

# Simulating commercial malting conditions with an advanced pilot-malting system

YUESHU LI (1), MICHAEL EDNEY (2), MICHAEL BROPHY (3) & RICHARD LEACH (1)

## ABSTRACT

The Canadian Malting Barley Technical Centre (CMBTC) in Winnipeg, Canada, has installed a sophisticated and automated pilot-scale malting system. The system was designed to produce malt of commercial quality while retaining the flexibility required by researchers and marketers to do applied research work, to evaluate new barley varieties, to be a demonstration and education facility for customers and clients and to develop new products for malting, brewing and food industries. Consultation with malting experts from around the world resulted in a system with many novel features. The system is composed of both a three-vessel malting unit and a single-vessel malting unit. The three-vessel system consists of a separate steep tank, germination tank and kiln while the single-vessel unit performs steeping, germination and kilning in the same vessel. All of the vessels are cylindrical and are designed to hold a maximum of 100 kg of barley with a bed depth of 1.2 metres and an inside diameter of 0.5 metres. The design allows for accurate replication of commercial malting conditions. The germination vessel and the single-vessel are equipped with centre-pivoted augers to provide for the turning of germinating grain. All vessels are equipped with sensors for temperature, humidity, oxygen and carbon dioxide. Sensors are connected to a data acquisition system to allow for continual monitoring of malting conditions. The system was designed with the help of Heavy Duty Products of Cambridge, Ontario who also manufactured the system.

- 1 Canadian Malting Barley Technical Centre, 1365-303 Main St., Winnipeg, Canada, R3C 3G7
- 2 Grain Research Laboratory, Canadian Grain Commission, 1401-303 Main St., Winnipeg, Canada R3C 3G8
- 3 Canadian Wheat Board, Box 816 Station M, Winnipeg, Canada R3C 2P5

## INTRODUCTION

Micro-scale malting facilities have been widely used by malting companies, barley breeders and research institutes related to malting and brewing research as a cost-effective procedure to assess the malting performance of the barley being tested. However, the results can only be used as a guideline since in most cases the quality of the malt produced from these facilities cannot match the quality of commercial malt, and the processing conditions used by the micro-scale facilities cannot simulate the malting conditions in a commercial malthouse satisfactorily. At the CMBTC we need a facility that is capable of producing different types of malt of commercial quality while closely simulating commercial malting conditions. The facility must also retain the flexibility required by researchers and marketers to do applied research work, to evaluate new barley varieties and to develop new products for the malting, brewing and food industries. By combining our expectations and our consultations with malting experts from around the world, we developed the concept and specs of the pilot-malting system in conjunction with Heavy Duty Products of Cambridge, Ontario who designed and manufactured this system for us.

## THE PILOT MALTING SYSTEM

The malting system (Fig. 1) at CMBTC comprises a steep unit, a germination unit, a kiln unit and a single-vessel unit (SGK unit). The batch size of the pilot malting system can be set for a batch of 50 kg to 100 kg of cleaned barley. All the vessels are made with food grade stainless steel and insulated with fibreglass wool.

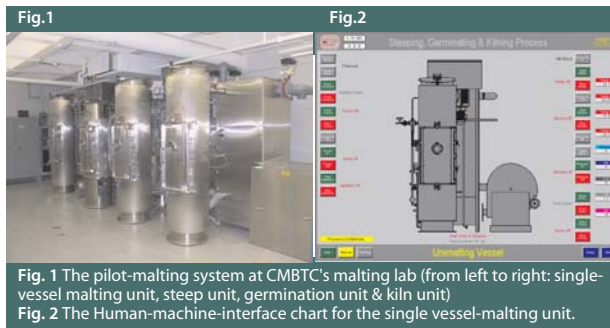


Fig. 1 The pilot-malting system at CMBTC's malting lab (from left to right: single-vessel malting unit, steep unit, germination unit & kiln unit)

Fig. 2 The Human-machine-interface chart for the single vessel-malting unit.

## STEEP UNIT

This unit is a stainless steel cylindrical-conical vessel equipped with water spray, aeration, CO<sub>2</sub> removal, water level and overflow control devices. These devices are arranged in a way which creates steeping conditions similar to a commercial steeping tank. Both water and air temperatures are regulated. Water level in the steep unit can be set for a full batch size or a half batch size. In addition, CO<sub>2</sub> removal is carried out by either suction or by compressed air push.

