IRRI-Hohenheim-NLU Automatic Downdraft Rice Husk Furnace

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Overview

- Trends in rice postharvest systems
- Rice husk as energy source and existing furnaces
- Rice husk furnace development
  - Design specifications
  - First prototypes for low-temperature drying
  - Adaptive R&D in Vietnam for heated air drying
  - Adaptive R&D in the Philippines
- Conclusions

Trends

- Quantitative and qualitative **postharvest losses** combined reach 30-50% at market
- Consumers become more **quality conscious**
- Better quality –> need to **use mechanical dryers** to replace sun drying
- Increasing prices for **fossil fuels** (doubled in Indonesia in 2005)
- **CO_2 emissions** contribute to global climate change
- Carbonized rice hull (CRH) – market as soil conditioner

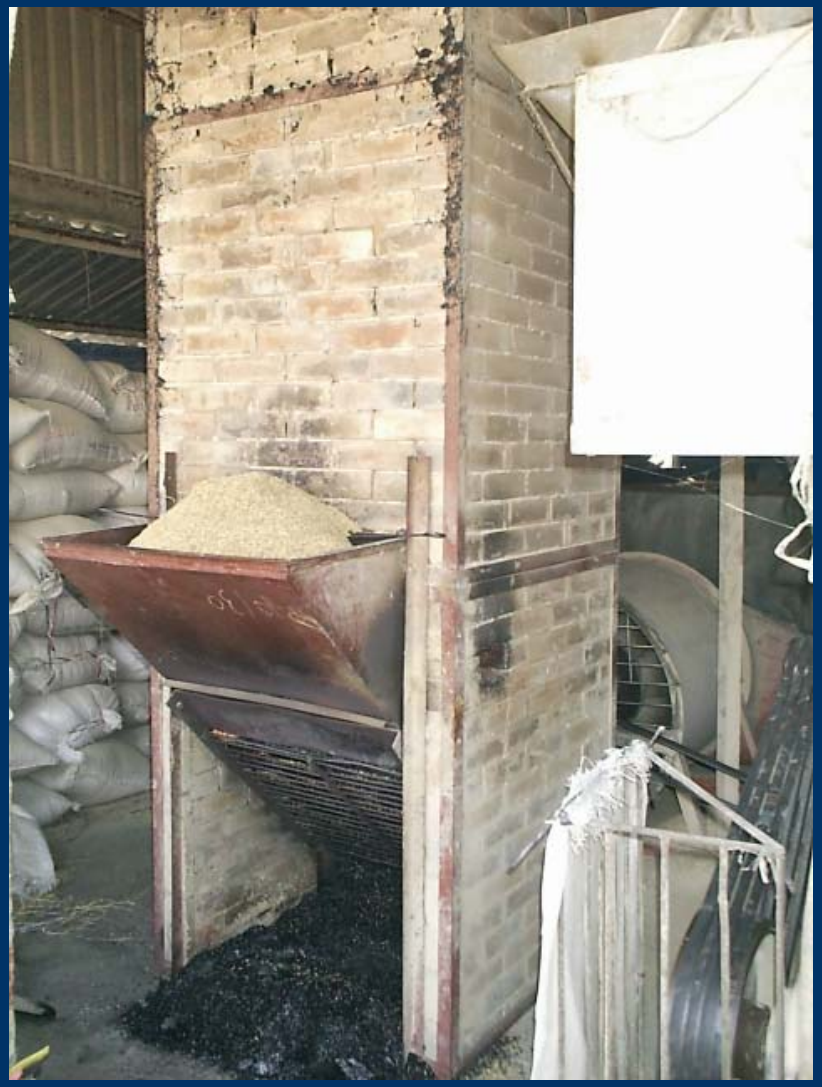
Rice husk as energy source

- Potential
  - Calorific value: 11-15.3 MJ/kg
  - Philippines: 2.8 million t = 930,000 l of kerosene
- Problem as fuel
  - Low bulk density: 70-140 kg/m³; 180kg/m³ as pellets
  - Transport over longer distance uneconomical

- Free of charge at rice mills, could reduce energy cost up to 95% (Braunbeck)

Problems with existing furnaces

- Bridging and clogging
- Small scale furnaces are labor intensive
- Automated furnace are expensive
- Uneven feed rate / temperature
- Fly ash
- Heat exchanger to prevent fly ash?
  - Expensive
  - Lower efficiency
  - Uncontrolled combustion



Furnace development history

- GTZ funded IRRI-UAF Postharvest Project 1993-1997
  - Small scale furnace for low temperature drying
- Vietnam 1998
  - Verification with a 2t low-temperature dryer
- Vietnam 2001 and Philippines 2004
  - Adaptation to heated air drying
  - Focus on dryers that are commercially accepted

Commercial dryer?

