**CAPSTONE DESIGN: REPORT GUIDELINES**

GRADERS  
(Faculty Advisors)

Evaluation rubrics are provided for the grading of written reports in capstone design. The students should include the correct rubric with the report they submit to you. If the correct rubric is not provided, or if you have questions regarding grading, please contact John Parmigiani (parmigjo@engr.orst.edu).

To use the evaluation rubric, (i) read the rubric description of the required content, (ii) refer to the corresponding text of the report (chapter and section are given in the rubric for each category) and (iii) assign a **letter grade** based on the criteria given at the top of the rubric.

Written assignments in capstone design consist of three reports in fall term and one report in winter term. The reports are written sequentially using the same template (i.e. all reports except the last will have some empty chapters). The first report, the Background Report, consists of chapters 1 and 2 of the template. The second consists of chapters 1, 2, 3 and part of 4. The third consists of chapters 1, 2, 3, 4, and 5. The fourth report contains all chapters. In order to allow students an opportunity to improve their writing based on your grading and comments, some chapters will regraded in subsequent reports.

With the exception of the Background Report, all of the reports are collaboratively written by the team (i.e. you will receive one report from each **team** you are advising). The Background Report is written individually (i.e. you will receive one report from each **student** you are advising). This information is summarized in the table below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Report Title** | **Submitted by Students** | **Due from Graders** | **Chapters of Template** | **Grading** | | **Authorship** |
| **New Content** | **Revised Content** |
| Background Report | Oct. 19 | Oct. 25 | 1, 2 | Chapters  1, 2 | None | Individual |
| Preliminary Proposal | Nov. 2 | Nov. 8 | 1, 2, 3, 4.1 | Chapters  3, 4.1 | Chapters  1, 2 | Team |
| Final Proposal | Dec. 6 | Dec. 10 | 1, 2, 3, 4, 5 | Chapters  4.2, 5 | Chapters  1, 2, 3, 4.1 | Team |
| Final  Report | Mar. 14 | Mar. 18 | All | All but chapters. 1-5 | Chapters  1-5 \* | Team |

\* Detailed grading of chapters 1-5 is not required, but tense and voice must be consistent and correct.

When grading, it is not necessary for you to extensively “mark-up” the text of the report. Include comments in the text of the document at your discretion, and add brief comments as you feel necessary to support the grades you have given. Line-by-line editing for writing quality is neither required nor desired. Refer students to Tracy Ann Robinson for detailed help with writing issues.

STUDENTS:

Hand in three copies of your report. One to your faculty advisor, one to your sponsor mentor, and one to the course instructor associated with your project. The copy to your faculty advisor must include this page and the **correct** evaluation rubric. The copy to your course instructor can be submitted in the drop box in 102 DB.

**Note: Remove all instructions (listed in square brackets, []) from completed sectionsEVALUATION RUBRIC FOR BACKGROUND REPORT – PRODUCT PROJECTS**

Faculty advisors: Please complete this rubric and return it, with the graded report, to 102 DB by **4:30PM** **on Oct. 25**

Student Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grader Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |
| --- | --- | --- |
| A+ | 100% | Truly outstanding technical work and writing. Difficult to imagine anything better by faculty. |
| A | 95% | Excellent. Substantial insight, originality, creativity, competence. Fully developed and detailed |
| B | 85% | Strong. Thorough. Shows good understanding, competence. Well developed, w/ supporting detail |
| C | 75% | Adequate. Demonstrates adequate understanding, competence. Adequately development, detail. |
| D | 65% | Weak. Shows some understanding and/or competence. Undeveloped or lacking supporting detail |
| F | 55% | Unsatisfactory. Demonstrates some effort, but little understanding or competence. Undeveloped |
| F- | 0% | Unacceptable. Completely omitted, or demonstrates very, very little effort. |

