# SOME STUDIES ON THE NOVEL CONCEPT OF PATTERN BLENDING APPLIED TO DRAWFRAME

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**Abstract**

Work has been reported on the novel concept of blending fibres with varying proportion in real-time (henceforth called "Pattern Blending"). A commercial Laxmi-Rieter DO/2S drawframe has been modified to incorporate pair of additional two-over-two drafting systems in a two-tier arrangement with appropriate drive mechanisms. The pre-drafts of two-tier zones are altered in complementary manner (by varying speeds of respective motors) in order to vary the blend proportion in output sliver, such that the mean pre-draft and thereby the delivered sliver hank remains constant. The main drafting zone rollers are driven from other set of motors such that a constant main-zone draft is maintained. The alteration in the pre-draft are performed in real-time using the multi-level computer based digital control system to produce multi-colour pattern in sliver at commercial production speeds. Space vector modulation direct torque control (SVPWM DTC) technique has been used for the 3-phase induction motor speed control. Software has been developed to achieve the real-time automation of the drawframe to produce desired colour patterns in the sliver, which can be used to produce different visual effects in the yarns and subsequently in garments and made-ups. Effect of different mean pre-draft and with different blend proportions on sliver and yarn uniformity are been studied. Variation in the transition time from one blend proportion to other at a constant mean pre-draft is also been studied to see the effect on the sliver uniformity.

**Key words:** Pattern blending, Drawframe, Direct torque control, Space vector, Transition time, Pre-draft, Drafting system

## 1. Introduction

There is unending search for design and novelty in apparel and furnishing fabrics, to create interest and give greater sales appeal. This search for novelty applies to both men's and women's wear. Design in fabrics may be a result of finishing, such as effect created by fancy shearing, embossing, printing and napping. The type of yarn interlacement used in construction of a cloth can create novelty effect, alone or in conjunction with coloured yarns. The greatest potential for fabric decoration, however, lies in the creation and use of fancy yarns, which may be piece dyed types, in one or in several colours. The novelty of these yarns may come from the use of fibres or filaments while retaining the usual contour of the yarn or from irregular contour or from a combination of the two. When yarn dyeing and fabric dyeing is used the product usually has an overall shade. If blends of fibres with different dye affinities are used, a simple mixed dyed mixture can be produced.

Blending of fibres of different colours can be done to produce some colourful fancy effects in the fabrics. Rapid growth in the area of micro-electronics and computer technology has led to development of several computerized blending systems featuring electronic weighing, computer controlled compensations, door alarms, bi-directional close loop controls etc., which are capable of monitoring a high degree of precision in blending. But, in none of these systems, the colour composition of the product can be changed in real time so as to produce a regular effect in the yarn according to a desired pre programmed pattern. No system at present can select or reject individual colour fibre in order to control different colour components in varying proportion to get a random or pattern distribution of single colour fibre along the length of the yarn.

In blending at drawframe, the blend proportion along the sliver length can be altered using a variable feed rate of sliver [1]. The concept has been applied to commercial drawframe of Laxmi-Rieter Model DO/2S for blending two colours of material [2]. The present work reports the studies undertaken on the drawframe to study the effect of mean pre-draft and blend proportion patterns on the quality of sliver.

## 2. The System

### 2.1. Overview

The arrangement of roller drafting system for blending slivers of two colours on the draw frame in a controlled manner is shown in Figure 1. The drafting system consists of two main sections: pre-drafting section, formed by the rollers $R_{4A}$, $R_{5A}$, $R_{4B}$ & $R_{5B}$; and the main drafting section, formed by the rollers $R_{1(A\&B)}$, $R_{2(A\&B)}$ & $R_3$. The pre-drafting section consists of two 2-over-2 roller drafting system in two-tier arrangement, formed by rollers $R_{5A}$ and $R_{4A}$; and roller $R_{5B}$ and $R_{4B}$ respectively. The main-drafting section consists of a 3-over-5 roller drafting system of DO/2S drawframe of Laxmi-Rieter.

The sliver of two different colours, A and B, are fed to the two pre-drafting zones through the back rollers $R_{5A}$ and $R_{5B}$ respectively. The slivers of different colours are first pre-drafted separately, in the respective pre-drafting zones, and then fed together into the main-drafting section. Between the two drafting sections is a zone where no draft is applied on the slivers. This zone has been named as convergence zone.

Changing its pre-draft can control the ratio of any colour in the output sliver. It is very important that the linear density of the output sliver remains constant with time. This means that, if the total draft D in the main-drafting section remains constant, then the total hank being fed into main drafting section should remain constant with time. Assuming that there are same numbers of slivers for each colour and all the slivers are of the same hank, then the above mentioned condition leads to the following relationship between the pre-drafts:

$$\frac{1}{D_A} + \frac{1}{D_B} = \frac{2}{D_o} \tag{1}$$

where, $D_A$ & $D_B$ are pre-drafts of two-tier zones, and $D_o$ is mean pre-draft defined as the ratio of the total hank delivered from the pre-draft zone to the total hank fed into the pre-draft zone.

