

“Heat Pipe Demonstration Unit”

Senior Capstone Design- ME486C Midpoint Presentation

Kaled Aleweehan
Abdullah Almutairi
Waleed Almutairi
Abdullah Ben Gheyam
Omar Alotaibi

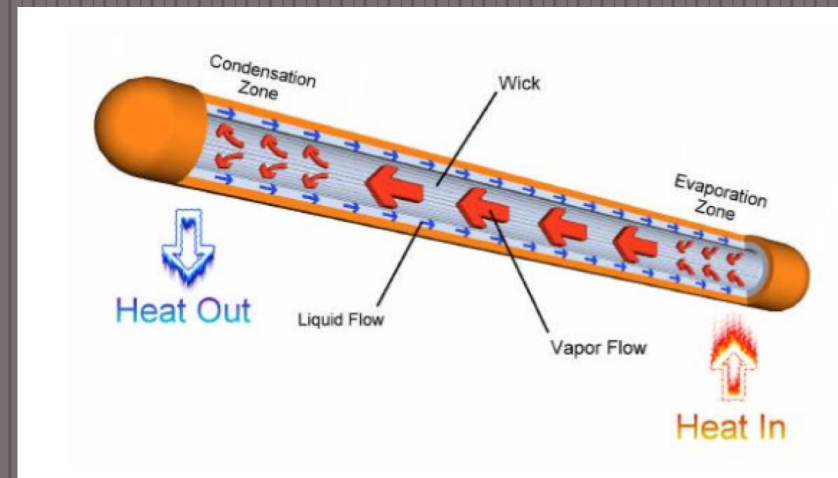


Figure 1: Heat Pipe [1]

Instructor: Dr. Oman
11/2/2018

Content:

- **Project Description**
- **Design description**
- **Images of the design with subsystems labeled**
- **Updates**
- **Design changes**
- **Analysis**
- **Plan for testing**
- **Schedule & Budget**
- **Hardware Review 2**

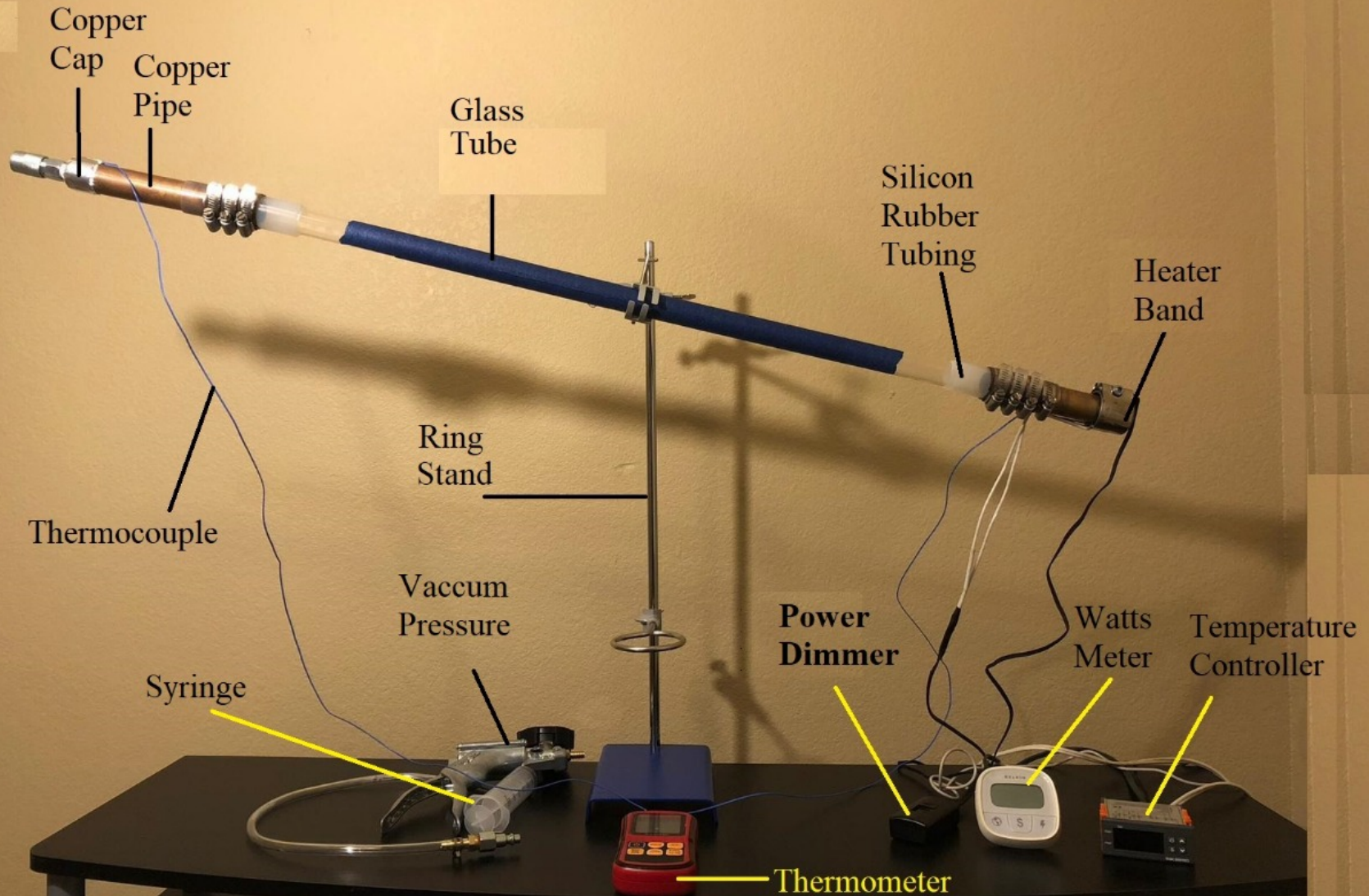
Project Description:

- What is the project about?
 - Heat pipe demonstration unit.
- Our sponsor?
 - Dr. David Trevas.
- Our stakeholders?
 - Mechanical engineering students and facilities at NAU.
- Why is it important?
 - For students, Learning the principles of mechanical engineering courses.
 - For facilities, applying their knowledge of the mechanical engineering courses.



Figure 2: NAU [2]

Image of our manufactured design with subsystems labeled



Updates: What have been accomplished?

Purchased:

- Copper pipes
- Copper caps
- Heater band
- Temperature controller
- Glass tubing
- Silicon rubber tubing
- Fittings, Connectors, etc..



Figure 4: Temperature Controller



Figure 5: Heater band



Figure 6: Silicon

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Updates: What have been accomplished?

Manufactured:

- Soldering (Copper pipes, Copper Caps, Fittings).
- Connecting the copper pipes with glass tubing by silicon rubber tubing.
- Setup the heater band.
- Hooked up the temperature controller.
- Bar to hold the cotton cloth



Figure 7: Fitting hole



Figure 8: Bar

Design changes with reasons

- Silicon rubber tubing instead of 4-way valve with epoxy
 - Does not exist! & Due to Thermal expansion.
- Copper pipes
 - Due to Heat Transfer.
- Temperature controller.
 - Able to control the temperature.
- Watt meter
 - To measure how many watts that applied by the heater band
- Power dimmer
 - To adjust the watts.

Nothing is left for manufacturing! except the plastic box.

Analytical analysis of inclination angle

- $Q_{max} = \left[\frac{\rho_l \sigma_l h_{fg}}{\mu_l} \right] \left[\frac{A_w K}{L_{eff}} \right] \left[\frac{2}{r_{cap}} + \frac{\rho_l}{\sigma_l} g L_t \sin \beta \right]$
- From this plot, once the value of the inclination angle increased, you will get higher value of the maximum heat transfer rate.
- The position for heat pipe that has the maximum heat transfer rate is the vertical position (90 degree).