Farm level dryer

- Cheap
- Simple heat sources

Service providers

- Usually flat bed dryers
- 4t/batch capacity

Commercial level

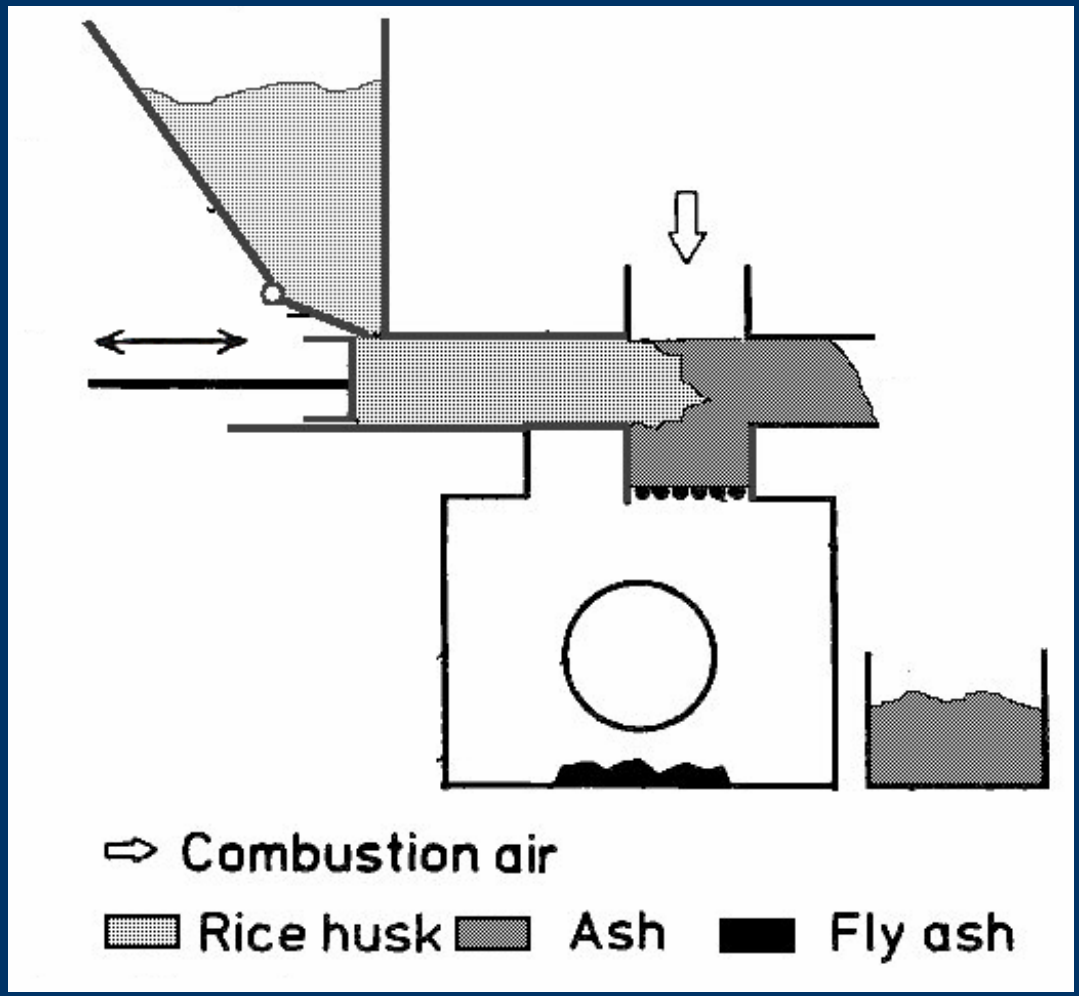
- Re-circulating batch dryers 4-10t/batch
- Continuous flow dryers

Design specs

- Using locally available materials
- Temperature rise 6°C - 15°C
- Automatic feeding (4 hours)
- Smokeless operation, low CO emissions
- Forced convection for controlled burning
- Easy ignition
- Automatic ash removal
- Safe and easy operation
- Low capital and running cost

