
**Summary:**

**Depolymerization of Nylon**

In 5 different runs, ca. 0.2g of phase transfer agent was mixed with 1g, 2g, 4g, 6g, and 12g of nylon 6,6 in 50 wt% aqueous solutions of NaOH. The mixtures and a blank containing no phase transfer catalyst but only nylon 6,6 and 50 wt% NaOH solution were heated under reflux for 24 hours with continuous stirring. On cooling, a white powder mixed with short whiskers settled out. After vacuum drying overnight, the samples were weighed.

It was discovered that the product of the run with no phase transfer agent showed a 16% increase in weight compared to the weight of the original nylon 6,6. The oligomer obtained had a viscosity-average molecular weight of 1,644 (the original nylon 6,6 had a molecular weight of 30,944). The other runs with phase transfer agent produced oligomers with decreases in weight of 40 - 50% in each case. These results suggest that in the absence of phase transfer agent only oligomers are formed; however, soluble low molecular weight products are formed in the presence of phase transfer agent.

**Nylon/Polypropylene Blend Technology**

Two types of mechanically shredded industrial carpet waste samples were obtained from Crown America Inc. One batch contained calcium carbonate-filled SBR, while the calcium carbonate and SBR were mechanically removed from the second batch to leave nylon 6 (and a small amount of nylon 6,6) and polypropylene. Maleic anhydride-grafted polypropylene (Polybond™ 3002) was obtained from BP Chemicals. The shredded carpet fibers from the second batch, which contained nylon and polypropylene were melt blended with 3 wt% compatibilizer (Polybond™ 3002) using a Haake Rheocord 90 torque rheometer equipped with a TW 100 twin screw extruder. To avoid problems arising from the hopper feeding of fibers, double feeding of the mixtures was necessary.

Extrusion of the first batch which contained chunks of calcium carbonate-filled SBR was unsuccessful. The extruded pellets were compression molded at two different temperatures (227°C and 277°C) and 2500 psi. The samples molded at 227°C had an average tensile strength of 10.8 kpsi (average of 20 specimens). The samples molded at 277°C had an average tensile strength of 7.4 kpsi. The compression molded specimens of the uncompatibilized extruded blends were too brittle for specimen preparation.

**Fiber Engineering**

**Research** in the design, development, manufacture and measurement of fibers

**Production and Properties of Fine- and Micro-Denier Fibers**

**Principal Investigators:**

Michael S. Ellison, Bhuvnesh C. Goswami (Clemson)

**Objectives:**

1. (Clemson and NC State) Demonstrate the limitations to structure development in fine denier fibers during high speed winding. Assessment of structure development will be accomplished on-line and off-line through measurements which include optical birefringence, X-ray diffraction, and dynamic mechanical thermal analysis and high strain torsional modulus measurements on single filaments. Instrumentation for these evaluations is available at one or more of the universities.

2. (GIT with cooperation from U. Tenn.) Investigate the efficacy of production of micro-denier per filament spun yarns from a melt blowing technique. Properties of these fibers will then be compared with those produced by the high speed spinning methods at Clemson and NC State.

**Summary:**

The donated Barmag SW 72 high speed winder is in place and has been tested in initial low-speed trials. Soundproofing material has been installed in the room.

There have been several obstacles encountered in making arrangements for the construction and installation of the godet and yarn control (sensors, aspirator blocks, etc.) support structure. Suppliers have been identified and donations promised or purchase order requests tiled for these items. The superstructure to support the yarn control and godets will be in place by August 31. At that time testing of the winder in ultradrawing applications will begin.

We have upgraded the data acquisition system on the extruder by installing a high speed (12Msamples/sec.) A/D board in the computer. This enabled us to more effectively exploit the higher speed pressure transducer previously installed.

**Cotton Fiber Quality: Characterization, Selection, and Optimization**

**Principal Investigators:**

Roy M. Broughton, Jr., W. S. Perkins, Yehia El Mogahzy.

