NC STATE UNIVERSITY

Department of Biological and Agricultural Engineering

Two systems to reduce flue-cured tobacco production cost and TSNA formation: woodchip fired hot water systems and variable firing rate gas burners

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Overview

- Variable firing rate burner technology (VFR)
- Woody Biomass fueled hot water heating systems
- Reduce production cost
- Minimize combustion gas inside curing environment

Heat Exchangers

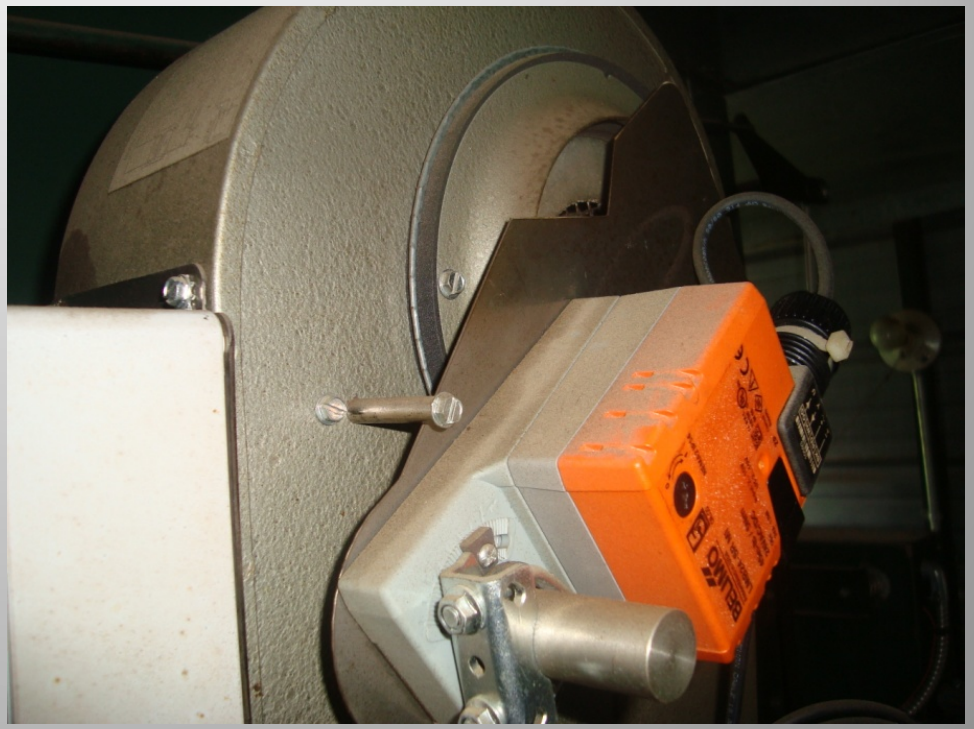
- Conversion from direct fired burners to indirect fired burners
- Thermal cycling cause material fatigue

Duty Cycle

Wayne County Average Cycle Times		
Day	On Time (min:sec)	Off Time (min:sec)
1	0:01:48	0:05:15
2	0:01:49	0:04:19
3	0:01:37	0:04:47
4	0:01:49	0:03:47
5	0:02:52	0:01:58
6	0:03:57	0:01:26
7	0:02:36	0:02:48
8	0:02:13	0:03:31
9	0:02:29	0:03:34
10	0:01:21	0:04:39

VFR Burners for Bulk Curing Barns

- Reduce the thermal cycling
- Steady-state conditions
- Increase heat exchanger efficiency



VFR Sites

- 2011 : 2 sites
  - Long / Evans / FBR
- 2012 : 2 sites
  - Long / Evans / FBR
  - Powell / DeCloet / Midco
- 2013: 3 sites
  - Long / Evans / FBR
  - Powell / DeCloet / Midco
  - Long / Breeze / Wayne HSG 400 burner

Data Collection

- Grower data sheets
- Gas meter
- Curing temperatures
- Heat exchanger temperatures
- Burner duty cycle
- Combustion air voltage control signal
- Burner gas pressure

VFR Control Programs

- Two-stage
- Variable firing rate
- Fully modulating

Results

VFR Burner Fuel Comparison Summary

Location	Nash	Wilson			Wayne		Greene
Year	2011	2011	2012	2013	2012	2013	2013
Number of Cures with VFR Burner	5	3	10	10	6	7	2
Fuel Reduction (gallons)	-197	51	-16.5	-47	167	295	0

Results

Greene County 2013 2-Stage Burner

	Time On (hours)			Number of On Cycles			
Cure	2-Stage	Automatic Controls	Manual Controls	2-Stage	Automatic Controls	Manual Controls	Cycle Reduction (%)
1	110	82	96	1,106	1,823	1,441	23
2	115	95	113	1,256	1,726	1,683	25

Results

Wayne County 2012 and 2013						
		Total Burner On Time (hours)		Number of On Cycles		
Year	Cure	Variable Firing Rate	Conventional Burner	Variable Firing Rate	Conventional Burner	Cycle Reduction (%)
2012	5			1,313	1,435	9
	6			1,981	2,124	7
2013	4	163	76	733	1,979	63
	5	128	94	575	1,823	68
	6	136	79	689	2,024	66
	7	136	88	594	2,096	72

Disadvantages

- Poor combustion at low firing rates
- Operating temperatures between 125˚F and 165˚F
- Initial cost

VFR Conclusions

- Fuel savings varied between locations
- Reduction of thermal cycling at all locations
- Best performance with fully modulating control program and small combustion chamber

Woodchip Fired Hot Water Systems

System Design

- Central boiler
  - Hot water circulated to each barn
- Woodchips
- Flue-cured tobacco production
  - Curing barns
  - Transplant greenhouse
  - Vegetable greenhouse

Data Collection

- Water temperatures
- Water flow rates
- Woodchip weights

Performance Information Summary

	Site 1 (2012)	Site 2 (2013)	Site 3 (2013)
Boiler Capacity	3.4 million Btu/hr	3.4 million Btu/hr	1 million Btu/hr per unit (2 units on site)
Number of Barns	17	18	11
Green Leaf Loading (lb/barn)	18,000	18,000 to 22,000	13,000
Cured Leaf Weight per Cure (average, lb/barn)	3000	2500	2375
Total Cures for Season	131	-	60
Total System Cost	$300,000	-	-
Fuel Type	Dry Wood Waste	Dry Wood Waste	Green Chips
Season Total Fuel Usage (ton)	250	-	216
Fuel Cost ($/ton)	$30	-	$25
Fuel Usage per Cure (ton)	1.9	2	3.6
Fuel Cost per Cure	$66*	-	$90
Fuel Cost per lb of Cured Leaf	$0.02		$0.04

***Includes electricity cost for boiler.**

Biomass Systems

- Lower cost fuel
- Eliminates gas heat exchangers in barn
- High initial investment
- Decrease payback period with increased use

Project Support

- Barnes Farming
- Mack Grady Farms
- Roy Woods Farm
- Scott Farms
- Gas Appliance Service
- Japan Tobacco International
- Suretrol Manufacturing Inc.
- Patterson Farms
- Newton Farms
- Ricky Rabon
- Philip Morris International
- NC Tobacco Research Commission

Questions