# Group Project 2: Operating Room Laminar Air Diffuser Flow Visualization over Manikin Using Smoke Wire Technique

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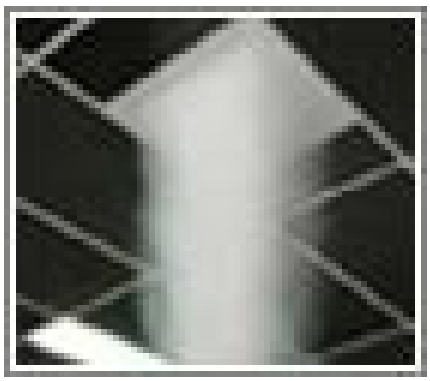

Introduction

For the second team project, we decided to investigate the air flow from the Laminar Air Diffuser (LFD) over a manikin using the smoke-wire technique for visualization. The manikin simulates the body of a patient lying on a surgical table. Pictures and videos were taken of the smoke-wire flow as the oil burned, and the pictures were analyzed to understand the physics of the fluid flows over the manikin.

Set Up

Two different set-ups were used in creating images of the flow. The first was only used in some of the video footage. This set-up included the manikin on the operating table located approximately 6 ft under the LFD field, roughly in the center of the room (see fig. 1). The reason why this particular set-up wasn't used was because the surgical light mounts and booms (2 each) obstructed the flow in the center of the room, creating re-circulations that were difficult to visualize taking digital photography.

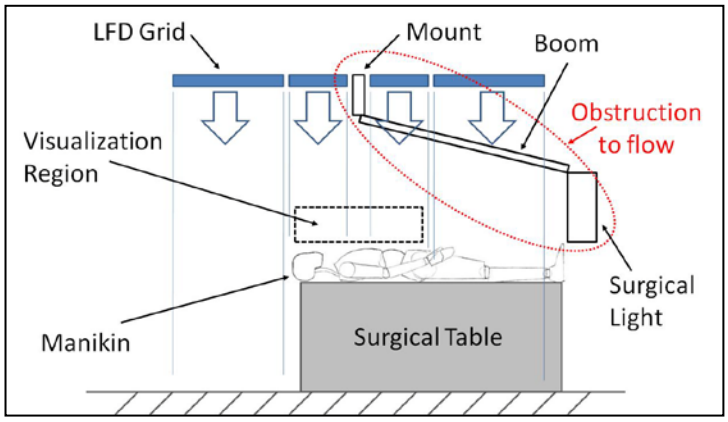


Figure 1: Visualization Region Located in Center of O.R.

An alternative set-up was used, which included the manikin and surgical table under a single LFD grid panel, with no obstructions (see fig. 2). This allowed for more uniform sheets that could be visualized with greater ease.

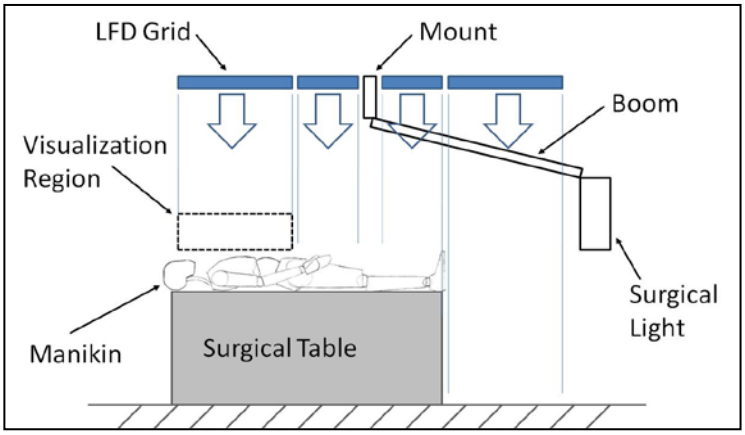


Figure 2: Visualization Region Located Underneath Single LFD Grid Panel

Two types of light sources were utilized (just like in the previous project) to create the digital camera images (2 surgical lights, and two high speed camera lights, see fig. 3). The surgical lights were placed at 120 degrees to the camera's position, and the high speed camera lights were placed 90 degrees to the camera's position. The camera was placed on a tripod approximately 6 ft from the manikin's head, level to the smoke wire.