**Project Leader (Auburn)**: M.S. Ellison, C. D. Rogers, H.

**National Textile Center Quarterly Report: April - June 1993**
Behery, S.R. Matic-Leigh (Clemson), Moon W. Suh, William Oxenhaum, Jon P. Rust (NC State)

Objective:
The overall long-term objective of this work is to provide the U.S. cotton industry and spinning/weaving industries with methodologies, techniques, and scientific approaches for improving testing capabilities, optimizing cotton fiber utilization, and improving the opportunities for a larger cotton market share.

Summary:
During this report period, the three universities have participated in various branches of the project. Results produced are characterized by their high level of specificity and their significant association with goals of the textile industry in this critical area. These results will be published in detail in the annual report. In this report, a summary of the progress of work is presented.

An Expert System of Cotton Fiber Quality Selection
The “SELECTEX” Expert System Software program being developed by Auburn group will be ready for detailed demonstration by the end of October 1993. This program will provide the industry with an easy to use expert system of critical issues related to cotton fiber selection for different end-products and fiber/yarn/fabric calculations. The software program will be first demonstrated on the project team and various inputs will be greatly considered. General features of “SELECTEX” Expert System Software program were summarized in the last quarterly report.

Cotton Fiber Quality Evaluation
Acoustic Analysis of Fiber Fracture: This area is mainly coordinated by Clemson [Mike Ellison and CD. Rogers]. Some cooperation from NC State has been made. Additional data has been acquired and processed in the manner reported in the NTC Quarterly Report of March 3 1, 1993. In that report, it was proposed to design a mechanism to directly couple the signal from the rupture of cotton fibers to the microphone probes. With this approach, the mechanical noise inherent in the tensile test stage of the HVI instrument precluded the successful acquisition of the signal. Accordingly, it was concluded that detecting the airborne acoustic pulse is the more effective method. Utilization of a microphone with a larger collection surface and focusing reflectors, to enhance the weak signal generated by cotton fiber fracture are now being considered.

A new software/hardware system is being utilized to improve signal acquisition of cotton fiber fracture. There have been the usual learning curve and start-up glitches associated with new instrumentation development; these problems have been identified, addressed, and most of them solved. The one critical problem that remains unsolved at the present time is a difficulty in configuring the computer hardware (the EISA motherboard in the computer) to recognize the high speed data acquisition board. The board manufacturer and the computer manufacturer are cooperating with us and with each other to solve this problem.

Both Clemson and NC State have been cooperating in using the current version of the acoustic pulse detector with the Mantis® tensile tester (located in NC State laboratories). The acoustic pulse from the fracture of a cotton fiber in this tester was detected by the acoustic instrument. Problems including significant noise level by the machine, and fitting microphone into the test location without restricting the minimum test length are being investigated. More on the outcome of this effort will be reported in the annual report.

Cotton Fiber Friction: The device developed by Auburn [El Mogahzy/Broughton] for measuring inter-fiber friction and fiber/metal friction is now being duplicated by two different USDA laboratories for two different purposes: (i) to be used for determining the level of sample preparation on the HVI length/strength station, and (ii) to investigate the frictional characteristics of chemically treated cotton fibers. This technology transfer is a result of long cooperation between Auburn and the USDA.

Cotton Fiber Fineness/Maturity Measurements Using Software Structure & Image Processing: According to Dr. Rose Matic-Leigh of Clemson, the objective of image analysis in general is to extract, from the very large amount of data in an image, that small set of measurements containing the information of interest. The standard strategy to achieve this is to break the whole task into a sequence of smaller, independent steps. The objective of each step is to achieve a limited but significant reduction in the amount of data by discarding irrelevant information. The result after each stage is a new representation of the image. Objects in an image have to be separated from each other and from their background before any measurements of object properties can take place. This strategy is analogous to the way in which human visual systems work, as one sees an object in a scene only because that object is different, and thus separable from its surroundings in some manner. An object in a digital image is a group of points that have some similar properties and are contiguous in two- or three- dimensional space. The process of isolating a meaningful object or region is termed ‘image segmentation’ and is a crucial stage in image analysis. Unfortunately, there is neither a standard approach to segmentation nor a general criterion of successful segmentation, and the performance of a segmentation method can be judged only by the utility of the measurements based on the segmented results. Different approaches, namely, grey-level thresholding and the use of a line operator, have been used, respectively, to achieve initial segmentation of raw images for the measurement of cotton fiber maturity. The simplest segmentation results are represented by binary images. In a binary image, there are only...
two grey levels, each of which represents one of sub-regions. The subregion of interest will be termed 'object' and the other sub-region 'background'. Pixels within objects and those within the background will be represented symbolically by Is and Os, respectively. This time OPTIMAS version 4.02 image analysis software package is used. There are 256 grey levels. Still the sub-region of interest will be termed 'object' and the other sub-region 'background'. The figure below shows a block diagram of the image analysis system.

