FINAL SCRIPT: APPROVED FOR FILMING

Submission ID #: 69373
Scriptwriter Name: Sulakshana Karkala
Project Page Link: https://review.jove.com/account/file-uploader?src=21158813

Title: Thermal Behavior and Power Efficiency Comparison of AC vs. DC Electrical Heating in a Distillation Column Using Infrared Thermography Analysis

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Author Questionnaire

1. We have marked your project as author-provided footage, meaning you film the video yourself and provide JoVE with the footage to edit. JoVE will not send the videographer. Please confirm that this is correct.

√ Correct

2. Microscopy: Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**

3. Software: Does the part of your protocol being filmed include step-by-step descriptions of software usage? **Yes, all done**

4. Proposed filming date: To help JoVE process and publish your video in a timely manner, please indicate the proposed date that your group will film here: **01/17/26**

Current Protocol Length

Number of Steps: 18
Number of Shots: 34

Introduction

INTRODUCTION:

~~What is the scope of your research? What questions are you trying to answer?~~

1.1. **Gregorio Moreno:** The scope of my research is to demonstrate the advantage of using AC and DC power supplies in a heating element within a distillation column boiler.

1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

~~What are the most recent developments in your field of research?~~

1.2. **Gregorio Moreno:** Recent studies address thermographic analysis and AC/DC-powered distillation columns separately but no work combines both approaches.

1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

CONCLUSION:

~~What advantage does your protocol offer compared to other techniques?~~

1.3. **Gregorio Moreno:** Our protocol uses TIR analysis to provide a clearer view of thermal behavior in relation to power sources within the process.

1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

~~How will your findings advance research in your field?~~

1.4. **Gregorio Moreno:** Our findings show that selecting appropriate AC or DC supplies optimizes performance, reduces energy costs, and improves distillate quality.

1.4.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

What questions will future research focus on?

1.5. **Gregorio Moreno:** Future research will investigate thermogram-based early fault detection methods and how thermal actuator fatigue influences process transient behavior.

1.5.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

Protocol

2. Thermographic Data Acquisition and Image Processing for Boiler Plate Temperature Measurement

Demonstrator: Gregorio Moreno Sotelo

2.1. To begin, set up the thermal camera for acquisition **[1].** Select the **Iron** color palette from the thermal camera menu **and** ensure it is correctly applied before proceeding **[2]**.

2.1.1. WIDE: Talent standing in front of the experimental setup with the thermal camera and boiler plate visible.

2.1.2. SCREEN: 69373_screenshot_2.mp4 00:00-00:11

2.2. Set the **emissivity correction value** to **0.95** from the thermal camera menu **[1]**.

2.2.1. SCREEN: 69373_screenshot_3.mp4 00:00-00:10

2.3. Then position the thermal camera approximately 80 centimeters away from the boiler plate **[1]**. Holding the thermal camera approximately 60 centimeters above the floor, orient the camera toward the boiler plate in the distillation column **[2]**.

2.3.1. Talent positioning the thermal camera at the specified distance from the boiler plate.

2.3.2. Talent holding the thermal camera at the specified height above the floor and aligning the camera toward the boiler plate in the distillation column

2.4. Press the **save** button to record the thermogram to the thermal camera memory **[1]**.

2.4.1. Talent pressing the save button on the thermal camera.

2.5. Capture thermograms every 5 seconds during samples 1 to 1500 on the local interface **[1]**. Repeat the acquisition for 20, 60, and 100 volts under alternating current and direct current conditions **[2]**.

2.5.1. SCREEN: 69373_screenshot_7.mp4 00:00-00:20

2.5.2. SCREEN: 69373_screenshot_8c.mp4 00:00-00:10
69373_screenshot_8b.mp4 00:20-00:25
69373_screenshot_8a.mp4 00:23-00:28
AND
TEXT ON PLAIN BACKGROUND:

For 100 V (AC and DC) : Capture every 10 s (samples 1500 – 2800)
Capture every 20 s (samples 2800 until steady

state)
For 20 V (AC and DC) : Capture every 10 s (samples 1500 to 5500) Capture every 20 s (samples 5500 until steady state)
For 60 V (AC and DC) : Capture every 15 s (samples 1500 to 4000) Capture every 30 s (samples 4000 until steady state)
Video Editor: Please play shots side by side in a split screen

2.6. Record the name of each captured thermogram and the corresponding boiler plate temperature sample displayed on the local interface **[1]**.

2.6.1. SCREEN: 69373_screenshot_9.mp4 00:00-00:06, 00:09-00:13

2.7. To begin acquisition of boiler plate temperature data, store the temporary files generated by the local process interface **[1]**. Rename and save the stored files into the **current process** folder **[2]**.

