows x $7.50/cow = $750
- Cost to remove breeding chute: 0.083man hrs x $8/hr = $0.66

Figure 11. Dark box with butt bar down and front gate open
Total cost per breeding = $752

Difference in Cost:

Difference for 1 breeding location = $862 - $752 = $110

Difference for 4 breeding locations = $110 \times 4 = $440

Years to pay for extra cost of the chute:

Difference in construction costs = $5238.39 - $2537.13 = $2701.26

Years needed = $2701.26 / $440 = 6.14yrs
RECOMMENDATIONS

After using and evaluating the breeding chute it is evident that there are a few key improvements to be made to the design of the chute. Changes like thickness of material, adding grease fittings, axle design, as well as adding an electrical circuit.

Instead of using the 3/16” thick angle for the main frame and gates of the breeding chute, using the 1/8” thick angle iron is strong enough to handle the weight and punishment from regular use. This will lower the cost of material and decrease the total weight of the chute which will ultimately save in fuel costs during transportation and increase maneuverability when setting into place by hand.

In addition to changing the thickness of the steel used, more time should be spent on the pivoting axle assembly, weld the pivot point square to the main frame using bushings, and material with a tight fit making sure that it pivots, does not have any free play in it and the axles do not have any side to side movement. Installing grease fittings on the pivoting axles as well as on the gate hinges will reduce wear on the moving parts while allowing to move freely, and prevent any corrosion possible.

Finally, in future designs of this breeding chute it should include a 110 Volt electrical circuit that powers sufficient lighting and at least one electrical outlet. In order to get power to the circuit in the trailer there should be at least a 50 ft extension cord to supply the power from an external power source. Adding the electricity will allow lighting in the area where the technician stores supplies and keeps any records needed. Power is also needed for use of other types of electrical tools needed such as an electrical semen thawing unit, or ultra sound equipment used for the breeding and pregnancy procedures.
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    Pp. 50-55, 222-235.
APPENDIX A
This is a sketch of the bottom of the frame for the AI trailer. This is all 3" square tubing.
Red lines indicate 2" iron angle and black lines indicate 1.5" square tubing.
Red lines indicate 2" iron angle and black lines indicate 1.5" square tubing.
Blue indicates gates made by 1.5\" angle iron and the block indicates 1.5\" square tubing.
Red lines indicate @" angle iron and black lines indicate 1.5" square tubing
Front View

Red lines are 2" angle iron and black lines are 1.5" square tubing.
Rear of trailer

Red lines are 2" angle iron and black lines are 1.5" square tubing
Materials List

340 feet of 1.5”x1.5” square tubing, 3/16” thickness

100 feet of 3”x3” square tubing, ¼” thickness

160 feet of 1 ½”x1 ½” angle iron, 3/16” thickness

280 feet of 2”x2” feet of angle iron, 3/16” thickness

20 feet of 3” hot roll, 3/16” thickness

10-1/2” 4x8 CDX, plywood

20-7’ corrugated paneling w/ 9” valley

3-16’ corrugated paneling w/ 9” valley

2-8 Hole, 4500 lb Straight Spindle Stub Axle Assemblies

2-235/75R 15 8 lug wheels with tires

1- 2” tow hitch quick lock trailer coupler with 3” channel

2- 2500 PSI, 2” bore, 8” stroke hydraulic tie rod end cylinders

   - Operation: Manual; 3-Position Valve
   - GPM at 1600 PSI: 1.4
   - Reservoir: 3 qt.

3/8” hydraulic hose, 1 pc at 5’. 2 pc at 6’

1-12V battery automotive battery

4-1 ¼” utility pulley

100’ ¼” rope

1-11/32”x1 7/8” ext spring

5-9/16”x 3” comp spring

2- 7/8”x6” ext spring
1- box rail and hanger set (delrin bearings)

4- 6” heavy duty strap hinges

2- boxes 1 ½” sheet metal screws.