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Dynamic Drape Behavior of Textile Fabric: Part I - Development of an Instrument and Its Implications

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Abstract
There are instruments available to measure the drape coefficient of fabric. The most widely accepted method (IS 8357:1977) is hang a circular fabric sample and measure the drape coefficient. This measurement technique gives quite a bit of fair idea about drape coefficient of a fabric in static condition. But when it's static condition is disturbed as the case in practical application of fabric in the form of using as garment or in the form of any domestic application like using it as curtain or table cloth, it's shape of fabric fall pattern i.e nodes in term of drape terminology changes. Therefore, to get some idea about the effect of above mentioned static condition to dynamic condition of the fabric, a need was felt to have some sort of simulation. Here simulation might not be possible exactly to the practical condition, but one can think of some sort of simulation, similar to it and find out the effect of the same on drape properties of fabric. Therefore, it was thought that some simple, inexpensive, easy to handle instrument would be developed to measure the dynamic drape coefficient of fabric. The present work is the result of the same.
Keyword:- drape, drape coefficient, instrument, dynamic drape, simulation

I. INTRODUCTION

The ancient Greeks successfully modeled fabric drape as a static geometrical system in their stone statues. They started a mathematics of movement in which curves were thought of as tracings made by moving points. Curves were also analyzed instant by instant trough the technique of slicing into infinitely fine segments. The first study in deformations of fabrics was conducted by Peirce (Peirce, 1937) [1].

There are subjective and objective methods to evaluate drape. The method of objective measurement of drape is basically fabric fall by itself in specific shape according to its properties, when part of it is supported and rest is unsupported. Studies of drape were first begun by C. C. Chu, when he published a measuring method for fabric drape using FRL drape meter(1950) [2]. The measurement of drape, factors affecting drape and its use has been further discussed by Chu *et al.* (1960) [3] and Cusick (1961, 1965, 1968) [4,5,6]. The most widely accepted method of drape test is IS 8357:1977

For many decades, much of the textile literature has been devoted to find linear relation to explain the natural way in which fabrics deform or drape. However, linear concept is not applied for essentially nonlinear phenomena which occur in the dynamic interactive processes involved in textile and apparel manufacture and technology (Postle 1995) [7,8].

The mechanical analysis of fabric deformation is expanding the application of computer simulation and computer aided design. In last couple of decades many researchers have given due concentration in the area of 3D deformation of fabric, dynamic condition of fabric, simulation and modeling of fabric drape etc. Some of them to mention here are particle-based model for simulating the draping of woven cloth by Breen *et al.* [9], physical based model of fabric drape using flexible shell theory by Chen *et al.* [10], modelling the dynamic drape of garments by Stylios *et al.* [11], drape simulation of woven fabrics by using explicit dynamic analysis by Yu *et al.* [12], modeling a fabric drape profile by Lo *et al.* [13].

The testing device is designed by Yang *et al.* [14] and they defined dynamic drapeability. They has explained many parameters of dynamic condition of fabric like effect revolution of fabric, effect of airflow etc. Dynamic drape study seems to be useful as opined by Matsudaira & Yang [15], from their work on silk fabrics for categorizing the fabric.

Therefore, it is obvious that dynamic drape behavior and dynamic drape coefficient are gaining more and more popularity day by day. It is so, because it gives to some extent close to real life situation. Many research workers in abroad are working on the same since last decade, but unfortunately very few information, particularly no data base information is available. No readymade instrument is available here to study the dynamic drape behaviour of fabric.

In the present work the main emphasis has been given to develop an instrument that will be very simple, easy to use and inexpensive. Accordingly an instrument has been developed keeping above mentioned point in mind and it is described in the following section.

II. FABRICATION OF THE INSTRUMENT

A. Fabrication of the Instrument

For the fabrication of the instrument, detailed drawings has been made by using Auto-CAD based on the literature studied and in consultation with various experts in the relevant field. The instrument has been fabricated with the help of M/s A. J. Engineers, G.I.D.C., Makarpura, Baroda, Gujarat, India.

The stages of development of the Dynamic drape tester is not much relevant here, but it will be highly unjustified if some information regarding it is not provided here, because it will help others who will read this report, to understand some of the technical procedural aspect which need to take care since beginning of any development and it may help to save cost as well as time.