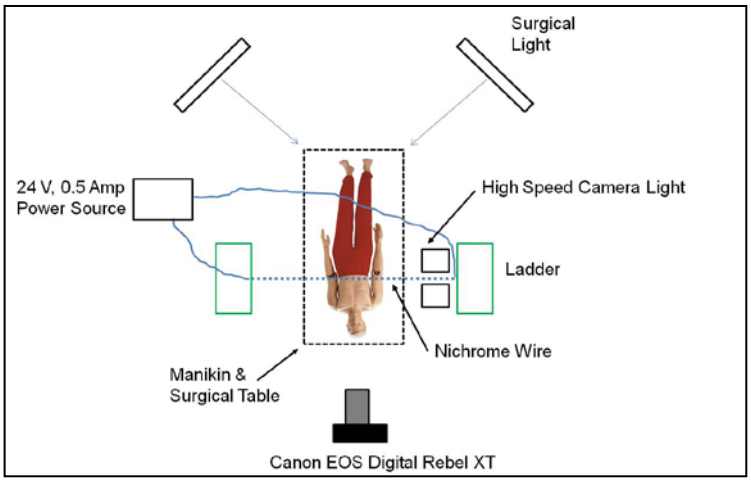


Figure 3: Image Set-ups for Digital Images

A single light source was utilized to create the digital camera video footage (2 surgical lights, see fig. 4). The surgical lights were placed at 120 degrees to the camera's position. The camera was placed on a tripod approximately 6 ft from the manikin's head, level to the smoke wire for the footage taken relative the transverse plane of the manikin. For the footage taken relative to the sagittal plane of the manikin, the camera was placed 3 inches from the centerline of the smoke wire approximately 3 ft from the manikin's torso.

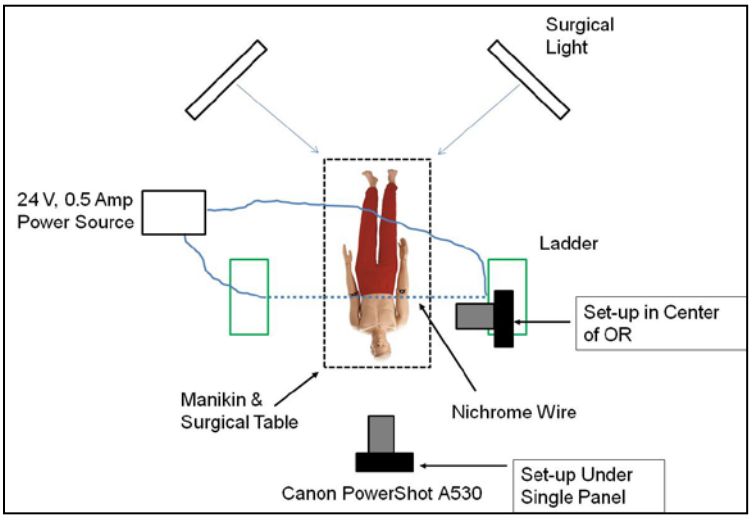


Figure 4: Image Set-Up for Video Footage

The LFD operating conditions were: flow velocity = 50 fpm and flow temperature = 50 degrees F. The ambient air temperature was around 60 degrees F for all of the images.

Visualization Technique

The visualization technique utilized was the same as the previous project using the smoke-wire technique to visualize the flow. The only difference for this project was that the 22 gage Nichrome wire used was tightened using ladders and weights in order to create a more uniform, straight wire. This seemed to produce more controlled results, i.e. repeatable flows. The 24 inch wire was placed in the center of the grid approximately 3 inches from the lower torso of the manikin.