|  |  |  |
| --- | --- | --- |
| **CATEGORY**  **(grade weight)** | **DESCRIPTION** | **GRADE (A-F)** |
| **BACKGROUND**  **Chapter 1**  **Section 1.1**  **(15%)** | A general description of the project: what is to be accomplished, relevance / significance to the sponsor, and benefits upon completion. |  |
| **EXISTING DESIGNS, DEVICES, AND METHODS:**  **SYSTEM LEVEL**  **Chapter 2**  **Section 2.1**  **(20%)** | A description of at least 3 relevant existing designs, devices, and methods related to the project topic at the system, or entire entity, level (e.g. if the project were to design a car, descriptions of other vehicles would be given) |  |
| **EXISTING DESIGNS, DEVICES, AND METHODS:**  **COMPONENT LEVEL**  **Chapter 2**  **Section 2.2**  **(20%)** | A functional decomposition of the project topic into its primary components. For each component, a description of at least 3 relevant existing designs, devices, and methods (e.g. if designing a car, describe steering, braking etc) |  |
| **CLARITY & CONCISENESS**  **(15%)** | Absence of “padding” and unnecessary repetition. Clarity, conciseness and focus.. |  |
| **ORGANIZATION**  **(15%)** | Proper sequencing, paragraph breaks, and flow of ideas. Transitions among sentences, paragraphs, and ideas. Details fit where placed |  |
| **CONVENTIONS**  Graded By Course Instructor  **(10%)** | Proper use of writing conventions (punctuation, spelling, capitalization, grammar, and usage). |  |
| **CITING SOURCES**  **(5%)** | Claims substantiated by correct citations in text and references in bibliography |  |

Note: Section 1.2, Requirements, graded by the course instructor.

OSU Mini Malter

Background Report

Aaron Mason

2010/11

Project Sponsor: OSU Food Science Department

ME 497/498

Project Number: 73

Faculty Advisor: Joe Hortnagl

Sponsor Mentor: Tom Shellhammer, Jeff Clawson

**DISCLAIMER**

This report was prepared by students as part of a college course requirement. While considerable effort has been put into the project, it is not the work of a licensed engineer and has not undergone the extensive verification that is common in the profession. The information, data, conclusions, and content of this report should not be relied on or utilized without thorough, independent testing and verification. University faculty members may have been associated with this project as advisors, sponsors, or course instructors, but as such they are not responsible for the accuracy of results or conclusions.

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# PROJECT DESCRIPTION

## Background

Oregon State University is always trying to make Oregon a better place. Part of this goal can be accomplished economically. Farmers already grow barley in this region. None of these barley growers are selling to breweries because there is no information available regarding the suitability of Oregon grown barley for malting. This project is to design and build a mini malter for the Oregon State University Food Sciences department. This mini malter will be able to malt barley with batches ranging from 200 to 300 pounds. These small samples will be compared to barley already being used in production and could potentially provide information that leads to large breweries placing orders for barley with Oregon farms. This project will benefit the university directly as well by providing another teaching tool for the fermentation science program.

## Requirements

This project requires the design and implementation of a device that is capable of malting 200 to 300 pounds of barley with a budget of $10,000.

### Project Description

Oregon beer and spirits are made from malts produced from barley not grown in Oregon. The reason Oregon barley is not in Oregon products is a lack of data on the suitability of Oregon barley for Oregon- produced malts. Currently, research samples are malted at 350 grams each and the minimum commercial run is 350,000 lbs. There is no opportunity for producing malts suitable for pilot brewing. The OSU Pilot brewery, located in the Department of Food Science and Technology, is the perfect facility for testing, developing, and demonstrating the suitability of Oregon barley for Oregon malts. The brewery requires ~ 200 lbs of barley to produce malt for a 100 gallon brew. Mechanical Engineering students will design, build, and develop a pilot malting unit - a “flex box” for steeping, germinating, and kilning in a single unit. The flex box will remove the malting bottleneck and get Oregon grain flowing to Oregon glasses. A project budget of $10,000 will be provided.

### Customer Requirements (CRs)

**Malter shall wash barley (Weight 5 pts.)**  
Washing the barley is essential to eliminate any excess dust and dirt on the barley. The barley should be washed for approximately 30 minutes. It is something the customer would like but is not on the top of their priority list. The weighting reflects this.  
  
**Malter shall steep barley (Weight 10 pts.)**  
Steeping is the first main process in malting barley. Steeping is important to increase the moisture content of the barley so that it can begin to germinate. Steeping should be done in stages with the following guidelines, though these can be experimented with if the steeping temperature is changed.

8-hour immersion followed by a 6-hour couch (drain). Barley moisture percentage after cycle: 33%-35%  
6-hour immersion followed by a 10-hour couch. Barley moisture percentage after cycle: 38-41%  
4-hour immersion followed by a 2-hour final couch. Barley moisture percentage after cycle: 44-47%  
  
**Malter shall aerate steeping water (Weight 20 pts.)**  
Aerating the steeping water is important to remove excess carbon dioxide produced by respiration of the barley. The barley grains can also suffocate if the water is not aerated.