In the process of the fabrication of the instrument, some of the major technical problems which were encountered, and to solve those issues various alternatives were tried and the final outcome of the same are described below with a brief outlines of the problems encountered and the way it was solved and the final instrument is developed.

The first important issue was to decide upon the location of the motor. Initially it was thought of that the motor would be mounted at the base of the instrument i.e. inside the base rectangular box. It was decided so, because, if the motor is mounted at the upper part of the instrument, there will be problem of vibration. But, due to insufficient space and some more other technical problems like, transmitting the drive and the reduction of the speed, etc. it was not possible to put it there. So, it was decided to place it at the side stand of the instrument. To avoid vibration, it was thought to place the motor at the bottom part of the side stand. But, unfortunately it was also not possible to do so, because the supporting stand of the disk holder was obstructing the free fall of the fabric and it could not be managed by placing the motor in this position. Therefore, finally the motor had to place towards the upper side of the side stand only.

The next most important problems were to bring down the speed of the testing disk to minimum level to about 20-30 rpm. which is required. As per the requirement, one single phase A.C. motors need to be attached to the system to give drive. Generally, the single-phase motor of small size and with low rpm is not available in the local market. The minimum rpm of the motor that could be managed from local market was 1440, but the motor need to run with low rpm by potentiometer. The motor was not taking load beyond a certain minimum r.p.m. and this was about 350-400 rpm. Therefore, even after putting motor pulley and the disk pulley ratio as 1:5, the minimum rpm of the disk that was possible to achieve was about 80 rpm. Therefore, it was thought that the problem will be shorted out by modifying transmission of the drive. In consultation with various experts and a thorough brainstorming, various alternatives were thought of and tried couple of ideas, but initially failed.

Finally, one small converter gearbox was managed from Ahmedabad, Gujarat, India which helped to solve the problem partially. Partially in the sense, when the speed is brought down and achieved about 20rpm of the sample holder disk, but the next problem was the higher side of the rpm. With this attachment maximum rpm that was possible was about 80. Therefore, again the drive had to be modified and made a two steps pulley. With the second step of the pulley, the maximum rpm of the sample holder disk that could achieve is about 180 r.p.m, which is good enough for our existing purpose. Therefore, this was accepted and the assembly was fixed up. Some of the important drawings of the assembly of the instrument are given in Fig 1 to 3 and photograph of the instrument is given in the Fig. 4.