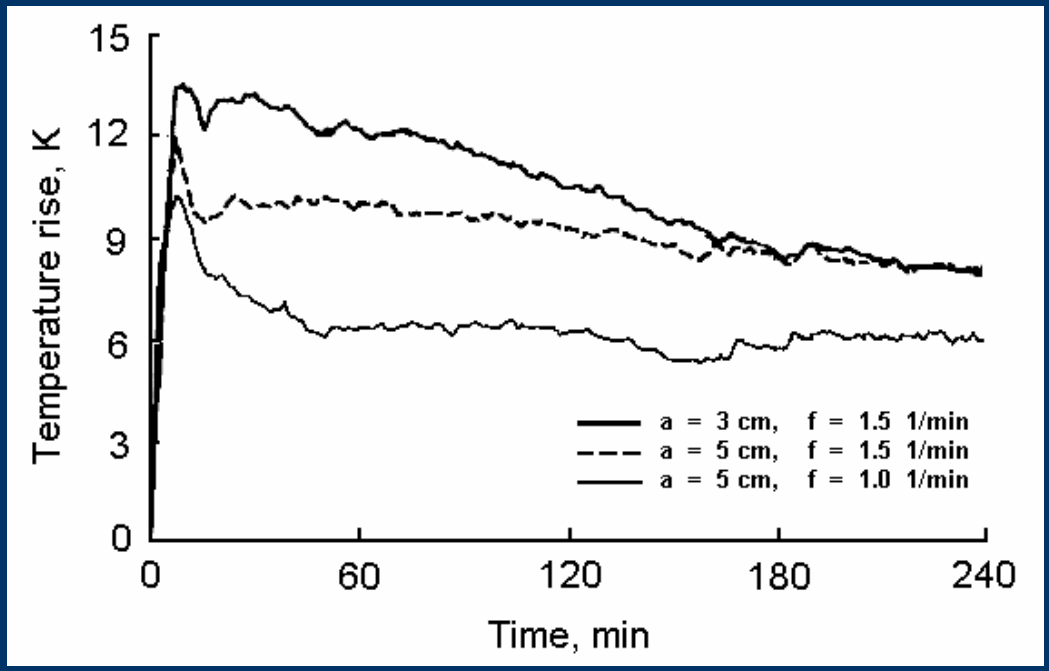
Furnace principle

- Automatic feeding system
- Controlled and clean combustion
- Even heat transfer
- Ash separation
- Automatic ash removal



Performance of the Hohenheim Prototype

- 8 hour continuous operation
- Designed for a 6t low temperature dryer
- Thermal output 9-17 kW (10kW constant)
- Rice hull consumption 2.6-5.7 kg/h
- Combustion efficiency 99%
- Furnace efficiency 70%

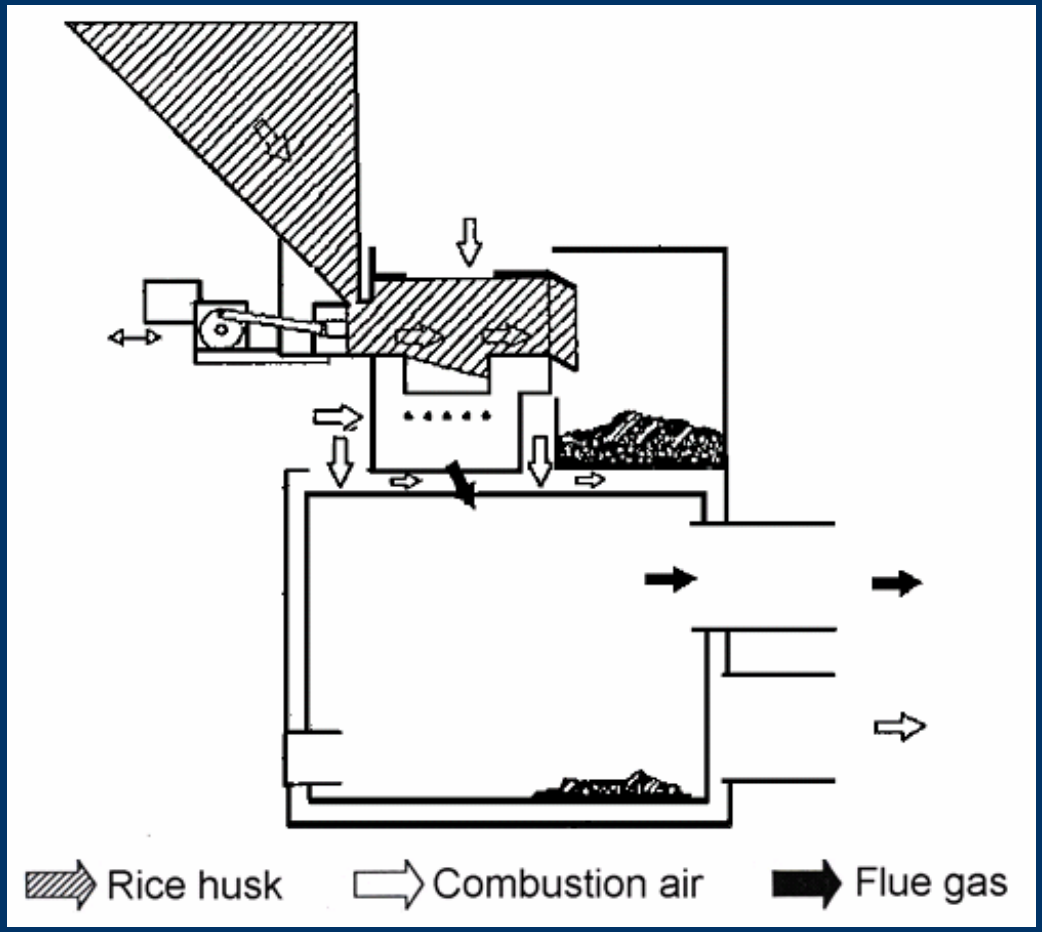


Temperature rise of the drying air in long-term operation at different piston strokes (a) and frequencies (b) (Braunbeck 1998).

Compression of husk and ash !!