**Malter shall allow control of inflow steeping water temperature (Weight 20 pts.)**  
By changing the temperature of the inflow steeping water the time spent in the steeping phase can be shortened or lengthened. This is something that large malters cannot do, and so the sponsor is interested in seeing the effects of temperature on steeping times.  
  
**Malter shall keep steeping water temperature below 70F (Weight 20 pts.)**  
Keeping the steeping water below 70F is essential. If the water is above 70F the barley gets too hot and can die. If the barley is killed by high temperatures the grain would have to be thrown away and the process restarted. The weighting reflects the importance of this requirement.  
  
**Malter shall couch barley (sit without water) (Weight 20 pts.)**  
Couching barley is important so the barley absorbs the moisture in its surroundings. This is where the barley absorbs the most moisture and so this is weighted more heavily.  
  
**Malter shall keep germination temperature below 70F (Weight 25 pts.)**  
The germination temperature should also not rise above 70F. Just like during steeping if the barley gets too hot it will die. Germination is when barley tends to heat up so this is an important requirement.  
  
**Malter shall keep germination temperature above 60F (Weight 5 pts.)**  
Keeping the germination temperature above 60F is needed so the barley can effectively germinate. If the air is too cold then the barley will not begin germinating. The malter will operate in room temperature surroundings and so low temperatures aren't likely.   
  
**Malter shall turn/mix barley during germination (Weight 25 pts.)**  
Mixing/turning the barley during germination allows for even moisture and temperature distribution. Turning also prevents the germinating barley from forming a thick mat of roots. The barley should be turned every eight hours after the initial 24 hours of germination. This first period of rest is to allow the barley to strengthen after steeping to prevent damage to the grain. Mixing/turning is a critical requirement for producing a consistent malted barley and is weighted accordingly.  
  
**Malter shall allow ample adjustment of air flow rate through the grain bed (Weight 20 pts.)**  
Being able to vary the air flow rate is important as the germination phase and kilning phase require different air flow rates. During kilning it's also important to adjust air flow rate so that different malted barley types can be produced.  
  
**Malter shall allow ample temperature adjustment of air (Weight 20 pts.)**  
When kilning the malted barley it's important to slowly ramp up the air temperature. This stops the enzymes within the barley from activating. Also, higher temperatures can be used to produce different malted barley types. Pale malts are kilned for a longer time and lower temperatures, approximately 24 hours at 100F to 120F, and darker malts are kilned at higher temperature for shorter times. The higher the temperature, the shorter the kiln time and the darker the malt.  
  
**Malter shall allow for air flow recirculation (Weight 15 pts.)**  
Air flow circulation will make the kilning phase more efficient in producing highly kilned (darker) malts.   
  
**Malter shall be easy to load and unload barley (Weight 10 pts.)**  
The customer does not want loading and unloading to be hard or take a long time. They also do not want to put any unnecessary stress on their body.  
  
**Malter shall be portable (Weight 10 pts.)**  
The customer would like the malter to be somewhat portable so it can be used in classroom demonstrations, as well as taking it to other places on campus. The malter should be easily transported by one or two people.  
  
**Malter shall handle 200-300lbs of barley per run (Weight 15 pts.)**  
The customer would like the malter to have a minimum capacity of 200-300 pounds. This is to allow enough malted barley to be produced to run a batch in the pilot brewery.  
  
**Construction and testing of the malter shall not cost more than $10,000 (Weight 10 pts.)**  
We are given a $10,000 budget and it is important that we work within this limit.

### House of Quality (HoQ)

| Customer Requirements | Weight |
| --- | --- |
| Malter shall wash barley | 5 |
| Malter shall steep barley | 10 |
| Malter shall aerate steeping water | 20 |
| Malter shall allow control of inflow steeping water temperature | 20 |
| Malter shall keep steeping water temperature below 70F | 20 |
| Malter shall couch barley (sit without water) | 20 |
| Malter shall keep germination temperature below 70F | 25 |
| Malter shall keep germination temperature above 60F | 5 |
| Malter shall turn/mix barley during germination | 25 |
| Malter shall allow ample adjustment of air flow rate through the grain bed | 20 |
| Malter shall allow ample temperature adjustment of air | 20 |
| Malter shall allow for air flow recirculation | 15 |
| Malter shall be easy to load and unload barley | 10 |
| Malter shall be portable | 10 |
| Malter shall handle 200-300lbs of barley per run | 15 |
| Construction and testing of the malter shall not cost more than $10,000 | 10 |
| Total (250 possible) | 250 |