**Tom Rachlin**

The only enhancements made to this image are slight Photoshop contrast, brightness, and tint modifications. I brought out some of the greens and yellows to reflect the hot and cold of the mannequin and smoke. This image does realize the intent. You can see as the smoke falls from the wire, to moves away from the body to either side, which demonstrates the turbulent nature of the flow around the body.

Figure 5: Tom's Image

**Specifications for Tom Rachlin's image:**Camera: Canon EOS Digital Rebel XT
f-stop = 1/4.5
exposure = 1/1600 s
ISO = 1600
Lens : 35-80 @ 44mm

**James Kostrzewa**

The image captured reveals a particularly interesting discovery. There is a disturbance in the turbulent flow which is a result of the mounting unit for the surgical lights. The mounting bracket is located in the center of the room directly above the operating table. There are vents located around the lights. When turned on the lower temperature air descends as the heat plume created from the human body rises. This shearing resulting shearing affect causes the laminar flow to become turbulent. This could potentially cause bacteria to re-circulate around a surgical wound.

I particularly enjoyed this image because of the turbulent flow caused by the opposing flows. I also thought that the manikin body was amusing.

Figure 6: Jimmy's Image

**Specifications for James Kostrzewa's image:**
Camera: Canon EOS Digital Rebel XT
f-stop = 1/5.6
exposure = 1/1600 s
ISO = 1600
Lens : 35-80 @ 44mm
No Flash

**Jeff Payne**

For my part of the group project, I decided to take video of the smoke-wire flow over the manikin. This produced very interesting results, considering a single image does not really give the whole story about the type of flow over the manikin. The video footage reveals that with the image set-up in the center of the O.R., there appears to be re-circulations (see fig. 7). The location of the surgical light mounts and booms in the center of the LFD field may be the reason for this disturbance (see fig. 1). The bulkiness and thermal plume created from these objects may disturb the flow causing re-circulations. This is an undesirable effect in the O.R. because these re-circulations can cause contaminants and infectious particles to remain in the sterile field above the patient. When the manikin and surgical table were moved under a single LFD grid panel away from the booms and mounts, the flow appeared to be more downward, lacking re-circulations (see fig. 8). The smoke also appears to be sweeping over the manikin away from the sterile field towards the intended re-circulation zones.

Figure 7: Inverted Screen Shot from Video Footage with Set-up in Center of O.R.

The above screen shot (fig. 7) was inverted to reveal the highest density of smoke, which appears above the manikin in a swirling pattern. The below screen shot (fig. 8) shows the smoke rippling away from the smoke wire over the manikin away from the sterile field.

Figure 8: Screen Shot from Video Footage with Set-up under Single Grid Panel

The total full length video was put together from clips taken from a Canon PowerShot A530 camera (see specs below). The video was created and edited using Windows Movie Maker.

I think that this video footage does an excellent job of revealing the fluid physics that occur over a simulated patient in an O.R. However, there are some things that could be done differently to improve the quality of the footage, allow for better editing, and reveal more about the fluid physics. A digital video camera with a higher resolution, preferably High Definition (720-1080p), would greatly improve the quality of the video which may reveal more about the fluid flow [1]. Better imaging software, such as Adobe Premiere Pro, could help improve the editing of the footage. And taking videos from multiple perspectives for a single set-up and comparing them to another set-up may allow for better conclusions about the flow to be made. An example of this would be to take video clips from the transverse plane of the manikin, with both the set-up in the center of the O.R. and under a single diffuser grid panel, to determine if there is a difference in the flow between the two locations (see fig. 1 & 2). Another set-up could include using a thermal manikin to determine if the heat plume affects the LFD flow.

**Specifications for Jeff Payne's Footage:**
Camera: Canon PowerShot A530, 5.0 Mega Pixels, 4x Optical Zoom
Auto white balance
Resolution: 640x480 pixels
Frame Rate: 30 fps
Aspect ratio: 4:3

References

1. http://en.wikipedia.org/wiki/High-definition_video