DUST CYCLONE MODELING

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Abstract

Preliminary numerical model results have yielded new insight into dust cyclone operation. If the model and its interpretation are correct, an important dynamic is air direction change abruptness. Trials will soon be conducted to validate this theory.

Introduction

Economical compliance with increasingly stringent air quality standards remains possible for cotton gins because of improvements made in dust cyclone designs. Federal, state, and industry funded research at USDA and University laboratories continues with the goal of meeting future demands of state and county air pollution regulatory agencies. Rigorous testing and independent verification has so far resulted in design recommendations that have substantially improved performance. Further improvements will be more difficult to achieve than past ones. They will require more insight into how dust cyclones work. Numerical models have advanced to the point that the complex dynamics of turbulent fluid flow can now be predicted with some accuracy. Hopefully, the understanding these models bring will help engineers further improve the performance of dust cyclones.

Model

To better understand cyclone behavior, CFX computational fluid dynamics software (AEA, 1999) was used to model streamlines in a modified 1D3D cyclone. This software allows for rapid entry of properties, boundary conditions and geometry. The configuration currently recommended (with 2D2D inlet and D/3 trash outlet, Green et al., 2000) was used. Several CPU hours on a Sun Ultraspark workstation produced a solution. The resulting graphic outputs enabled visualization of airflow. This supplements previous visualization (through windows or glass-bodied models) where air turbulence limited researchers to seeing the flow of larger particles only.

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Model Results

In the plan view of cyclone streamlines (Figure 1) air circulating in the cyclone is shown making an abrupt change in direction near the entrance, where it collides with incoming air. The fact that the air is leaving the dust behind at that point appears to be more important to cyclone efficiency than the fact that the dust is reintroduced into incoming air. This alternate approach to understanding cyclone dynamics may better explain the results of an earlier experiment attempting to prevent such reintroduction:

> The inlet helix was placed inside the cyclone cylinder and spiraled downward from a point at the top of the air inlet extending one revolution around the cyclone and ended at the bottom of the air inlet. [The] inlet helix reduced cyclone back pressure. Unfortunately, [it] also reduced collection efficiency. About three times as much trash material was lost from cyclones using [this] device as compared to an unmodified cyclone. (Baker and Stedronski, 1967).

Adding the helix prevented the re-entrainment of particles crossing the incoming air stream, but paradoxically also reduced the collection efficiency.

Planned Research

Figure 2 illustrates the CFX model prediction of airflow with the 1D3D cyclone modified to have a square inlet. The square inlet was chosen because it causes airflow to make an even more abrupt change in direction. Planned research includes testing cyclones with inlets so modified.

Summary

Without validation from actual tests, recommendations for design changes will be withheld. Even if the changes prove to be beneficial, wear patterns throughout a ginning season will be studied prior to releasing any recommendations. However, the numerical model appears consistent with observations made previously. The potential for improved understanding of air behavior in a cyclone is encouraging.

References

AEA Technology plc. 1999. CFX Computational Fluid Dynamics Software release 4.2.

Baker, R.V. and V.L. Stedronski. 1967. Collection efficiency of small diameter cyclones. The Cotton Gin and Oil Mill Press **68**(12): 7-8.

Green, J.K., P.A. Funk and G.A. Holt. 2000. Current recommendations for gin emission control. Proc. Beltwide Cotton Conferences. (in press).

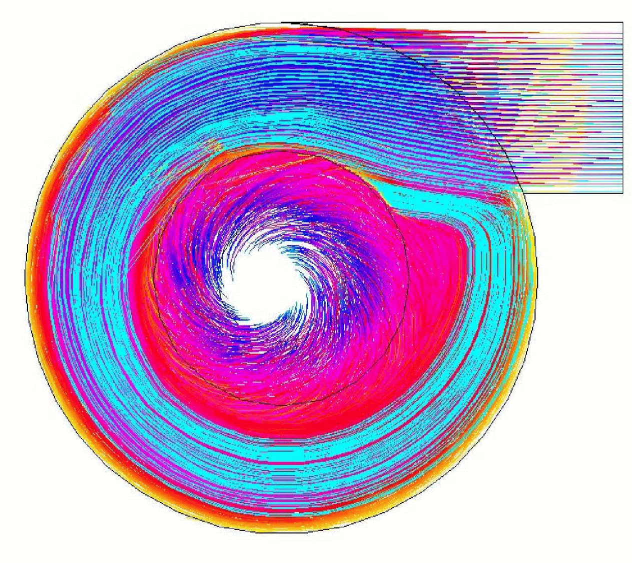

Figure 1. Plan view of CFX computational fluid dynamics model streamlines.

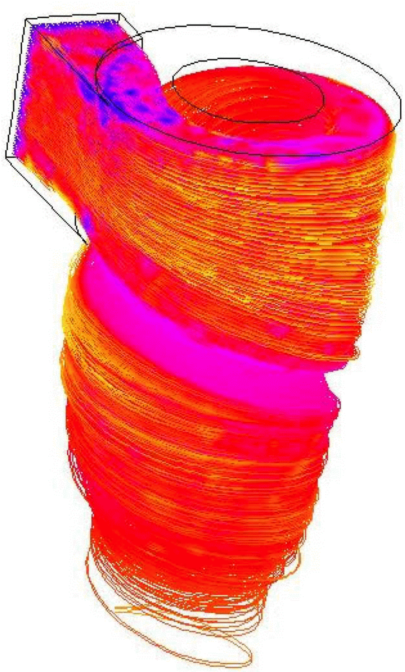

Figure 2. CFX model streamlines for a cyclone with a modified inlet.