## GERMINATION UNIT

This unit is a circular stainless steel vessel with a perforated floor equipped with a water spray nozzle and a centre-pivoted auger. The maximum grain bed depth is 1.2 m. The germination fan and the auger are driven by variable speed motors. Airflow, air temperature and the turning speed and frequency of auger turning and water-spray can be programmed to simulate the germination conditions in a commercial malthouse. In addition, air flow during germination can be conducted in either downdraft or updraft mode.

## KILN UNIT

This unit is a circular stainless steel vessel with a perforated floor equipped with an electrical heater and variable speed fan, which provide a wide range of temperatures and airflow to precisely simulate the kilning conditions of a commercial malthouse. The maximum grain bed depth is 1.2 m. The exhaust air can be recirculated, and its portion can be adjusted according to the requirements of the processing conditions.

## SINGLE-VESSEL MALTING UNIT

This unit is also a circular stainless steel vessel like the germination vessel. It is equipped with all the devices for steep, germination and kilning. Basically it has all the functions of the above three units combined. Among the unique features of this unit is the elimination of the need to transfer barley from the steep unit to the germination unit to the kiln unit. At steep stage the unit functions as a flat bottom steep tank. The batch size of this unit is the same as the three-vessel unit, processing from 50 kg to 100 kg of barley.

## AUTOMATION AND CONTROL

The pilot malting plant is controlled by Allen-Bradley PLC and Cimplicity automation software. This system provides various displays such as real-time control and monitor screens and trend charts. The processing recipes can be easily set up, and stored for future use. Processing conditions can be easily modified even while the system is executing a recipe. The malting process can also be monitored and controlled remotely via the Internet. All the operations can be carried out automatically except for barley transfers between the vessels. An example of the Human-machine-interface chart is provided in Fig. 2. The parameters for monitoring and controlling processing conditions are listed in Table 1.

Table 1. The parameters monitored for processing control

Parameters	Single-vessel malting unit	Steep unit	Germination unit	Kiln unit
Water temperature	YES	YES	YES	NO
Air on and air off temperature	YES	YES	YES	YES
Grain temperatures	YES	YES	YES	YES
Relative humidity	YES	YES	YES	YES
pH of steep water	YES	YES	NO	NO
Dissolved O <sub>2</sub> content	YES	YES	NO	NO
Oxygen content	YES	YES	YES	YES
CO <sub>2</sub> content	YES	NO	YES	YES
Recirculation air ratio	YES	NO	YES	YES

## MALTING TRIAL RESULTS

The pilot-malting system was found to be capable of producing commercial quality malt. The pilot-malting system was compared to a commercial malthouse by malting the same commercial barley sample in both plants using the same processing conditions. The quality of the malts produced was similar (Table 2) indicating that the pilot-malting system can simulate commercial processing conditions and produce malt with commercial quality.

Table 2. Quality comparison of malts produced from the pilot-malting trials and commercial production (2000 crop)

Analysis	Manley Commercial*	Manley Pilot-malting	Harrington Pilot-malting**
Moisture, %	4.2	4.2	4.1
Fine extract, % d.b.	81.9	81.4	79.5
Coarse extract, % d.b.	80.5	80.0	78.8
F-C Difference, % d.b.	1.4	1.4	0.7
Diastatic power, ASBC	130	130	137
Alpha-amylase, D.U.	58.0	59.0	56.5
Wort viscosity	1.42	1.42	1.42
Malt protein, % d.b.	11.4	11.3	12.8
Soluble protein, % d.b.	5.0	5.11	5.40
S/T ratio, %	43.9	45.2	42.1
Beta-Glucan, ppm	106	110	78
Friability, %	89.0	88.0	90.2

\* Average of five production batches with the same lot of barley used for pilot malting trials  
 \*\* Malt extract is lower than commercial malt because the barley sample used in the trials has higher protein content.

## CONCLUSIONS

A pilot malting system has been developed which is able to simulate commercial-scale processing conditions and to produce malt of commercial quality. The versatile control and monitoring capacity equipped with this malting system enable it to carry out applied research and new product development at the CMBTC. The test results indicated that the quality of the test malt correspond well to the quality of commercial malt. The flexibility in control and data acquisition built in the pilot-malting system will allow us to do applied research work and to develop new products for customers and clients in malting, brewing and food industries.

