5. A new graduate assistant Ekaterina Popdimitrova (Ph. D. student in Textile Technology Management) began working on the project.

**Fundamental And Practical Aspects Of The Perception And Analysis Of Real And Illusory Appearance Defects in Fabric**

*File: S92C9*

*PI(s): R. McGregor*

**QUARTERLY REPORT ENDING: March 31, 1993**

**OBJECTIVES:**

The long term objectives of this research program are to develop a quantitative understanding of perceived fabric defects, to develop knowledge which can be used to identify the true sources of defects, and to provide methods for making fabrics of uniform appearance from non-uniform yarns.

Key objectives for this year are:

- Collect human response data on computer-generated color images
- Calibrate the computer-generated images instrumentally
- Collect human response data on real fabrics
- Correlate the data generated from the two different approaches
- Formulate first generation numerical models for predicting human visual responses

**SUMMARY:**

The final evaluation of the candidate color printers has been completed, and our choice of printer has been independently confirmed and supported by Milliken Research Corporation, whose assistance is greatly appreciated. A disagreement on the contract conditions for the purchase of the printer has delayed the purchase, and prevented progress on the color printing essential for this project.

An invited plenary presentation on "Perception, Detection and Diagnosis of Appearance Defects in Fabrics", by Ralph McGregor, Donald H. Mershon, and Christopher M. Pastore, was given by Ralph McGregor at the National Textile Center 1st Annual Forum, Auburn, Alabama, on Friday February 12, 1993, under the general topic heading of "Measurement and Sensors".

A poster display on "Appearance Defects in Fabrics" was prepared by the principal investigators, with the help of Mary Taylor, a graduate student in Psychology at N. C. State University who is working on this project, and who was present in Auburn together with Ralph McGregor to discuss the research poster presentation.

This meeting was stimulating and interesting for both of us. Contacts were made with representatives from the National Laboratories of The Department of Energy, and it became clear that we have common technical interests related to automated fabric inspection, an initial priority area for the new AMTEX Partnership.

Our NTC colleagues Chuck Tewksbury at ITT, and Fred Cook at Georgia Tech., are heavily involved in this new initiative. They invited Ralph McGregor to attend the first meeting of a recent working group at Oak Ridge National Laboratory. This further expanded our contacts with national laboratory scientists, and will also lead to closer interactions between our group and the NTC colleagues.

Our group has obtained and interfaced an HP ScanJet IIc 600 dpi., 24 bit color scanner, and an HP LaserJet 4m 600 dpi grayscale printer, to our Quadra 950 system. The scanner and printer have been successfully integrated with our software. We hope that we can soon complete our system with the chosen, but so far unobtainable color printer.

Professor Toshiichi Soen, now retired from Kyoto Institute of Technology but living in Raleigh, N. C., has long been interested in color and appearance problems, and has discussed with us some of his analytical work on the Cornsweet Illusion. We will continue to interact with him on this project. Warren Jasper of the College of Textiles at N. C. State University has considerable experience in using neural networks, in addition to other valuable expertise, and we will collaborate with him in developing and using neural network models of the visual processes involved in detecting fabric defects, and in the subtler visual effects which may mislead fabric inspectors.

Hawthorne Davis has suggested that, as a physical process, the detection of a streak in a fabric by an observer might be considered a signal-to-noise problem. Accordingly some experiments were proposed to test the hypothesis that along-end noise, of a particular type and amplitude, will interfere with a person’s ability to see a streak. An initial set of experiments was carried out. A computer program was developed to create grayscale-image simulated fabrics. These simulated fabrics consisted of rows of yarns (or rather yarn brightnesses) which were randomly sampled from a normal distribution having a mean reflectance of 20%, and a coefficient of variation CV of .01. These numbers have been shown to be typical for critically dyed knit fabrics, and are also consistent with our preliminary simulations of streaky fabrics using an IRIS color printer. Superimposed on the end-to-end variability was an along-end variability which ranged from .00-.09 of the mean.