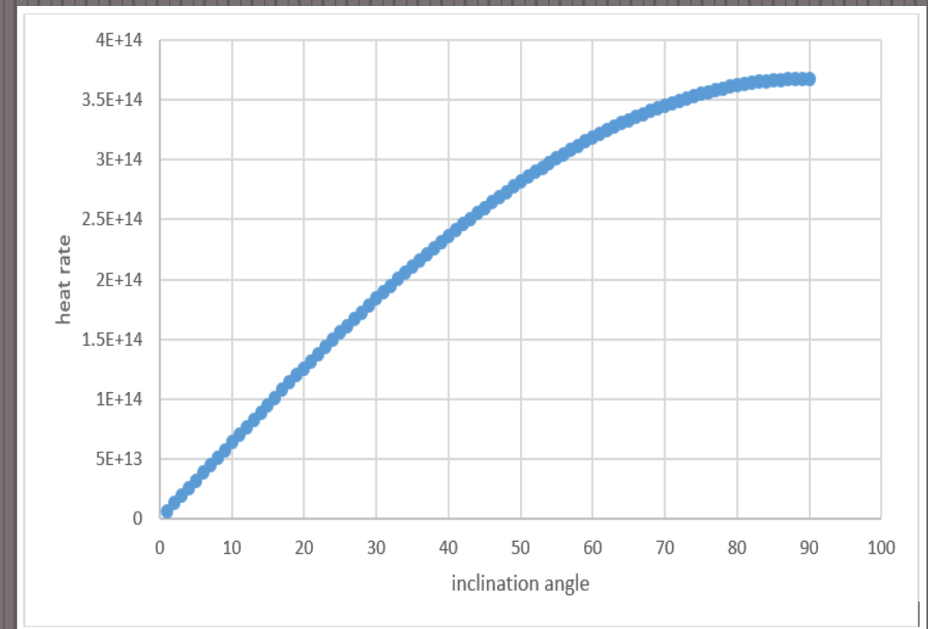


Figure 9: inclination angle Vs. Heat rate

Wick Materials

- When the heat flux is low (in Region I), the boiling section length is 0.
- When the heat flux surpasses Region I and spreads into Region II, boiling occurs.
- In Region III, dry-out/boiling takes place in the entire wick length.
- Region II is very narrow.
- Vapor fraction.
- Cotton mesh wick appears to be an appropriate material.

- $$\alpha = \frac{r_{max} - r_{critical}}{r_{max} - r_{min}}$$

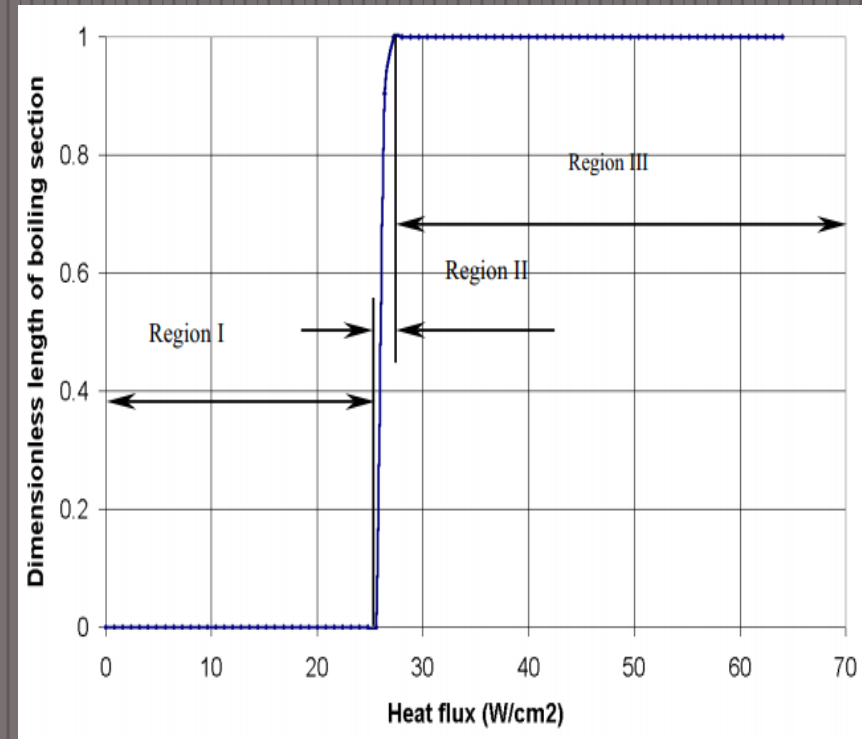


Figure 10: Rise of boiling section length at rising heat fluxes.

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Additional analysis- Silicon Testing

Physical experiment of the behavior of the silicon rubber tubing



Figure 11: Silicon with clamps

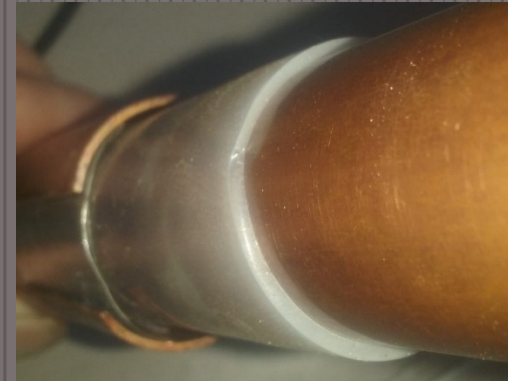


Figure 12: Silicon supported with metal and copper



Figure 13: Silicon supported with metal, copper, and clamps.

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Additional analysis- Glass Testing



Plan for Testing

- Apply different fluids.
- Apply the wicking material.
- Apply different temperatures.
- Vacuum different values of pressure.
- Change the angle.