2.7.1. SCREEN: 69373_screenshot_10.mp4 00:20-00:37

2.7.2. SCREEN: 69373_screenshot_11.mp4 00:00-00:15,00:20-00:23

2.8. Collect the .csv *(C-S-V)* files generated during the test and generate a single file containing all acquired process data **[1]**. Save the consolidated file for analysis **[2]**.

2.8.1. SCREEN: 69373_screenshot_12.mp4 00:33-00:50

2.8.2. SCREEN: 69373_screenshot_13.mp4 00:00-00:20

2.9. To begin preparation of the data, extract thermograms from the thermal camera **[1]**. Transfer all image files to the analysis workstation **[2]**. Review the extracted thermograms and discard any unwanted images **[3]**.

2.9.1. Talent connecting the thermal camera to the workstation.

2.9.2. SCREEN: 69373_screenshot_15.mp4 00:15-00:29

2.9.3. SCREEN: 69373_screenshot_16.mp4 00:00-00:12

2.10. Manually mark a reference point on each thermogram **[1]**. Then create a process temperature overview graph using the previously generated process data file **[2]**.Relate the boiler temperature data from the local interface to the captured process thermograms **[3].**

2.10.1. SCREEN: 69373_screenshot_17.mp4 00:09-00:16

2.10.2. SCREEN: 69373_screenshot_18.mp4 00:00-00:13

2.10.3. SCREEN: 69373_screenshot_19.mp4 00:08-00:22

2.11. To develop an algorithm for thermogram processing, first load an image into a variable within the analysis environment **[1]**. Define the size of the vectors for the graph axes using the image variable **[2]**. Then define the area for detecting minimum and maximum temperature ranges based on the analysis image **[3]**.

2.11.1. SCREEN: 69373_screenshot_20.mp4 00:00-00:16

2.11.2. SCREEN: 69373_screenshot_21.mp4 00:00-00:07

2.11.3. SCREEN: 69373_screenshot_22.mp4 00:21-00:42

2.12. Prepare the figure for graphing **[1]**.

2.12.1. SCREEN: 69373_screenshot_23.mp4 00:00-00:10

2.13. Next, load the thermogram image into a variable for processing. Define a search area for the previously marked reference point **[1]**.

2.13.1. SCREEN: 69373_screenshot_24.mp4 00:00-00:20

2.14. Isolate the reference point and obtain its coordinates **[1]**. Then use the coordinates to indicate the analysis area **[2]**.

2.14.1. SCREEN: 69373_screenshot_25.mp4 00:00-00:12

2.14.2. SCREEN: 69373_screenshot_26.mp4 00:00-00:12

2.15. Now, convert the analysis area to grayscale **[1]**. Calculate the mean temperature value of the grayscale area **[2]**.

2.15.1. SCREEN: 69373_screenshot_27.mp4 00:00-00:09

2.15.2. SCREEN: 69373_screenshot_28.mp4 00:08-00:22

2.16. Isolate the maximum and minimum temperature areas in the image **[1]**. Convert the graphical numbers to numeric text **[2]**.

2.16.1. SCREEN: 69373_screenshot_29.mp4 00:00-00:15

2.16.2. SCREEN: 69373_screenshot_30.mp4 00:00-00:10

2.17. Convert the mean values to scaled maximum and minimum temperatures according to the image ranges **[1]**, and store the total mean values and corresponding labels **[2]**.

2.17.1. SCREEN: 69373_screenshot_31.mp4 00:00-00:19

2.17.2. SCREEN: 69373_screenshot_32.mp4 00:30-00:58

2.18. Lastly, plot the total mean results to visualize the processed thermogram data **[1]**.

2.18.1. SCREEN: 69373_screenshot_33.mp4 00:00-00:15

Results

3. Results

3.1. The temperature measurements using 100-volt DC varied throughout the process, while the measurements using 100-volt AC remained more stable **[1-TXT]**.

3.1.1. LAB MEDIA: Figure 5A.
TXT: DC: Direct Current; AC: Alternating Current
Video editor: Please sequentially highlight the orange (VDC) and blue (VAC) lines

3.2. At 100-volt DC, thermal variation across the boiler section was higher than with alternating current **[1]**. DC presented more controlled areas due to smoother progression and increasing but not abrupt dispersion **[2].**

3.2.1. LAB MEDIA: Figure 6 A, B and C,D . *Video editor: Please highlight 6C and D*

3.2.2. LAB MEDIA: Figure 6E. *Video editor: Please highlight the blue line*

3.3. Under 60-volt conditions, temperature measurements were more stable with AC **[1]**.

3.3.1. LAB MEDIA: Figure 5B. *Video editor: Emphasize the blue smoother VAC curve*

3.4. Thermal evolution using 60-volt AC showed a gradual temperature increase during start-up **[1]**, whereas with 60 volt DC, the heating was more pronounced and rapid **[2]**.

