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Visualization of Wood Dust Emission from a Circular Saw Using a Laser Sheet

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Introduction

Airborne wood dust released during machining is considered as a harmful substance, mainly for its inhalable fraction. Some species, and particularly beech and oak, are recognised as carcinogenic in the European Union (1). Exposure Limit Values of the order of 1 to 3 are recommended or mandatory in a majority of the European countries. Such low levels can be achieved by integration of capture devices when designing new machines or fitting them afterwards on existing ones. Moreover attention should be paid to an appropriate design of this device in order to remove efficiently dust and ships emitted during each kind of machining (sawing, moulding, sanding, routing, drilling...) and each type of woodworking machine.

Guidelines for a proper design are necessary before machine manufacturing or refurbishment. A brochure describing a general methodology is to be published soon in France (2). Examples of application to some specific woodworking machines are presented.

The first stage of this methodology consists in observing the dust source all along a given machining in order to obtain such information as: Is the source staying at a fixed position or mobile? Is the direction of the dust projection constant or not ? Then, the shape and the dimensions of the dust projection should be determined. Once the designer has selected a fixed or mobile capture device, which follows or not the direction of the projection, he must size this device in order to cover the projection span entirety.

Objectives of the Study

As most of the projections show a conical shape (whatever the directrix may be), they can be characterised by their span in two orthogonal planes: perpendicular to the tool axis (or to the axis of the driving wheels) for the radial span and in a plane parallel to the axis for the axial span. These spans can be expressed either by angles or by widths at a given distance. Visualization techniques of the dust jet constitute a reliable method to characterise the dust emission and evaluate these spans.

The method chosen is the laser tomography (3, 4). It consists in generating a laser light sheet in order to illuminate only a plane amidst the flow. The light source is an Argon laser, with 5 Watt power. At the laser source exit, the laser beam is directed into an optical fibre at the end of which a cylindrical Plexiglas lens transforms the laser beam into a laser sheet. This sheet has a low thickness (1 to 2 mm) and can stretch over several square meters. The optical fibre allows displacing the laser sheet in any position, making accessful any observation plane. A camcorder Sony HI8 CCD – TR800 is used to record the images of the visualizations.

In the framework of an INRS study aiming at improving the capture efficiency of some woodworking machines, the visualization technique has been applied to a radial arm sawing machine.

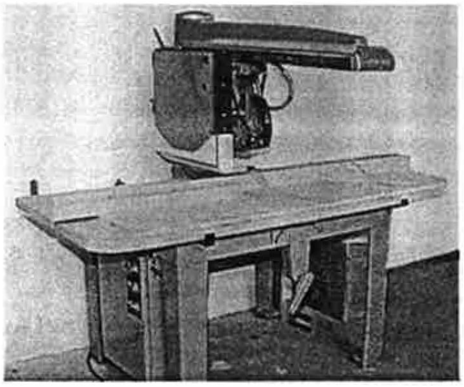

Figure 1. Example of a radial arm sawing machine

Results and Comments

A series of tests have been performed with two kinds of material: beech and MDF (Medium Density Fibreboard). As a first result of this study, beech and MDF dusts emitted from this machine can be employed as aerosol tracers, enabling to get rid of the tricky problem of simulating the source using a surrogate and an appropriate generator. The pictures presented in this paper correspond to MDF, but similar flow patterns were obtained with solid wood.

Observations in the vertical plane of the blade are shown in figures 2 and 3 at different machining stages. Initially, the main part of the dust jet follows the slot made by the blade in the wooden table and emerges from it with a low radial span. A secondary jet emerges earlier from the fence with a higher span, its upper expansion is limited by the sawing area guard acting as an obstacle deflecting the jet downwards. The guard rests on the fence (the pieces of wood were thinner) all along the cutting.