# EXISTING DESIGNS, DEVICES, AND METHODS

## System Level

Malting has not significantly changed for a very long time. The process has become more automated and precise, but the fundamentals remain the same. It is possible to malt barley by hand, though the results would likely not pass quality standards for large breweries. The current system that the Oregon State Food Science department is using to malt barley is not the most effective. They have been using several pieces of food processing equipment that gets the job done, though the equipment was not designed for this particular use. Due to this, a system level discussion of the current process will be included here. Also included will be a pilot malter that is available for purchase, as well as the process followed by Great Western Malting, a large commercial malting company.

### Design, Device, or Method #1

Currently the food science department is using several different pieces of equipment in the pilot brewery to produce malted barley. First they steep in a brewing kettle, germinate in second vessel equipped with a ribbon mixer, then finally they are kilning in a dehydrator that they can reset to perform the task. With relation to the customer requirements the current system falls short in several places. The tank used to steep may allow for washing of the barley, though it may not have a simple way to remove the chaff and dirt. It does steep and couch the barley and allows for control of water temperature. It does not aerate the steeping barley, so there is a risk of death to the barley. When it comes to germination, the barley first has to be moved to another vessel. While there, the germination temperature is uncontrolled, unless someone sprays or dumps water on it by hand. The ribbon mixer likely works well when preventing matting among the germinating grains though it may subject the grain to unnecessary rough handling. After that, another move of the barley from one tool to the next is required. There the grain can be dried. The equipment currently being used for this allows for some control of air temp and flow but it does not meet all of the customer requirements. Lastly, due to the number of different pieces of equipment used in the process, it is not portable.

### Design, Device, or Method #2

Schmidt-Seeger currently sells pilot malting units. These are designed to handle 1500 to 1800 pounds of finished barley malt (www.schmidt-seeger.com). This is a larger batch than the customer requirements indicate. The pilot malting unit can be set up to run automatically or manually. This unit allows for water temperature control during the steeping stage, as well as aeration control during both the steep and germination stages. Augers are used to turn the barley during germination, much in the same way Great Western Malting does. The largest problems with the customer requirements that this pilot malting unit has is that it produces much more malted barley than needed, it is not portable, and it likely exceeds the project budget.

### Design, Device, or Method #3

Great Western Malting Co. is a large commercial malting company located in Vancouver, WA. They produce batches of malt that range from 140,000 to 300,000 pounds. At Great Western they perform the same process that both the Food Science department and the Schmidt-Seeger unit do. Their focus is on solving different problems though because they are making such large batches of malt. Uniformity is the goal. There are kilning beds, for example, that are so large that the air temperature from one end of the kilning bed to the other can have as much as ten degrees Fahrenheit difference. With regard to our customer requirements, many of them were developed with information gathered from the help of professionals from Great Western Malting. Similar discrepancies between the pilot malting unit sold by Schmidt-Seeger and our customer requirements show up with Great Westerns design. Theirs is a large factory which is neither portable nor within our budget. We also require a much smaller batch size.

## Component Level

Malting barley involves a number of key steps. For this device to produce malted barley and satisfy the customer requirements it must be able to do a number of things. First is must steep the barley. Then it must turn the barley while it germinates. Finally, after it has been dried it then has to be unloaded so that the pilot brewery can use it for suitability testing.

[Include in Background Report and all subsequent documents]

### Component #1

Steeping is an integral component in the production of barley malt. It is necessary to raise the moisture content of the grain to around 45% to initiate germination. This is commonly done by periods of immersion and couching or sitting without water. The couching has been found to speed up the steeping process because it allows for respiration to take place within the grain. Respiration then lets the barley absorb more water the next time it is immersed.

### Design, Device or Method #1

Flat bottom steeping is much as the name implies. Either a rectangular or circular vessel that has a flat bottom is repeatedly flooded and drained with water. These vessels can either have a lid or not. If they do they also require a CO2 removal system. If open topped, the ambient air dilutes the CO2 produced from respiration. These vessels can be aerated in a number of ways. Commonly, aeration nozzles are placed evenly about the floor of the vessel. As long as there is some sort of temperature control on the steeping water this would satisfy all of our customer requirements that involve steeping.