![Block Diagram of the Image Analysis System](image)

**Fig. 1** Block Diagram of the Image Analysis System

### Selection and Optimization

Two new algorithms of cotton fiber selection have been developed by El Mogahzy. The first one is called proportional weight category (PWC) picking and the second optimum category picking (Optic). These techniques are believed to provide excellent results with regard to both within and between laydown variability. The techniques also deal with the mini-mix problem.

Auburn has developed a blending uniformity index which makes use of the change in both mean and variability of fiber properties through different stages of processing. Both the AFIS and HVI systems have been utilized to confirm the index capability.

Dr. Behery (Clemson) is cooperating with Auburn to establish the uniformity index. He is also doing similar effort with NC State in process optimization.

NC State has completed first stage mill experiment involving MANTIS, HVI and yarn/fabric data; the results of the analyses are now being summarized as an M.S. thesis by H. Koo under Moon Suh. The second stage experiment that began in January is in the seventh month. This study, unlike the elongation-based’ laydown and blending, is based on the normal production data except the MANTIS testing of the cottons being used.

Simulation of fabric quality through Uster 3 signal processing made a further progress; numerous simulations were run to mimic the yarn uniformities within woven fabrics. Inverse Fourier transform analyses are now being applied to the yarn density measurements. This work is led by Moon Suh.

Bill Oxenham led the experimental work for assimilating the data from the tests carried out on raw stock and part-processed fibers. Whilst each test may provide useful data it is believed that the AFIS system could be sufficient for routine monitoring (and, ultimately, possible control) in a spinning mill. This tentative conclusion has been reached after analyzing the available data and although the HVI line could possibly generate more information, this must be balanced against the potential problems of fiber selection and preparation, and the variability within and between results obtained from the instrument. AFIS provides data on the fiber length and fineness together with information on nep content and it is believed that the processibility of a fiber and fiber-machine interactions can be inferred from this data. Further work is underway to verify whether the above conclusions are valid for a wide range of samples.

Study on optimal bale laydown was expanded to “simulate annealing algorithm” in order to handle 3-dimensional problems (length, strength and fineness). The preliminary results on 754 bales (26 laydowns of 29 bales) are highly encouraging. This work is carried out by Fred Robin (OR) as his M.S. thesis under Moon Suh.

John Rust and S. Peykamian have done much literature survey on a new research to define and measure the appearance qualities of spun yarns. As a first step, the yarn hairiness will be modeled statistically based on the fiber properties followed by an instrumentation aimed at measuring the yarn hairiness along with uniformities.

### The Use of Instrumental Analysis to Determine Quality Characteristics and Processing Performance of Reclaimed Fiber Mixtures

- **Principal Investigators:**
  - Clarence D. Rogers, E. A. Vaughn (Clemson), Y. El Moghzy (Auburn) [reported by E. A. Vaughn and Ashish Bokil]

- **Objective:**
  Develop a rapid method for (1) analyzing the physical parameters of reclaimed fiber mixtures and (2) determining the relationship of these parameters to fiber processing performance and fabric properties.

- **Summary:**
  - Ashish Bokil, a graduate student pursuing a master’s degree in Textile Science at Clemson, has joined our research team. Efforts during the past quarter were concentrated on our previously defined tasks (1) and (2), namely, organizing and conducting a survey of reclaimed fiber processing practices.