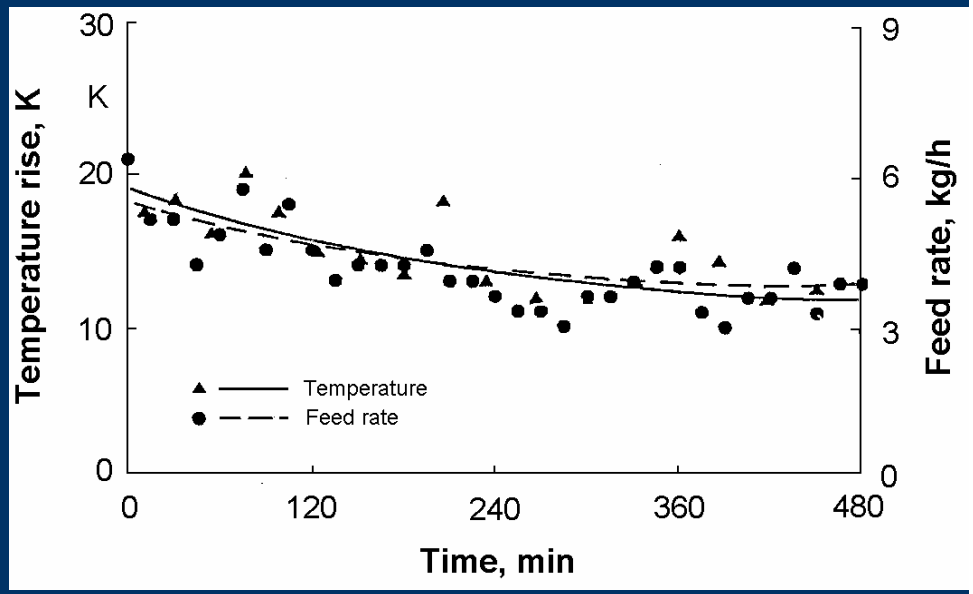
Practical evaluation in Vietnam

- Local prototype with design changes
  - Shorter feed duct
  - Double layer burning chamber
  - Declining grate



Some results

- Optimized at 50mm piston stroke and 40s feeding interval
- Temperature increase of 12K
- Feed rate / temperature drops over time despite measures to reduce friction



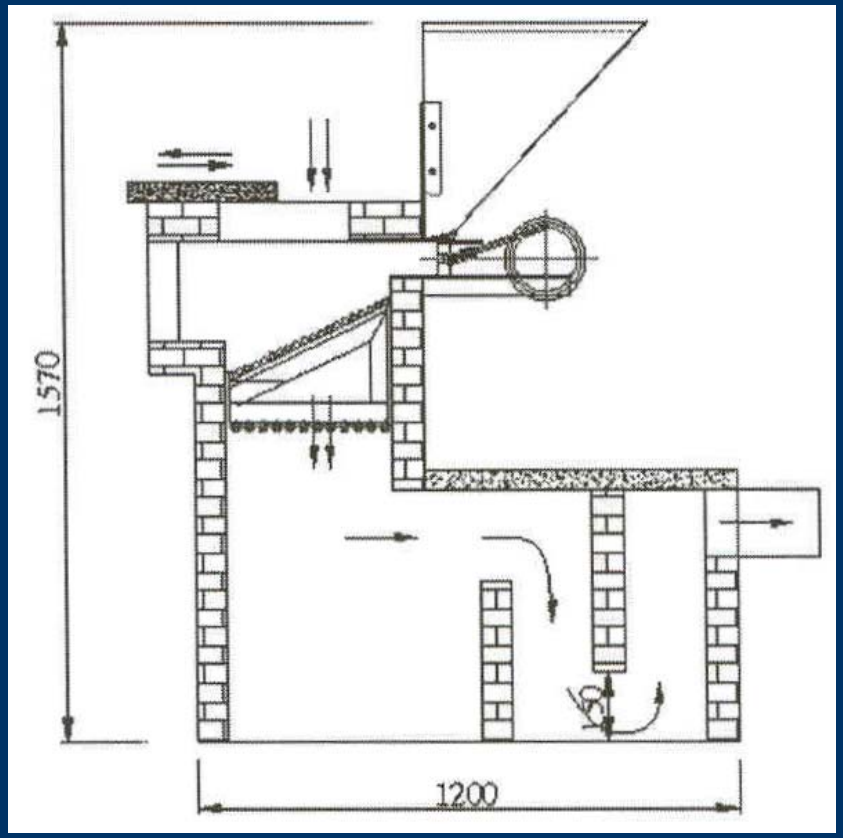
- Long term testing with Low cost dryer, 2t capacity
- 48 h drying time with
- 32 h furnace operation

Further development / Commercialization?

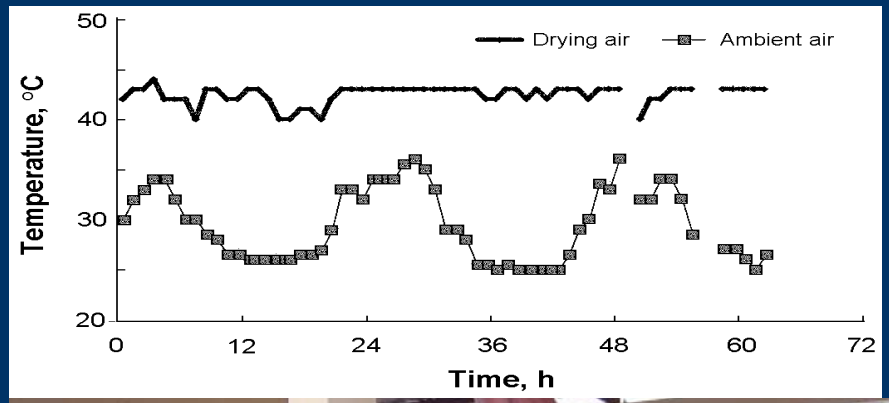
- 1997
  - IRRI-GTZ/UAF project terminates at IRRI
  - German PhD student finishes his studies and wants to start production in the Philippines but gives up
  - No further development of low temperature drying
- 2002
  - Vietnam: alternative to existing furnaces for heated air drying
- 2004
  - Philippines: Increasing fuel costs – alternatives for kerosene fired dryers