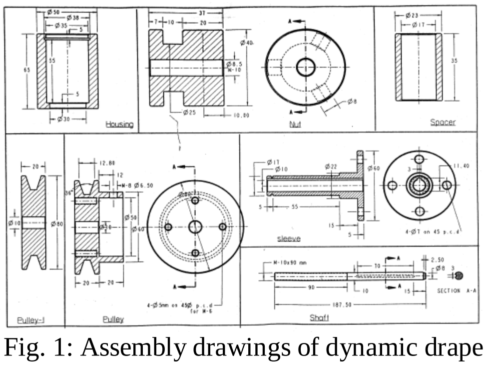


Fig. 1: Assembly drawings of dynamic drape tester

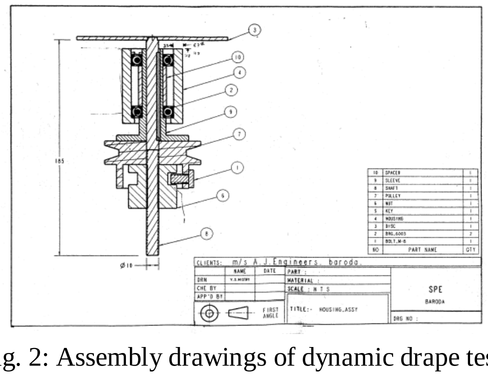


Fig. 2: Assembly drawings of dynamic drape tester

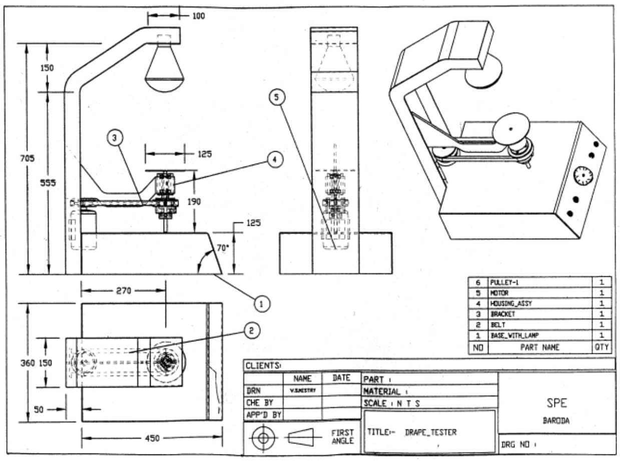


Fig. 3: Assembly drawings of dynamic drape tester

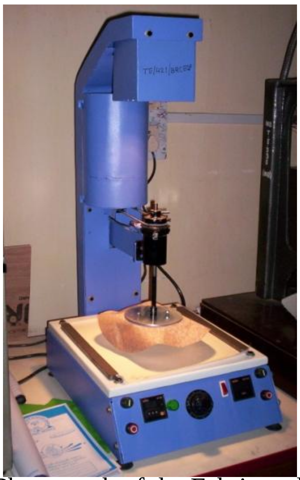


Fig. 4: Photograph of the Fabricated Instrument

The instrument has some special feature attached to it. One of its unique feature is automatic time settings. Time for rotational motion of the disk could be set and after the preset time is elapsed, the motor will automatically stops. The time could be set from 9.99 seconds to 999 hours. Therefore, a wide range of settings can be done and experimental plan can be set accordingly.

The instrument has auto standby mode on each segment. It means on power cut or on-off of main switch, it will go to standby mode, which will save the instrument from any undue damage due to power cuts. Digital Display of r.p.m . of the disk already mentioned earlier. Because of the same it is possible to set the experimentation parameters very precisely.

B. Illustrative Study of Dynamic Drape Behaviour

To illustrate the study of dynamic drape behaviour of the fabric of the above mentioned instrument, two suiting fabric samples – a plain and a twill(2/1) of following particulars have been taken:

Sample No.	**Count (Ne)**		**Yarn Density**		**Weave**
	Warp	**Weft**	**EPI**	**PPI**	
S1	14	14	56	52	Plain
S2	13	16	76	56	2/1 Twill

These fabric Samples were measured for drape coefficient at the five levels of rotations (clockwise) i.e. 0, 25, 75, 125 & 175. The test data are given in the following table no. 1& 2, Graphical representations of these data are shown in chart no. 1 to 4. In the charts, the series (i), represent drape coefficient at different r.p.m. and the series (ii) represent number of nodes at different r.p.m. The series (a) represent the trend line drawn by using linear equations and the series (b) by using logarithmic scale.

From the above mentioned tables i.e.1 & 2 and the charts i.e. 1 to 4, in general it can be seen that for almost all the cases there is increase in drape coefficient with the increase in r.p.m. It can also be noticed that compare to static (initial drape coefficient without revolutions), the change in drape coefficient with 25 r.p.m. in almost all the cases as well as for some cases with 75 r.p.m. also, is not much. In case of higher r.p.m. i.e. 125 and more there is increase in drape coefficient. It can also be noticed from the charts of number of nodes and the series (ii) that increase in drape coefficient is highly associated with number of nodes. As the number of nodes increases, the drape coefficient also increases.

Table No. 1: Sample No. S1: Drape Coefficient at Different rpm (clockwise rotation)

RPM	**Face**			**Back**		
	Draped Area	Drape coefficient%	Nodes	Draped Area	Drape coefficient%	Nodes
0	281	43.0	5	276	41.6	4
25	284	43.8	5	276	41.6	4
75	286	44.4	5	290	45.4	5
125	293	46.3	6	300	48.2	7
175	297	47.3	7	306	49.8	8

Chart No. 1: Drape Co-efficient of Sample No. S1 at different rpm, rotating clockwise

