Compost Heat Capture

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Motivation
In 2012 the EPA reported 251 million tons of trash were produced in the United States. They state 20-30% of this is compostable. Capturing the heat from 20% of the trash produced in 2012 would equal 12% of the energy used for household water heating in 2009 [EPA].

Objective: Design and implement a residential-scale compost heat recovery system which produces high-quality finished compost.

Customer: Wasatch Community Garden’s Green Team Farm

Methods

Theoretical Model:
- Optimize system i.e. maximize the amount of heat captured.
- Function of heat exchanger layout, tube diameter and length, container volume, flow rate and head loss.
- Estimated 85.4 kJ/(hr-kg of compost).

Assumptions:
- Constant surface temperature, laminar flow, free convection from long cylinder.

Prototype:
- #Tubes = 4 passes, Flow Rate = 0.5 L/min, Tube Size = 1/4” Dia.

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Final Design

Electrical:
- Monitor and record temperature profile.
- Autonomous water pump and valves.

Components:
- Arduino MEGA 2560,
- 2 valves, 1 pump, 15 temperature sensors, an LCD screen and a flow sensor.

Power:
- 120 Ah battery and 100 W solar panel providing off grid power.

Mechanical:
- (2) 0.63 m³ tumblers each with independent heat exchangers.
- 4 tubes with 4 passes per tube in each exchanger minimizing pump work/maximizing heat capture.
- Two tumblers alternating compost input ensuring active compost.

Prototype:
- 1) Heat captured from compost pile = 69.6 kJ/hr-kg compost)
- 43% efficient.
- 2) Unevenly mixed, nearly finished compost cooled down prematurely.

Interpretations
- 1) Increase insulation thickness - R-value
- 2) Increase composter capacity, organized heat exchanger.
- 3) Centralize heat exchanger in the compost.

Conclusion:
- All metrics were met as shown in the metrics table.
- Compost is a reliable off grid heat source.
- Practical for winter farm heating uses: greenhouse, vegetable/fruit seeds.

Further improvements of system:
1) Forced aeration with heat exchanger would capture heat from exiting air.
2) Automated humidity control would maximize heat generation.
3) Automated tumbling motor would increase efficiency.

Funding was provided by the Sustainable Campus Initiative Fund.