Adaptations for heated air drying Vietnam

- Increase of feed rate to 25kg for a drying air requirement of 3.1m³/s
- Simplified design
- Improved fly ash separation through baffles

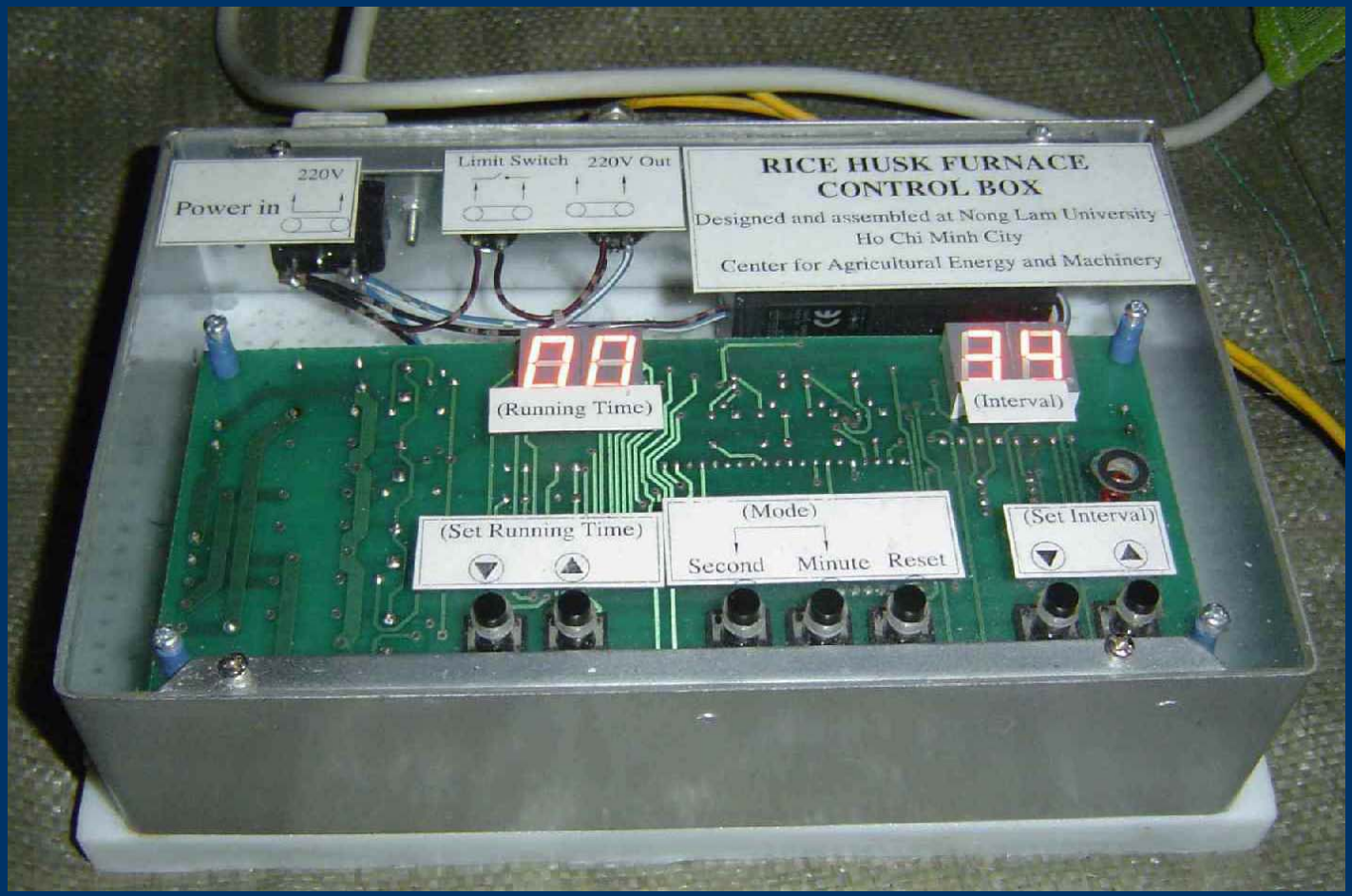


Some results



- Suitable for 4t flat bed dryer
- Furnace efficiency: 48-80%
- Installation at Tay Ninh Peanut center, 64 h drying time / batch
- Plans to deliver new furnace with new flat bed dryer installations

Electronic Controller Prototype



For easy control of the ram frequency

4t reversible airflow batch dryer

Simple drive

Next steps at NLU

- Complete a furnace for a brick kiln with 100 kg / h capacity
- Design a furnace with 50 kg/h capacity for 8t dryers
- Optimization

