Final Report

Project B-1309

DEVELOPMENT OF A DYNAMIC ENDURANCE LIMIT APPARATUS AND THE ANALYSIS OF INDUSTRIAL SEWING THREADS USING THIS APPARATUS AND A DYNAMIC MODULUS TESTER

By C. Willard Ferguson

Prepared for:
Bemis Brothers Bag Company
Talladega, Alabama

A. French Textile School
Georgia Institute of Technology

TABLE OF CONTENTS

		Page
I.	Introduction	1
II.	Materials and Equipment	1
III.	Experimental Work	1 - 4
IV.	Discussion	4 - 5
V.	Conclusions	5

LIST OF TABLES

		Page
I.	Determination of Average Breaking Strength and Elongation	2
II.	Determination of Tex, Tenacity and Cotton Count	2
III.	Evaluation of the Dynamic Modulus	3
IV.	Dynamic Rupture Point Evaluation	4

I. Introduction:

The purpose of this project was to evaluate dynamically the sewing threads used by the sponsor in his various operations. The sponsor was able to determine the static properties of the threads but not the dynamic properties. The School of Textile Engineering at Georgia Tech had performed dynamic tests during a preceding project "The Basic Physics of Seam Pucker", a federal government sponsored project.

The federal government project required the construction of a device to rupture a thread under dynamic loading conditions. This device was constructed in such a manner that only fine threads (70/2 and up) could be used on the device. For this project a similar device was required but able to handle larger diameter threads.

II. Materials and Equipment:

Bemis Company, Inc. supplied nine sewing threads which were labeled A through I. These threads were tested for breaking strength and elongation on the Instron Tensile Testing Machine as a means of determining their static properties. The dynamic properties were evaluated by means of the Dynamic Modulus Tester Model PPM-5R and on the heavy duty dynamic rupture device built by Georgia Tech. The densities of each thread were determined by use of a density-gradient tube.

The heavy duty dynamic rupture device required the purchase of a Jensen 15 inch speaker, Model 1520, rated at 75 watts peak power and a Marantz Amplifier Model 8B Stereo rated at 75 watts peak power. The amplifier was modified to produce 75 watts power. A sine wave oscillator was used to generate the necessary signal which duplicated dynamic loading.

III. Experimental Work:

Breaking strength and elongation tests were performed upon reception of the threads. The results of this test are given in Table I.

TABLE I

DETERMINATION OF AVERAGE BREAKING STRENGTH AND AVERAGE ELONGATION

Thread No.	Average Breaking Strength (lbs.)	Average Elongation (%)
A	15.3	14.4
B	12.6	28.8
C	9.9	9.4
D	10.7	11.6
E	10.4	11.2
F	10.0	10.2
G	14.6	13.9
H	14.6	13.9
I	10.3	10.9

In order to compare one thread against another the tenacity of each thread was calculated.

The tex of each thread was calculated from the weight of a 120 yard skein. Tex is calculated by the following equation:

$$\text{Tex} = \frac{(1000)(\text{grams})(39.37\ \text{in./m})}{120\ \text{yd.} \times 36\ \text{in./yd.}}$$

Table II shows the tex, tenacity and cotton count.

TABLE II

DETERMINATION OF TEX, TENACITY AND COTTON COUNT

Thread	Tex	Tenacity (g/tex)	Cotton Count
A	181	38.4	3.26
B	125	45.6	4.72
C	249	18.0	2.37
D	247	19.6	2.39
E	248	19.0	2.38
F	245	18.5	2.41
G	248	27.0	2.41
H	249	26.5	2.37
I	100	46.7	5.90

After evaluating the static properties of the threads, the dynamic modulus of each thread was determined using the Dynamic Modulus Tester PPM-5R.

Basically, the Dynamic Modulus Tester transmits a pulse via a transducer along a test specimen which is under load. A second transducer along a test specimen which is under load. A second transducer "picks up" a pulse and the instrument records the time in microseconds that the pulse required to traverse the test specimen. A scanner is incorporated in the instrument to permit testing various lengths continuously.