### Design, Device or Method #2

Great Western Malting uses steeping vessels that are essentially large cylindrical tubes with funnel shaped bottoms. This allows them to load and unload the barley much more easily than a flat bottom steeping vessel by pumping the barley in and out through the funnel at the bottom. The aeration nozzles are placed in concentric rings around the funnel. They can pump water into and out of the vessel as well as remove CO2. With the temperature control on the water inlet this design also satisfies all of the steeping customer requirements. The problem with this design is that it would likely require a separate steeping container, which would eliminate the portability of the device.

### Design, Device or Method #3

Another steeping technique is to spray water over the grain with a freely draining bottom. Respiration is constant with this method but there are problems with uniform moisture gain. The barley on top will receive more water than the barley near the bottom. This could potentially be a large problem with commercial production because of the sheer size of the batches produced. With the batch sizes associated with this project it would seem that this problem would not be much of an issue, if at all. Aeration would not be a problem with this design so those customer requirements would be satisfied. A simple control of the water temperature being sprayed on the grain would control the steep temperature, as well as potentially allowing for control of the germination phase as well. Furthermore this method would not require a separate vessel, thus not affecting the potential for a portable device.

### Component #2

During the germination phase the barley begins to grow rootlets. If let to sit, these rootlets will get longer and begin to mesh together. The grain will then be unable to dry properly which will produce inferior malt. To prevent this, the grain is turned, mixed, or tumbled every eight hours.

### Design, Device or Method #1

Barley malt, until around the 1940’s was turned by hand. Around then, malters began using automatic devices for preventing matting. Hand turning does technically satisfy the customer requirements and would be the easiest to implement. The problem with that design is that the barley must be turned about once every eight hours. This means hiring someone, or having a student be responsible for turning the grain. It can be done with a shovel or other hand tool. This design is not ideal, due to the fact that the barley may need to be turned at inconvenient times of day and forgetting to perform this duty could ruin the batch.

### Design, Device or Method #2

The germination beds at Great Western Malting, as well as the pilot malter sold by Schmidt-Seeger use augers to turn the barley. Both of these designs boast a series of augers in a line parallel to the length of the bed (Figure 1). These lines of augers then move back and forth the length of the bed on tracks, turning the barley every eight hours. These augers move slowly to limit damage inflicted on the grain by handling. This design has proven successful by industry and does satisfy the customer requirement regarding turning of the barley.



Figure 1 – A germination bed in the process of turning barley to prevent matting using a series of parallel augers that move up and down the bed on tracks. (www.mopos.com)

### Design, Device or Method #3

Disc ploughs are used across the country to prepare fields for planting. Disc ploughs work by dragging a series of sections of concaved discs. They are arranged offset from one another to allow them to pickup and turn the soil they are being used on. A similar device might be used to turn the grain. This would satisfy the customer requirement. One potential problem with this is that the discs may be too rough with the grain, thus damaging it and adversely affecting the quality.

### Component #3

The malted barley has to be removed from the mini malter in order to be useful for brewing. This process will depend on the design of the vessel, but some methods will apply regardless of the shape.

### Design, Device or Method #1

Similar to the turning of the malt, this process could be done by hand. One or two people with shovels could unload 200 to 300 pounds of malt though this would be very labor intensive. Unloading by hand would also take significantly longer than automatic methods. This does not satisfy the customer requirement of being easy to load and unload. On the other hand, it would not require any special designs, nor would it cost anything to implement. This method would also eliminate the chance of mechanical failure.

### Design, Device or Method #2

At Great Western Malting they are producing batches of a size that makes unloading by hand unfeasible. Instead they have a system that lowers a beam into the grain on one end of the kilning bed. A winch is then attached to that beam and the grain is scraped off one layer at a time. With the amount of barley this project is designed for, it would only take one run of a similar method to empty our device of grain. This would meet the customer requirement of being easy to unload in that it requires little physical labor, and is not very technologically complicated.

### Design, Device or Method #3

A third method of unloading the grain would be to design something similar to a dump truck. If one wall or section of a wall was capable of being lowered or opened, the bed could then be tipped up and the grain emptied. This satisfies the requirement of being easy to unload. This design would have more points of failure, but would also require the least amount of effort.

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