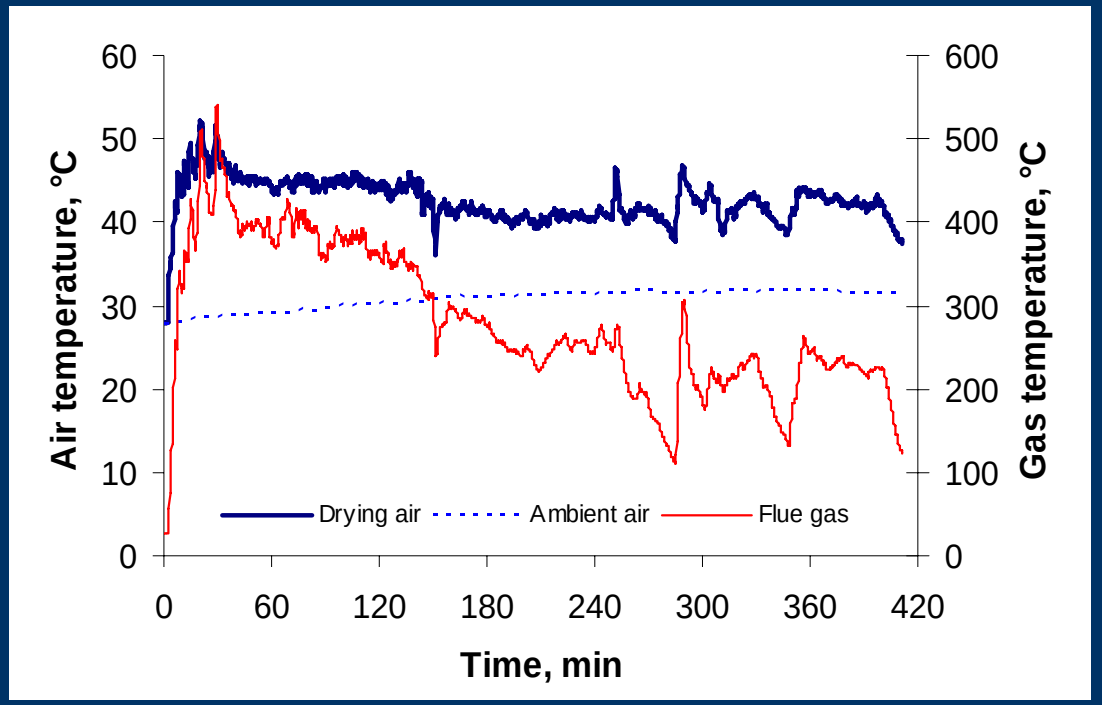
Furnace with 100 kg/h rice husk feed rate

Adaptations for heated air drying Philippines

- Mobile prototype
- Double layer burning chamber
- Reversed husk flow
- Shorter grate, reduced duct sizes (less friction)
- Declined grate
- Baffles for fly ash separation
- Analog electronic timer

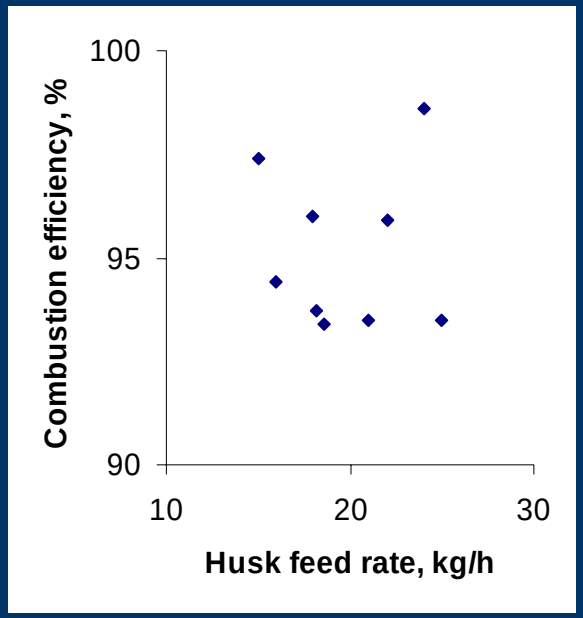
Results

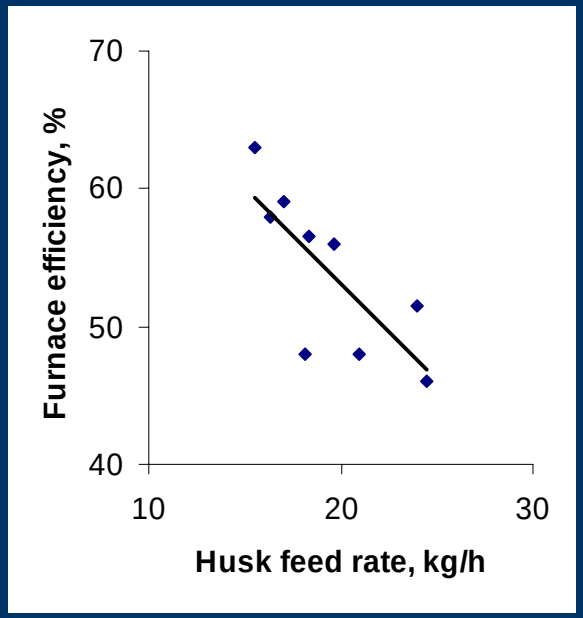
- Feasible for 4t flat bed dryer
- Furnace efficiency: 48-63%
- Combustion efficiency: 93-98%
- Even but declining feed rate