The dynamic modulus is then calculated according to the equation $E = PC^2$, where E is the dynamic modulus, P is the density in grams per cubic centimeter and C is the sonic longitudinal velocity. (Note 1).

For this project a modification of the above equation was used. The modified equation is $E = PC^2 \times 1.45 \times 10^5$. The units of measurement are in PSI.

Each thread was loaded initially with a 100 gram weight. The instrument was turned on and 2 inches to 10 inches of each thread were scanned. Table III gives the results of this test.

TABLE III

EVALUATION OF THE DYNAMIC MODULUS

Thread	Dynamic Modulus (in PSI)
A	22.17×10^5
B	11.40×10^5
C	10.96×10^5
D	11.92×10^5
E	10.41×10^5
F	11.41×10^5
G	12.08×10^5
H	11.86×10^5
I	17.97×10^5

NOTE 1: The density of each thread was determined by placing each thread in a calibrated density gradient tube. This device is composed of two liquids which do not swell the fibers and are of different densities. Carbon tetrachloride and xylene were used in the chemistry gradient tube and fibers of known densities were used to calibrate it.

Following the determination of the dynamic modulus, the dynamic rupture point was determined using the device built by Georgia Tech. This device utilizes a signal generated by an oscillator and amplified by the amplifier. One end of a thread is fastened to a hook which is mounted on the 15 inch speaker. The other end of the test specimen is attached to a 100 gram weight to provide the load. After loading a clamp is placed on the thread between the hook and the 100 gram weight. Following this the oscillator is set to operate at a rate equal to those of actual operating conditions. The specimen is dynamically loaded for 1 minute. The clamp is opened and any elongation removed. The clamp is then closed and the oscillator operated until rupture occurs. The time required for rupture to occur is recorded and the next specimen is mounted.

Using the above described technique, the dynamic rupture point in minutes was determined for each of the test threads. Table IV lists the values for each thread.

TABLE IV

DYNAMIC RUPTURE POINT EVALUATION

Thread	Dynamic Rupture Point (min.)
A	5.6
B	6.7
C	11.9
D	13.1
E	13.9
F	23.0
G	7.6
H	7.1
I	19.4

IV. Discussion:

Table I shows that when the above static tests are considered, specimens A, B, G, and H are the most sturdy of the group. Not until one actually looks at Table II are any decisions on a comparison allowed. Table II shows that

A, B, and I are stronger than the others in the group.

When the dynamic tests were performed, a significant change is in the order of durability may be seen. The dynamic modulus yields results which are indicative of the elastic properties of the threads. Whereas, the dynamic rupture point is indicative of both the elastic properties and plastic properties of a thread right up to the point of rupture.

Any differences between the dynamic modulus and the dynamic rupture point may be readily explained by the following procedure. If the dynamic modulus of a thread is high (relatively speaking, when compared to the other threads) and the dynamic rupture point is low (as is the case of specimen A), then this indicates that the thread in question will support a load in its elastic region and be able to recover sufficiently to support another load; however, if the load exceeds that elastic region then rupture is likely to occur very rapidly. (Again, A is example of this). When both dynamic modulus and dynamic rupture point are high, the thread will perform excellently. It is capable of carrying large loads without rupturing. It will never recover completely. (I is an example of this). The final case is high dynamic rupture point and low to medium dynamic modulus. (Such a thread would be F). The elasticity of such a thread is low while the plasticity is very large.

V. Conclusions:

On the basis of the dynamic rupture point evaluation and the dynamic modulus, the threads with the best durability are I and A, in that order. Thread F showed a high dynamic rupture point but a low dynamic modulus value. This indicates that the thread would not recover very well from a load.

Threads C, D, E, and F compose the next best group of threads. B, G, and H are in the last group. These threads are the least durable.