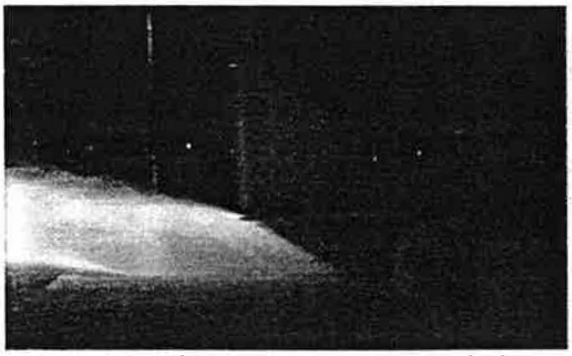

Figure 2. Observation in a vertical plane Beginning of machining

Figure 3. Observation in a vertical plane Later on

Some tests were performed with the bottom part of the guard removed. It can be observed on figure 4 a much higher radial span than on the preceding pictures. The presence of an obstacle leads to a span decrease from more than 45° to 25 and even 15°.

Figure 4. Observation in a vertical plane
Bottom part of the guard is removed

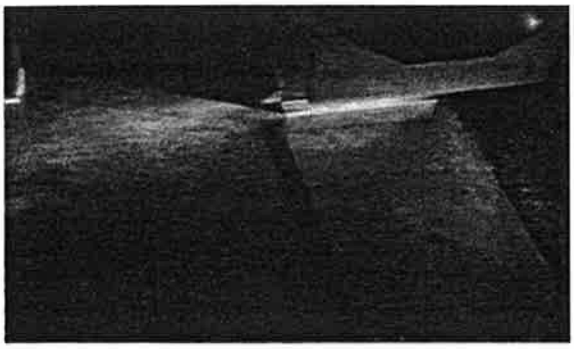

Figure 5. Observation in a horizontal plane
Left part of the fence is removed

The next three pictures show observations in the horizontal plane flush with the top of the piece of wood. Special conditions have been set up to facilitate recording for the purpose of this paper: mid-thickness cut, left side of the fence removed, cut thickness lower than the one of the blade (only for figures 6 and 7 where the blade is visible). Normal use of the machine applies when tests are intended to contribute to designing of the capture device.

On figure 5, the main part of the dust jet emerging from the cut in the piece of wood can be easily identified. The corresponding axial span lies between 30 to 40°.

Considering figures 6 and 7, the axial span remains quite constant on the right side, as the emission source is fixed and located at the beginning of the "slot" in the piece. On the left side, the span increases during the stroke of the blade as the jet can expand freely.

A secondary jet perpendicular to the blade appears at the front side of the piece of wood, probably due to dust driven inside the teeth, released when entering the piece and following the edge. This emission increases slightly from figures 5 to 6 and 7 with the blade stroke.

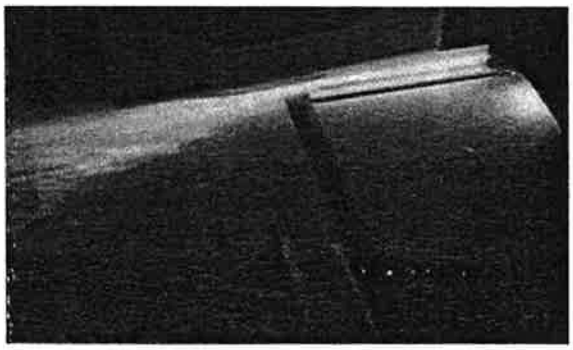

Figure 6. Observation in a horizontal plane
Beginning of machining

Figure 7. Observation in a horizontal plane
Later on

Conclusions

The dust emitted by the radial arm sawing machine, and most of wood working machines, is generally characterised by a high initial velocity of wood particles and quick changes of location and direction. A better description of this emission versus time is essential for designing the appropriate capture device. This study proves the feasibility of a visualization technique using a Laser source and the real dust as a tracer. Moreover, an image by image examination of the recording enables a precise follow up of the dust flow. Applications to other machines are foreseen in the near future prior to any design.

References

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4. 4) Merzkirch W, Flow Visualization, Academic Press.