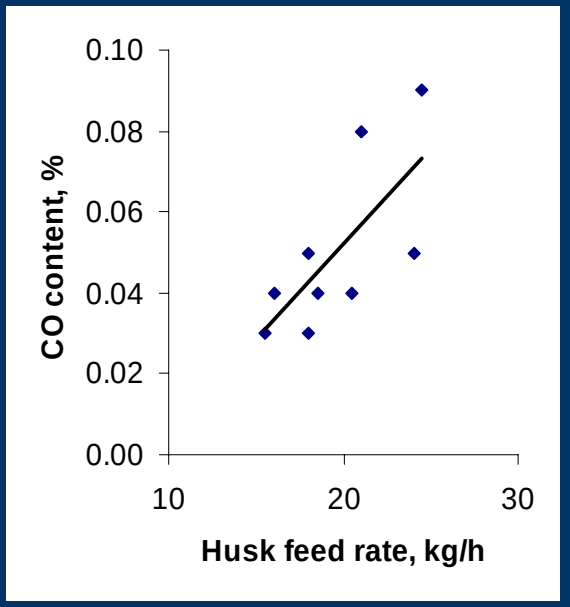


- Temperature stable (± 2.5°C), can easily be adjusted by varying the fan-furnace distance

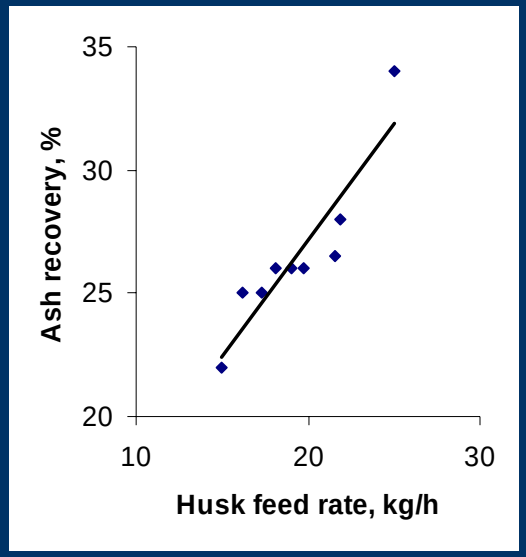
Effect of feed rate

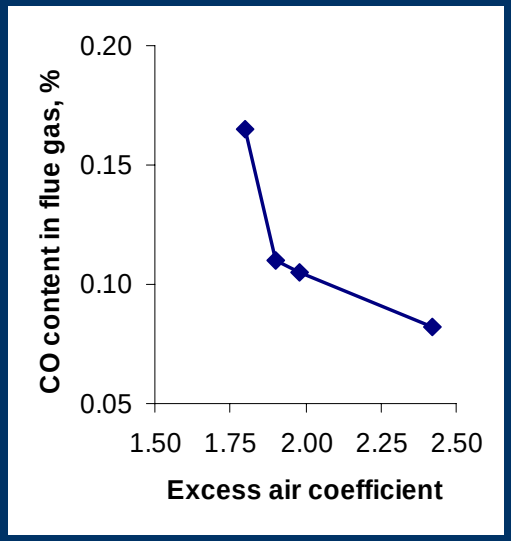






- Higher feed rate -> carbonization -> lower furnace efficiency
- Higher feed rate -> more CO, can be compensated through providing more secondary air

