Continued Study of Sunflower Dust Properties that Contribute to Combine Fires

January 9th, 2013

NSA Research Forum

Fargo, North Dakota

Joseph Polin

Ag. & Biosystems Engineering Dept.

South Dakota State University

Brookings, South Dakota

Outline

- Introduction and Background
- Brief Review of Previous Work
- Laboratory Testing
- Results
- Conclusion

Introduction

Background

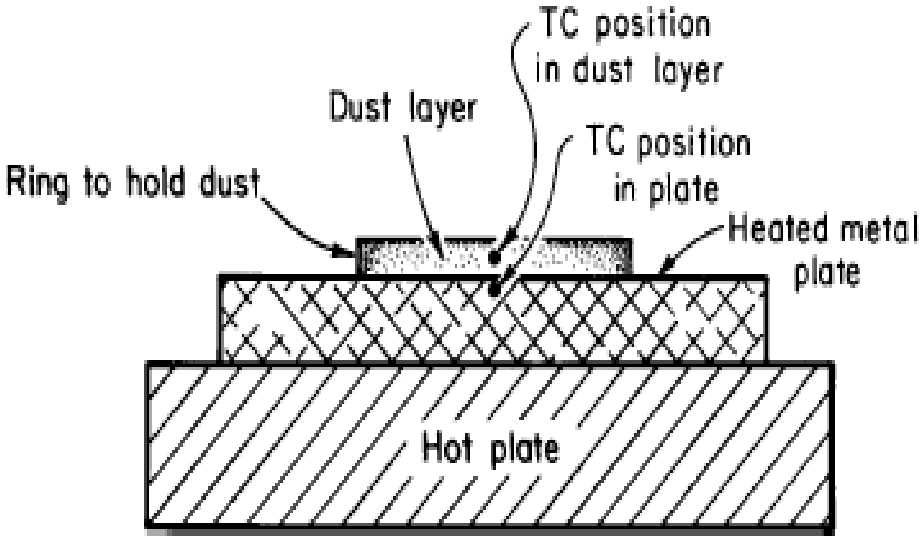
- Harvesting sunflowers lead to fires on combines
- More sunflower related fires than other crops

Project Goals

- Investigate primary ignition source
- Develop a system to help prevent fires from this source

Brief Review

- Dust layer auto-ignition point identified using a hot plate apparatus
- Auto-ignition defined as sustained combustion



Brief Review

- Sunflower dust has lower ignition point than corn stover

Mesh #	Particle Size (µm)	Corn Stover		Sunflower	
		Ignition Point (Deg. C)	Ignition Point (Deg. F)	Ignition Point (Deg. C)	Ignition Point (Deg. F)
50	710-300	320	608	290	554
100	300-150	310	590	280	536
230	150-63	310	590	280	536
500	63-25	290	554	260	500

Conclusion of Previous Work

- Sunflower dust has lower ignition points than corn stover
  - Unique physical characteristics
  - Higher surface area and porosity