Several types of along-end uniformity were examined:

1) normally distributed, 2) sinusoidally distributed with
phases randomly determined, 3) light slubs, and 4) light and dark slubs.

Of the along-end uniformities studied, the normally distributed one interfered with streak discernment most effectively. Even so this interference was effective only when the along-end variability was 5 or more times larger than the end-to-end variability. Random-phase sinusoidal variability produced severe chevroning, and failed to cover streaks at all, while simulated slubs produced effects which were similar to, albeit slightly less effective than, those generated by normally distributed noise.

As is evident, there is a practically infinite list of possible types and magnitudes of along-end noise. We are continuing to look for good ideas in this regard, because this type of approach is conceivably commercially viable, assuming an effective solution can be found.

Real-Time Data Acquisition, Theoretical Modeling, And Adaptive Control Of Batch Dyeing Processes

File: S92ClO

PI(s): Brent Smith

QUARTERLY REPORT ENDING: March 31, 1993

REPORT COMPILED BY: Brent Smith

OBJECTIVES:

Longterm Goals

1. To develop novel state-of-the-art methods for real-time sensing of dye concentration
2. To utilize those methods for the generation of a database for improving and testing theoretical models of the dyeing process
3. To adaptively control the dyeing process through the use of advanced control algorithms and/or neural networks
4. To investigate dye and chemical dosing as means of controlling the dyeing process, minimizing effluent discharge, and reusing dyebaths

Year Two Goals

1. To further develop flow injection analysis (FIA) and investigate a planar waveguide as tools for measuring dye concentrations in mixtures.
2. Enhance database development by installing equipment for sampling multiple dyebaths.
3. Close the loop in the current lab dyeing system so that the process is computer controlled.
4. Recruit a graduate student to work jointly on data acquisition and controls.
5. Utilize equipment developed in year one to study dosing of chemicals and dyes.
6. To improve and validate theoretical dyeing and control models through data acquired from designed experiments.
7. Design a database management system to facilitate technology transfer and user access to data by expressing results in terms of standard data structures.

a. Explore joint efforts with researchers at the Swiss Federal Institute of Technology to use supercomputers in studying the dyeing process.

SUMMARY:

At this time, five faculty and six students are working on the project. The faculty are K. Beck, R. McGregor, W. Jasper, G. Lee, and B. Smith. The students are G. Birsttresser, IV, M. Arora, M. Lefebre, J. Lu, M. Kashif, and J. Peterson. Also, Bill Hunter (Adjunct Professor of Textile Chemistry) of Ciba, and other interested industrial parties are collaborating. During this reporting period, activities focused mainly on collection and analysis of data, equipment fabrication and upgrading. Within the main project, there are essentially three subprojects: dye process modeling; real-time data acquisition and analysis; and control systems development. Work progresses well in all areas, and poster and plenary session presentations of all progress were made at the NTC national meeting in Auburn, AL.

Dyeing experiments were continued to validate and upgrade certain aspects of the models. These models are proving very useful in predicting the ultimate state the dyeing system (thus the ultimate color obtained) from state variables. This information is being integrated into the control protocols to give real-time estimates of final dye shade, thus facilitating real-time multi-channel adaptive control. The non-dimensional equilibrium model for the dyeing of ionic fibers by ionic dyes was extended to include polyelectric dyes, and mixtures of dyes. Data obtained from the literature were fitted to the model. Very good least-squares non-linear fits to the data were obtained. Experimental work is also being done on the control of the dyeing of nylon by acid dyes. The dyeing will be controlled by dosing the acid dye into the dyebath. Kinetic models will be developed and will be used to design the control strategies for the dyeing process.

Flow injection analysis (FIA) data from pilot plant dyeings done at Ciba in Greensboro using three different calibration models showed that FIA peak measurements are linear in the range of 0 to 2 absorbance units (AU), with excellent agreement between FIA peak and extended back-slope calibration sets. There was good agreement between