Schedule

We are ON TIME

Table 1: Schedule

| Task Name | Team member | Start Date | End Date | Duration |
|--|-------------|------------|------------|----------|
| Final Report Rewrite | All | 8/18/2018 | 8/29/2018 | 11 |
| Finalization of design | All | 8/27/2018 | 9/3/2018 | 7 |
| Canvassing of parts | All | 8/27/2018 | 9/7/2018 | 11 |
| purchasing parts | All | 9/8/2018 | 9/28/2018 | 20 |
| Progress Presentation | All | 9/17/2018 | 9/17/2018 | 0 |
| Hardware Review 1 (50% of the final project) | All | 10/5/2018 | 10/5/2018 | 0 |
| Individual Analytical Analysis | All | 10/12/2018 | 10/12/2018 | 0 |
| Testing the heater band | Waleed | 10/14/2018 | 10/16/2018 | 2 |
| Hook up the temperature controller | Waleed | 10/14/2018 | 10/16/2018 | 2 |
| Soldering the copper caps with copper pipes & Fittings | Kaled | 10/15/2018 | 10/16/2018 | 1 |
| Connect the copper pipes with glass pipe by silicon rubber tubin | Kaled | 10/17/2018 | 10/18/2018 | 1 |
| Midpoint Report | All | 10/19/2018 | 10/19/2018 | 0 |
| Initial implementation on the final project | All | 10/21/2018 | 10/25/2018 | 4 |
| Improvements on the final project | All | 10/27/2018 | 11/2/2018 | 6 |
| Midpoint Presentation | All | 10/31/2018 | 10/31/2018 | 0 |
| Hardware Review 2 (100% of the final project) | All | 11/2/2018 | 11/2/2018 | 0 |
| Testing our final project | All | 11/3/2018 | 11/16/2018 | 14 |
| Final Draft of Poster | All | 11/18/2018 | 11/30/2018 | 12 |
| Final operation and Assembly Manual | All | 11/18/2018 | 11/30/2018 | 12 |
| Final Presentation | All | 11/18/2018 | 11/30/2018 | 12 |
| Final CAD Package and BOM | All | 11/24/2016 | 12/5/2016 | 11 |
| Final Report | All | 11/24/2018 | 12/7/2018 | 13 |

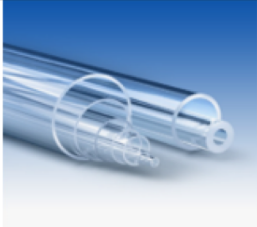





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Schedule cont..



Budget

Table 2: Budget

| Component Name | Model Number | Picture | Cost | Supplier |
|-----------------------|--|---|----------------------------|------------------------------|
| Glass tubing | Dimension: L = 2.5 ft ID = 22 mm OD = 25 mm |  | \$23.00 | Technical glass products [3] |
| Copper caps | 1 in Copper Caps Qty: 2 |  | Each \$2.91 = \$5.82 | The Home depot [4] |
| Silicon rubber tubing | Semi-Clear White, Durometer 50A, 1" ID, 1-1/8" OD |  | \$3.18 | McMaster-carr [5] |
| Fittings | Includes gauge, chuck, 1/4-in. NPT (F) coupler, (4) 1/4-in. NPT (M) plugs, (2) 1/4-in. NPT (F) plugs, female coupling, (2) male couplings, (2) inflation nozzles, safety nozzle & tapered nozzle |  | \$14.48 | Amazon [6] |
| Vacuum Pump | Silverline Elite hand vacuum/ pressure pump w/ 2 inch compound gauge w/ rubber boot; |  | \$49.95 | ToolDiscounter [7] |
| Water | 1-liter water as working fluid. |  | \$0.35 | Walmart [8] |

Budget cont..

Table 3: Budget cont...

Total dollars available:
\$500
Anticipated expenses:
\$356
Actual expenses to date:
\$206.12

| | | | | |
|--|---|---|----------------------------|--------------------|
| LCD thermometer w' thermocouples wires | Dimension: 7.1 x 4.3 x 1.7 inches |  | \$24.79 | Amazon [9] |
| Heater band | Uxxell 110V 380W Injected Mould Heating Element Band Heater 35Mm x 35Mm |  | \$8.99 | Amazon [10] |
| Cotton cloth | 3 Yards |  | \$17.97 | Joann fabrics [11] |
| Timer | To measure time |  | \$5 | Amazon [12] |
| Temperature controller | Size: 71(L)*29(W)mm Voltage 110.00 volts |  | \$15.99 | Amazon [13] |
| Copper Pipes | Two copper pipes 1 st copper pipe: L= 0.5 ft OD= 1 in 2 nd copper pipes: L= 0.4 ft, OD = 1 in |  | Each \$2.44 = \$4.88 | Homco [14] |
| Ring stand | Laboratory Grade Metalware Set - Support Stand (8" x 5"), 12mm Dia. Rod (24" L), Cork Lined Burette Clamp with Boss Head and Retort Ring (2.5" dia) |  | \$29.72 | Amazon [15] |

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Hardware Review 2



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Thank you - Any questions?