- Inner stalk pith material appears to be source of field sample dust

Combustion Thermodynamics

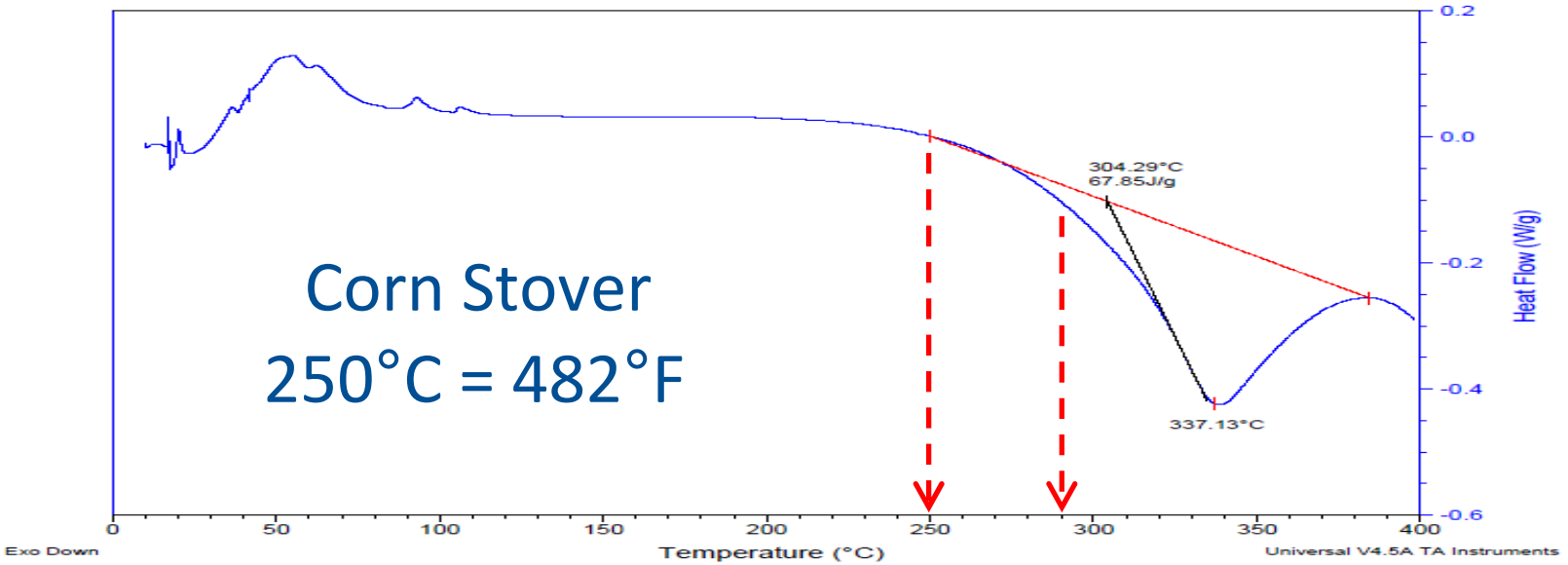
Differential Scanning Calorimeter (DSC)

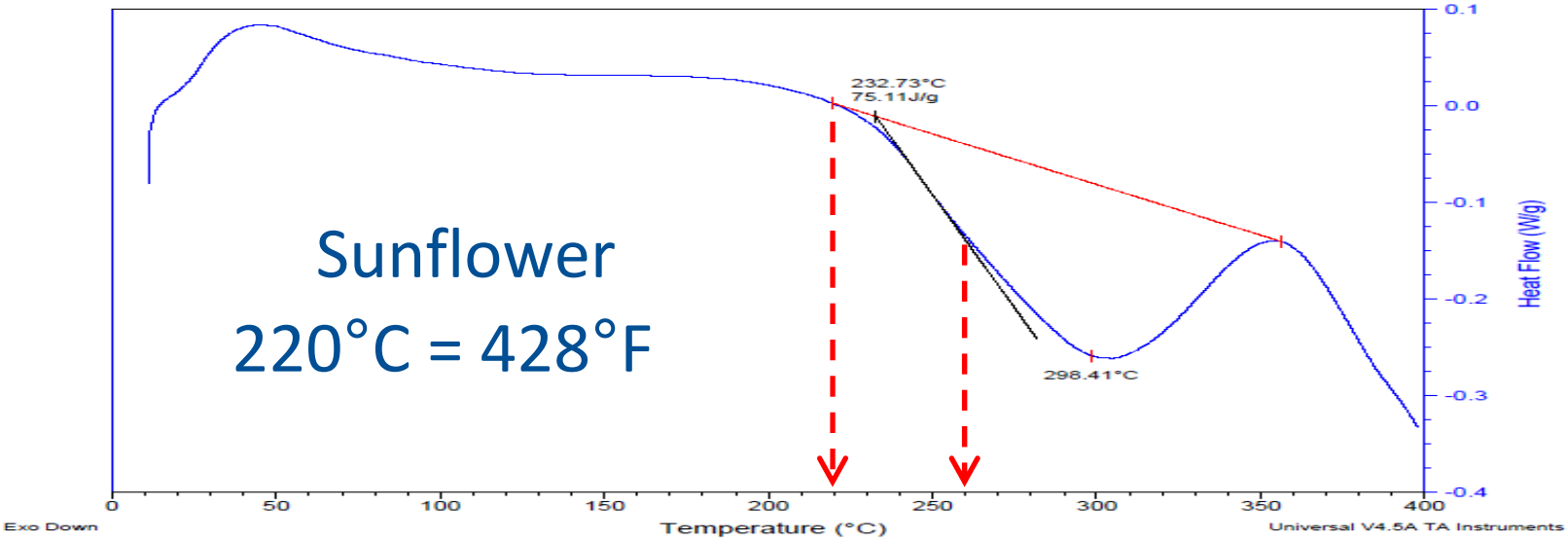
- Applies temperature ramp to analyze combustion reaction
- Monitors heat flow absorbed (endothermic) or released (exothermic) from the sample