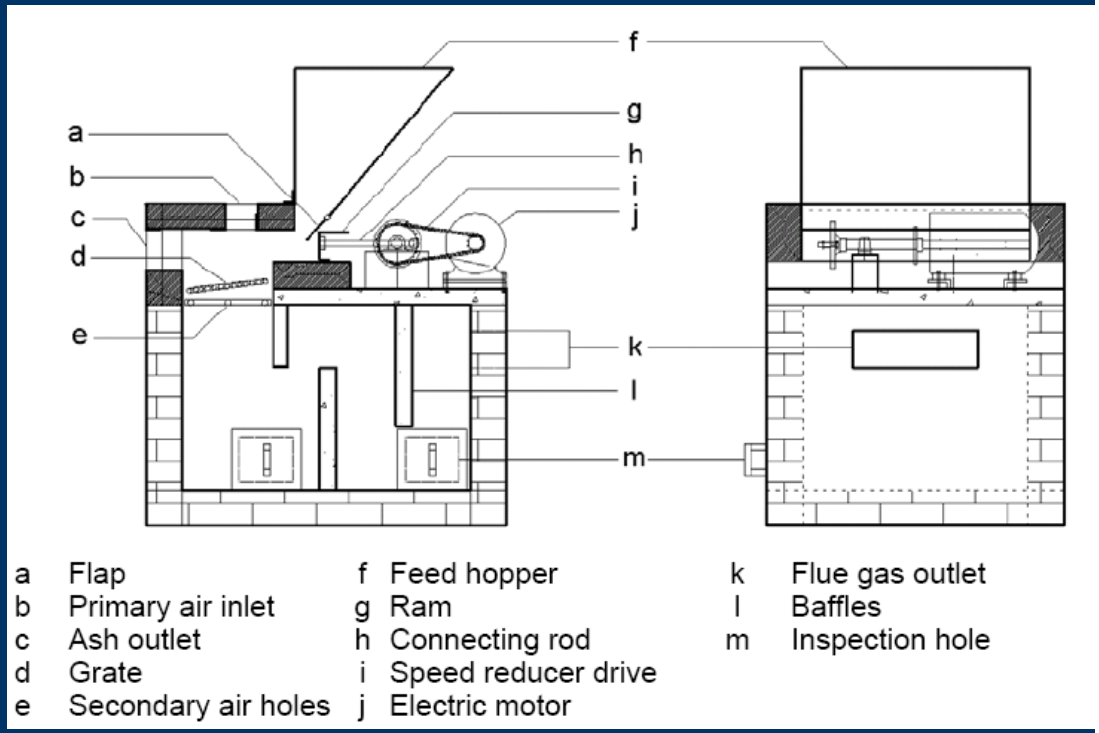




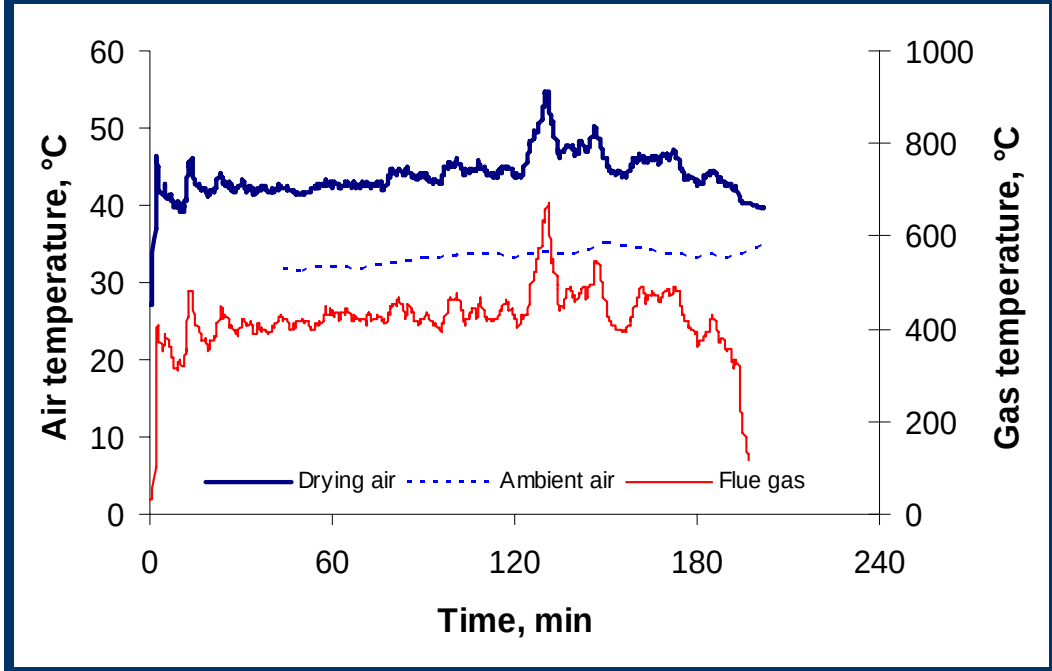
- Higher feed rate -> furnace can produce carbonized rice hull
- CO content can be minimized by providing more excess air

Production Prototype at PhilRice

- Adapted to local materials
- ‘Over-designed’ for higher feed rates to minimize compression
- Max feed rate of 28kg/h
- Increased combustion chamber volume and one additional baffle for more effective separation of fly ash



Initial Results



Peak at 130 minutes: End switch at ram dislocated

- Initially tested in the off-season, with 1.8 t of paddy (50% capacity).
- Higher airflow rate.
- Temperature rise of 11 K
- 40-second feed interval, equivalent to a
- Rice husk feed rate of 28.7 kg/h

Status as of now

- Vietnam:
  - Commercial unit for peanut drying
  - Commercial unit for 4t paddy dryer will be delivered with next dryer installation
- Philippines
  - Commercial prototype for paddy seed drying
- Other countries
  - Assessment in Myanmar

Conclusions

- Semi automatic, down draft furnace has better performance than existing small-scale rice husk furnaces. It has
  - Low labor requirement
  - More constant temperature
  - Clean burning process (low CO, no fly ash)
- From of 3–4 kg/h to a rice hull consumption of 15–36 kg/h for use with commercially available heated-air dryers with a batch capacity of around 4 tons
- The next steps include long-term evaluation and commercialization of the design
- Further up-scaling to fit larger dryers can easily be done

Further development needs

- The effect of the decreasing feed rate
  - Wet paddy can be dried with higher temperatures than dry paddy
  - Quantify whether this is a problem
- Modify electronic timer for feed-rate / temperature control
- Higher feed rates for producing CRH in the Philippines
  - Economic assessment
  - Effect on decreasing feed rate over time
- Optimizing long-term performance and durability of the components and the drive system
- Adaptation for use with re-circulating batch dryers

Thank you

- Partners
  - NLU, Vietnam
  - PhilRice, Philippines
  - Hohenheim University, Germany
  - Various students and researchers

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