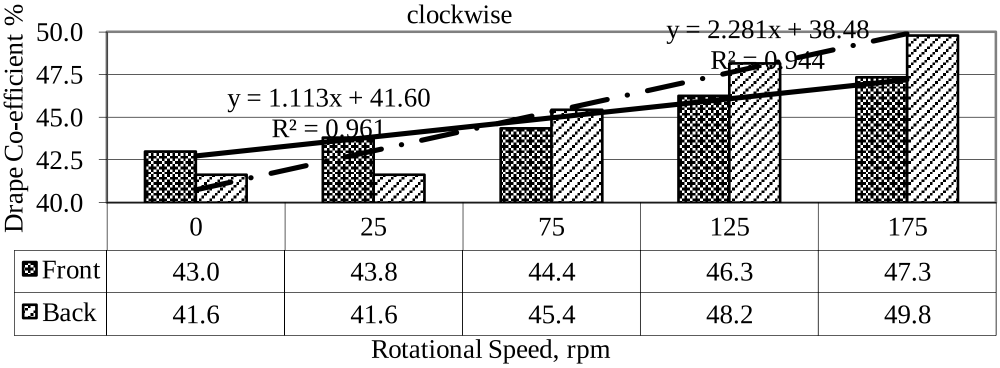


Chart No. 2: Number of Nodes for Sample no. S1 at different rpm

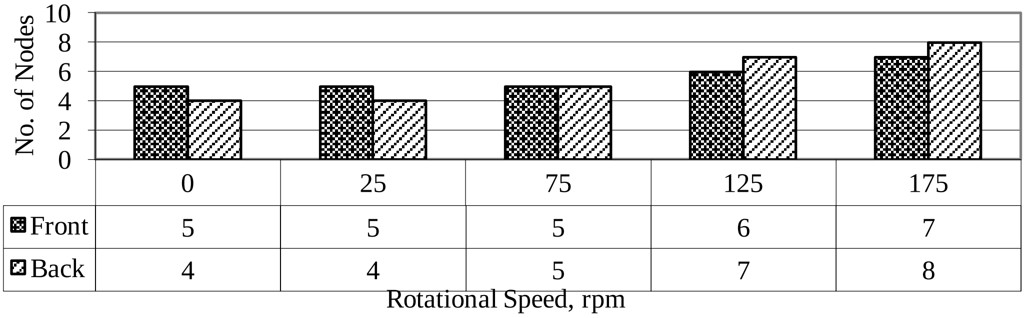


Table No. 2: Sample No. S2: Drape Coefficient at Different rpm (clockwise rotation)

RPM	**Face**			**Back**		
	Draped Area	Drape coefficient%	Nodes	Draped Area	Drape coefficient%	Nodes
0	334	57.4	5	330	56.3	5
25	338	58.5	5	331	56.6	5
75	339	58.7	5	341	59.3	5
125	349	61.5	5	345	60.4	6
175	351	62.0	5	349	61.5	7

Chart No.3: Drape Co-efficient of Sample No. S2 at different rpm, rotating clockwise

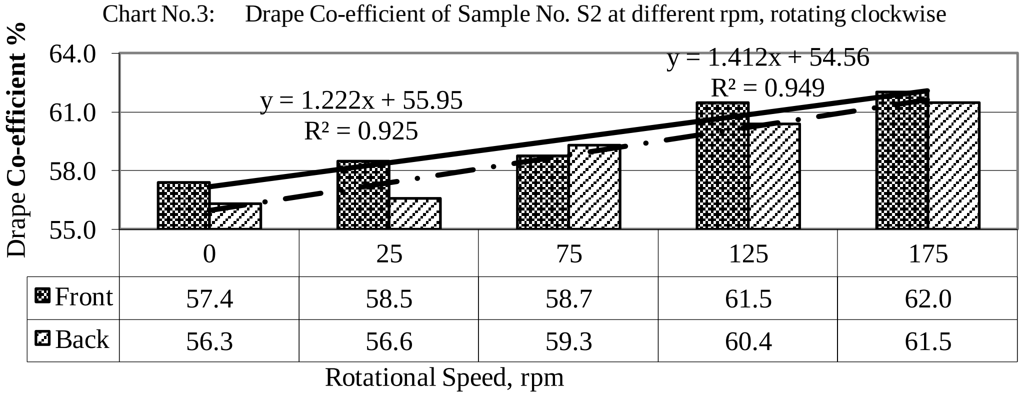
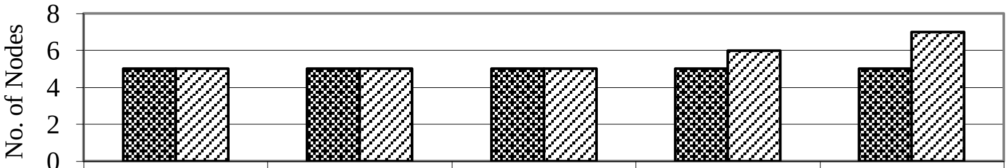