Bomb Calorimeter

- Ignites entire sample
- Calculate heat of combustion

DSC Results


Corn Stover
250°C = 482°F
304.29°C
67.85J/g
337.13°C
Heat Flow (W/g)
Exo Down
Temperature (°C)
Universal V4.5A TA Instruments


Sunflower
220°C = 428°F
232.73°C
75.11J/g
298.41°C
Heat Flow (W/g)
Exo Down
Temperature (°C)
Universal V4.5A TA Instruments

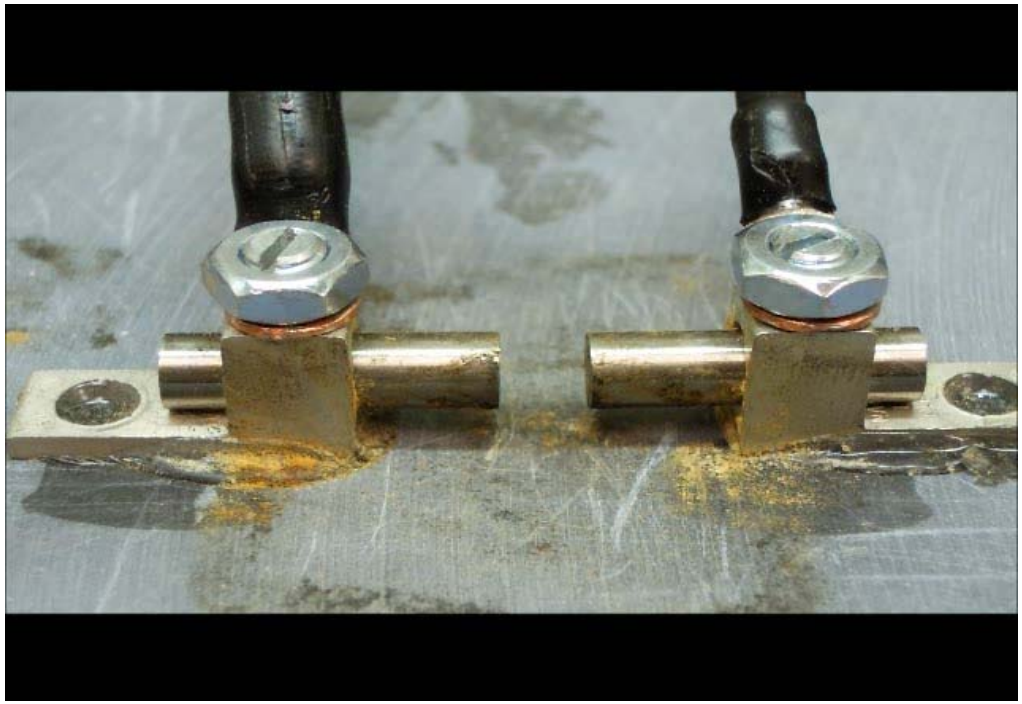
Calorimeter Results

Mesh #	Particle Size (µm)	Ignition Temp. (Deg. F)	
		Corn Stover	Sunflower
50	710-300	608	554
100	300-150	590	536
230	150-63	590	536
500	63-25	572	500
500 Mesh Samples Volatilization Temp.		482	428
Volatilization Energy (J/g)		67.85	75.11
Total Combustion Energy (kJ/g)		12.48	13.77

- Sunflower releases volatiles at a lower temperature
- Sunflower releases more energy through volatilization and total combustion

