Laboratory 2: Stroboscopy
To: R&D Team
From: James W. Bales
Date: 22 September 2005
Re: Applications of stroboscopy in our manufacturing plant.
IM2-JWB

Background
Engineers in our manufacturing facility believe that many of our Quality Control (QC) difficulties stem from erratic performance of motors and other rotating machinery in our plant. One approach is to instrument each shaft in the factory with a speed sensor, but that is prohibitively expensive. We need a technique that will enable our maintenance staff measure rotational speeds of shafts without having to stop production to instrument the shafts. I believe stroboscopy may be the answer.

A second area of QC concern is the "piddlers" - devices that deliver metered amounts of fluid into our production vats. It has been suggested that stroboscopy can also help us diagnose problems with the piddlers. As they send out pulses of fluid at a high rate, they appear as continuous streams of liquid to the naked eye. At this point even qualitative information about the dynamics of the stream leaving a piddler would be of great help.

Assignment
Investigate the use of stroboscopic techniques for measuring the speed of rotating equipment. Also look into using stroboscopy to observe the behavior of a piddler. Report your results in a memo to the TA/laboratory manager, who will forward your results to me. Your memo should:

1. Tell us if these techniques are feasible approaches.
2. Discuss the calibration of our existing equipment.
3. Determine the practical accuracy of the rotation measurements when used in the factory and the maximum rotation rate that can be determined.
4. Provide the production team with a description of your procedures with sufficient detail to allow them to recreate your results.
5. If you can, come up with an interesting visual image that I can use to illustrate the technique to the new Vice President for Production.
6. Discuss the qualitative performance of the piddler device.
7. Investigate the cause of the spray of droplets observed around the piddler stream.
8. Suggest a method that will allow us to install a spinning blade that can swing through the piddler stream without getting wet.

Laboratory 2 -- STROBOSCOPY
Pre-lab questions, to be handed in at the beginning of lab:

Question 1 Describe, in plain English, why the stroboscope is able to (1) make the image stand still, and (2) make it appear that the man is sawing wood forward or backward in time. Imagine you are writing for a high school or junior high school class.

Question 2 Read part 1 of the assignment. Develop the equations that will allow you to predict the two flash rates (expressed relative to the rotation rate of the motor) that satisfy the following constraints:

1. They produce the forward and backward illusion of the man sawing wood
2. They are the closest to the rotation rate of the motor.

Assume that the motor spins clockwise, that the disk spins clockwise to produce a forward illusion, and that the images are distributed in chronological order clockwise around the disk.

Work in the Laboratory:
Read the attached memo from your supervisor. Document your work as an engineering memo. The memo is to be handed in at your next lab session. It will be graded on technical content (50%), organization (20%), and writing quality (30%).

1. In the lab you will find a disk mounted to a motor. Around the edge of the disk are 16 images of a man sawing wood. By adjusting the frequency of the Model 1531 Strobotac you will be able to make the image stand still, or to make it appear that the man is in motion.

   Measure the fundamental frequency of rotation of the disk. Use both the dial on the strobotac and the digital oscilloscope combined with the vacuum photocell. Are they the same? If not, explain the difference. Which one do you believe, and why?

   Using the equations you determined prior to lab, calculate the expected flash rates for forward and backward progression of the milk drop. Then adjust the strobe to produce those effects and measure the actual rates. Calculate the error, if any, and discuss where it might come from.

2. There is a high-speed motor in the lab. Its rotation speed is faster than the highest repetition rate of the Model 1531 Stroboscope. Use the procedure presented in class to determine the rotation rate of the motor. Use at least 4 subharmonics. Show all your calculations in your lab report. Discuss any discrepancies in the results.

3. Use the vacuum photocell and the oscilloscope to measure the BCPS of the Strobotac in its medium- and high-range settings.

4. Write a short message that occupies three or four lines, or find an interesting image. Cut up the message or image so that it is on separate strips of paper. Attach those strips of paper *at separate places* on a plain disk (provided in lab) that will be attached to the spinning disc motor. (Or, create an image or icon with 3-fold or 4-fold symmetry).

   The motor rotates at about 1000 to 1200 rpm. Determine the Strobotac frequency necessary to produce your “blended” image. Show your results to your TA (as well as your rationale for these numbers) before beginning this part of the lab session. Set the strobe to those rates and check if they do the job. If not, figure out why not and make them work.

   Photograph the intact message on 35mm film using the strobe as the sole illumination source.

   Consider what is required to produce the best photograph, including (but not limited to) camera position, strobe position, shutter speed, (in the lab), and the choice of contrast filter, dodging and burning (in the darkroom).

5. In the lab you will find a single-nozzle 'piddler', similar to the ones at either end of Strobe Alley. Illuminate the piddler with the Strobotac and describe as many things as you can about the behavior of the droplets or the stream. Try to separate describing what you see from explaining what you see! (e.g., to say the stream of water appears to be moving downward is an observation, to say that gravity pulls the water down is an explanation that invokes knowledge beyond what you are observing).

   Do the drops change shape as they fall? Are all the drops the same size? Are there tiny droplets shooting out to the side? If so, describe them. In the Discussion section, you should speculate about why these things are seen.

   Hint -- Run a comb through your hair (or rub a balloon against your hair) and put it near the stream -- what happens?

   In your memo, describe how you might go about making and using a spinning blade that would pass through the space between the droplets without getting wet.

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Objectives

1. To determine the strengths and weaknesses of stroboscopy as a method of measuring the rate of periodic phenomena.
2. To explore how stroboscopy can be used to slow down the apparent motion of a periodic phenomena.

Deliverables

The deliverable for this effort is a report that will

1. Provide the background that the reader needs to understand
    a. What is meant by "stroboscopy"
    b. How it can be used to determine the speed of, e.g., motors and other systems undergoing periodic motion.
    c. How it can be used to provide a slow-motion view of a fast, periodic, phenomenon.
2. A detailed procedure (with set up diagrams and/or photos and a list of equipment used) that would allow a reasonably skilled researcher to re-create your experiments
3. Estimates of the accuracy of your measurements of motor speeds.
4. A discussion of the use of stroboscopy to determine the rotation rate of a motor that spins faster than your strobe can flash.
5. A photograph that shows how a composite image can be created from a set of 3 or 4 sub-images mounted on the periphery of a spinning disk, and a photo of the stationary disk.
6. A qualitative description of the operation of a piddler, how the drops behave as they leave the piddler, and a discussion of the practicality of having a spinning blade pass between piddler drops without getting wet.
7. Recommendations of ways to improve the results of the experiment if it were done again