Chart No. 4: Number of Nodes for Sample No. S2 at different rpm



	0	25	75	125	175
Front	5	5	5	5	5
Back	5	5	5	6	7

Rotational Speed, rpm

III. CONCLUSION

An instrument has successfully been fabricated with various digital display and other required features for measuring dynamic drapeability of fabric, which will help in future for various studies undertaken by the various researchers. The illustrative study mentioned above indicates, some trend has been observed in these cases of the fabric tested. As the rotational rpm of the fabric increased, it's drape coefficient also increased. Trend is more prominent for the fabric samples whose drape coefficient is low i.e. limpy fabric, as in the case of fabric sample S1.

The preliminary work carried out here in the newly fabricated instrument substantiates many of the work done in the past as mentioned earlier. More elaborative study is required on the said instrument to conclude the same with more clarity and evidence. Apart from that it can be claimed that the instrument is very simple and facilitate objective measurement of dynamic drape properties of fabric. Study of correlation between various mechanical and processing parameters of the fabric and their relationship with dynamic drapeability of fabric can be studied using the said instrument. It should be very much useful by various stakeholders like fabric manufacturer, process house, quality control department, garment manufacturer, researchers, etc. We are very much hopeful that the instrument will find its new arena of application.

IV. ACKNOWLEDGEMENT

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REREFENCES

[1]. Peirce, F.T., (1937) The geometry of cloth structure. Journal of the Textile Institute, Vol.28, No. T45, pp.43-77.

[2]. Chu C C, Cumings C L and Teixeira N A (1950), "Mechanics of Elastic Performance of Textile Materials, Part V: A Study of the Factors Affecting the Drape of Fabrics – The Development of a Drape Meter", *Text. Res. J.*, **20**(8), pp 539-548.

[3]. Investigation of the Factors Affecting the Drapeability of Fabrics by C. C. Chu, M. M. Platt and W. J. Hamburger *Text. Res. J.*, **30**, 66-67 (1960).

[4]. The resistance of fabric to shear forces by G. E. Cusick, *J. Text. Inst.*, **52(9)**, T395-T406 (1961).

[5]. The measurement of fabric drape by G. E. Cusick, *J. Text. Inst.*, **59(6)**, T253-T260 (1965).

[6]. The measurement of Fabric Drape *J. Text. Inst.*, vol 59, pp. 253-260

[7]. Fabric Drape by Jacqueline R. Postle and Ron Postle, *Textile Asia*, Jan. 2000, pp 30-32.

[8]. Modelling fabric deformation as a non-linear dynamical system using Backlund transformations, Special Edition of *International Journal of Clothing Science and Technology*, vol **8**, No. 3.

[9]. A Particle-Based Model for Simulating the Draping Behaviour of Woven Cloth by David E. Breen, Donald H. House and Michal J. Wozny, *Text. Res. J.*, **64(11)**, 663-685(1994).

[10]. A Physical Based Model of Fabric Drape Using Flexible Shell Theory by B. Chen and M. Govindaraj, *Text. Res. J.*, **65**, 324-330 (1995).

[11]. Modelling the dynamic drape of garments on synthetic humans in a virtual fashion show by George K. Stylios, T. R. Wan and N. J. Powell, *International Journal of Clothing Science and Technology*, vol 8, No. **3**, 1996, pp. 95-112.

[12]. Drape Simulation of Woven Fabrics by Using Explicit Dynamic Analysis by W. R. Yu. T. J. Kang and K. Chung, *J. Text. Inst.*, 2000, vol **91**, part 1, No. 2 pp. 285-301.

[13]. Modeling a fabric drape profile by W. M. Lo, J. L. Hu and L. K. Li, *Text. Res J.*, 2003, **72(5)**, pp. 454-463 (2002).

[14]. Measurement of drape coefficients of fabrics and description of hanging shapes of fabrics Part 4: Evaluation and dynamic drape behavior of fabrics using a testing device by Yang M. and Matsudaira M., *Journal of the Textile Machinery Society of Japan,* 1999; **52(9),** T167-T175(1999).

[15]. Features of conventional static and new dynamic drape coefficients of woven silk fabrics by Matsudaira M. & Yang M., *Text. Res J.*, 2003, **73(3)**, pp. 250-255.