Static Spark Testing

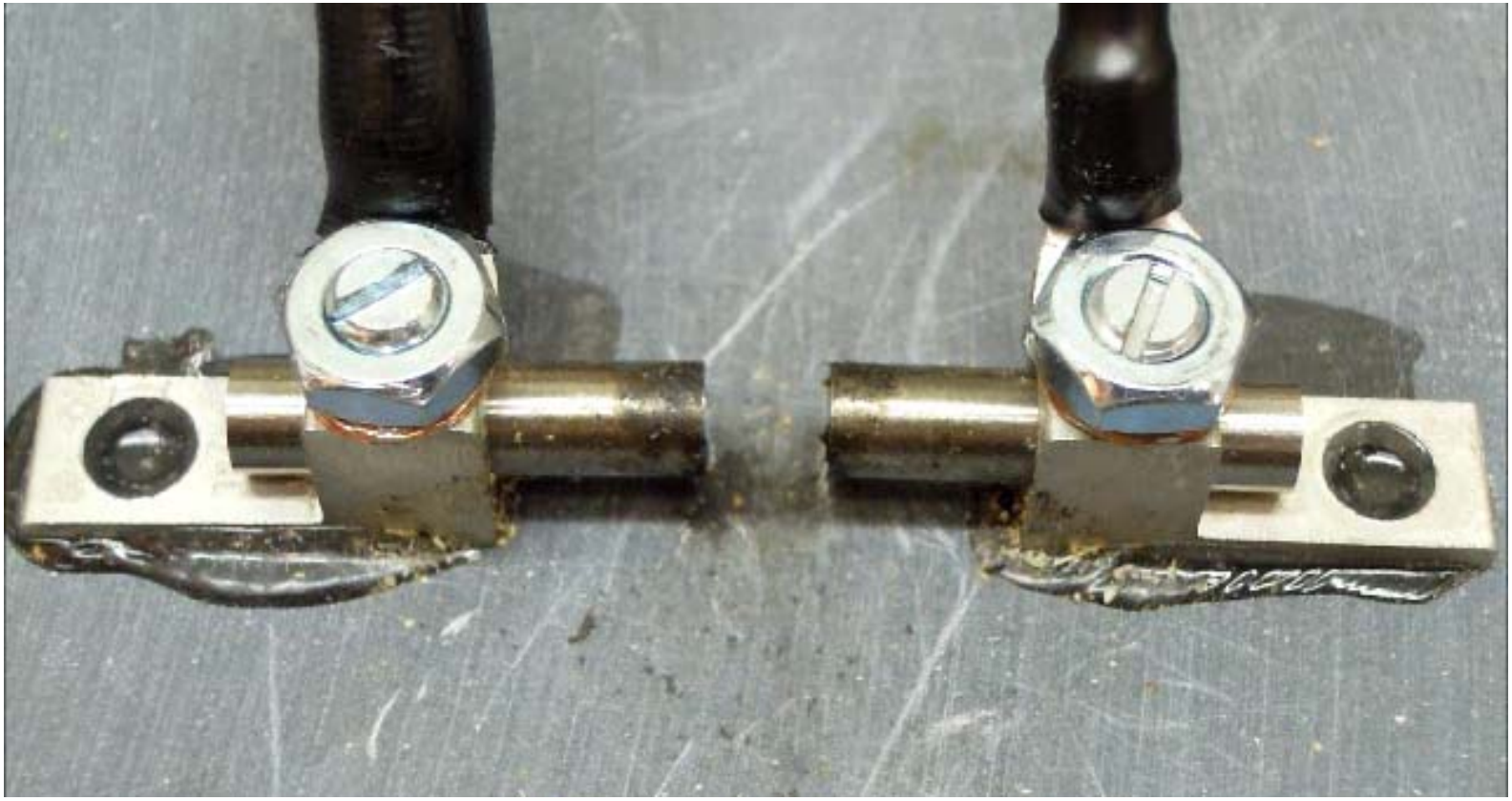
- Identify whether static electric discharge is a significant ignition source
- Experimental design is capable of various intensity and frequency



Single Sparks Dust Layer

Single Sparks Field Sample

Increased Intensity



Increased Intensity

Dust Layer Analysis

- Single static sparks aren't able to provide enough energy to start auto-ignition
- Electricity continues through charred material and extends "flame front"
- One ember is enough to start a new smolder

Dust Cloud Spark Testing

Conclusion

- Sunflower has a lower volatilization point than corn stover
- Sunflower releases more energy during volatilization and total combustion
- Single static sparks aren't able to provide enough energy to start auto-ignition
- Must prevent first initial "flying embers"

Reference from Related Research

- Dr. John Shutske at the University of Minnesota
- Estimates that over 75% of all combine fires start in the engine compartment
- http://www.extension.umn.edu/cropEnews/2006/06MNCN46.htm

Acknowledgements

- Funding Agency
  - South Dakota Oilseeds Council

- Research Team
  - Prof. Daniel Humburg
  - Prof. Zhengrong Gu
  - Mr. Kevin Dalsted

- Collaborating Farmer
  - Scott Foth

Thank You
Any Questions?