3.4.1. LAB MEDIA: Figure 9B. *Video editor: Please sequentially show each image. Emphasize the box with the temperature on the top left corner of each image*

3.4.2. LAB MEDIA: Figure 10B. *Video editor: Please sequentially show each image. Emphasize the box with the temperature on the top left corner of each image*

3.5. The graphical temperature trend at 20 volts showed noticeable variation DC **[1]**, while AC resulted in a more gradual and stable profile **[2]**.

3.5.1. LAB MEDIA: Figure 5C. *Video editor: Highlight the orange VDC line with visible fluctuations.*

3.5.2. LAB MEDIA: Figure 11A. *Video editor: Highlight the smooth upward trend of the VAC line.*

3.6. Thermograms under 20-volt DC showed temperatures ranging from 22.8 degrees Celsius to 26.3 degrees Celsius **[1]**.

3.6.1. LAB MEDIA: Figure 11B. *Video editor: Highlight each thermogram from IR_3068 to IR_3178, Emphasize the box with the temperature on the top left corner of each image*

Pronunciation Guide:

▯ Thermography
Pronunciation link: https://www.merriam-webster.com/dictionary/thermography
IPA: /θərˈmɑːgrəfi/
Phonetic Spelling: thur·maa·gruh·fee
▯ Thermographic
Pronunciation link: https://www.merriam-webster.com/dictionary/thermographic
IPA: /ˌθərməˈgræfɪk/
Phonetic Spelling: thur·muh·graf·ik
▯ Distillation
Pronunciation link: https://www.merriam-webster.com/dictionary/distillation
IPA: /ˌdɪstəˈleɪʃən/
Phonetic Spelling: dis·tuh·lay·shuhn
▯ Infrared
Pronunciation link: https://www.merriam-webster.com/dictionary/infrared
IPA: /ˌɪnfrəˈrɛd/
Phonetic Spelling: in·fruh·red
▯ Emissivity
Pronunciation link: https://www.merriam-webster.com/dictionary/emissivity
IPA: /ˌiːmɪˈsɪvɪti/
Phonetic Spelling: ee·mi·si·vuh·tee
▯ Thermogram
Pronunciation link: https://www.merriam-webster.com/dictionary/thermogram
IPA: /ˈθɜːrməˌgræm/
Phonetic Spelling: thur·muh·gram
▯ Alternating Current
Pronunciation link: https://www.merriam-webster.com/dictionary/alternating%20current
IPA: /ˈɔːltərˌneɪtɪŋ ˈkɜːrənt/
Phonetic Spelling: awl·ter·nay·ting kur·uhnt
▯ Direct Current
Pronunciation link: https://www.merriam-webster.com/dictionary/direct%20current
IPA: /dəˈrɛkt ˈkɜːrənt/
Phonetic Spelling: duh·rekt kur·uhnt
▯ Thermogram-Based
Pronunciation link: No confirmed link found
IPA: /ˈθɜːrməˌgræm beɪst/
Phonetic Spelling: thur·muh·gram bayst
▯ Actuator
Pronunciation link: https://www.merriam-webster.com/dictionary/actuator
IPA: /ˈæk.tʃuˌeɪtər/
Phonetic Spelling: ak·choo·ay·ter
▯ Thermographic Analysis
Pronunciation link: No confirmed link found
IPA: /ˌθərməˈgræfɪk əˈnæləsɪs/
Phonetic Spelling: thur·muh·graf·ik uh·nal·uh·sis

? Emissivity Correction
Pronunciation link: No confirmed link found
IPA: /ˌiːmɪˈsɪvɪti kəˈrɛkʃən/
Phonetic Spelling: ee·mi·si·vuh·tee kuh·rek·shuhn
? Grayscale
Pronunciation link: https://www.merriam-webster.com/dictionary/grayscale
IPA: /ˈɡreɪˌskeɪl/
Phonetic Spelling: gray·skayl
? Thermodynamic
Pronunciation link: https://www.merriam-webster.com/dictionary/thermodynamic
IPA: /ˌθɜːrmoʊdaɪˈnæmɪk/
Phonetic Spelling: thur·moh·dye·nam·ik
? Transient
Pronunciation link: https://www.merriam-webster.com/dictionary/transient
IPA: /ˈtrænʒənt/ , /ˈtrænsjənt/
Phonetic Spelling: tran·zhuhnt; tran·syuhnt