As long as drafts in the two pre-drafting zones are changed such that the mean pre-draft, $D_o$, remains constant and Equation (1) is satisfied, an output sliver with varying colour composition and constant linear density is obtained.

The pre-drafts are varied by changing the speeds of the back rollers $R_{5A}$ and $R_{5B}$ while the speeds of all other rollers remain constant. Let $S_{5A}$ and $S_{5B}$ be the surface speeds of the rollers $R_{5A}$ and $R_{5B}$ respectively. Since there is no draft in the convergence zone, rollers $R_{4A}$, $R_{4B}$ and $R_3$ will be running at the same speed. Let this speed be denoted by S.

Multiplying Equation (1) by S,

$$\frac{S}{D_A} + \frac{S}{D_B} = \frac{2 \times S}{D_o}$$

Or,

$$S_{5A} + S_{5B} = \frac{2 \times S}{D_o} = Constant \tag{2}$$

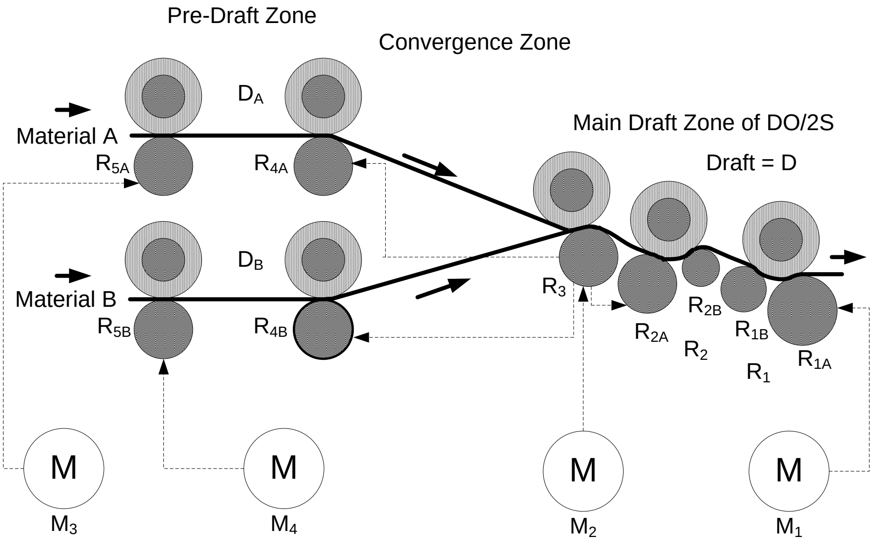



**Figure 1 Arrangement of drafting rollers**

For a constant mean pre-draft Do, Equation (2) gives a complementary speed requirement of the two back feed rollers of pre-draft zone, as illustrated by the example shown in Figure 1.

Speed profiles of the back rollers, $R_{5A}$ and $R_{5B}$ with respect to the length of the sliver to obtain a particular colour effect in the output sliver is shown in Figure 2. The centreline corresponds to the speed when the two pre-drafts, $D_A$ and $D_B$, are equal to the mean pre-draft $D_o$.

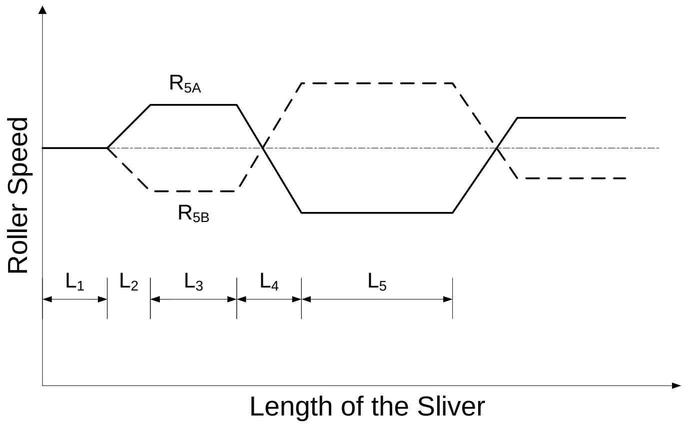



**Figure 2 Speed profiles of rollers $R_{5A}$ and $R_{5B}$**

During length $L_1$ of the output sliver, both rollers are running at the same speed and the two colours have equal ratio in the output sliver. Then the speed of the roller $R_{5A}$ increases and that of the roller $R_{5B}$ decreases at the same time satisfying the Equation (2). Due to this, the draft $D_A$ decreases while the draft $D_B$ increases. As a result, colour A starts dominating in the output sliver during length $L_3$. The opposite happens during length $L_5$ when roller $R_{5B}$ is running at higher speed and colour B dominates in the output sliver. Portions marked by $L_2$ and $L_4$ correspond to the transition periods when the output sliver has intermediate ratios of the two colours. During all transitional as well as steady states, the two back rollers have complementary speeds maintaining a constant level of the mean speed. This is necessary in order to maintain a constant linear density of the product sliver.

The pre-drafted slivers are fed into the main drafting section in such a fashion that each sliver from the upper pre-drafting zone is paired with the corresponding sliver from the lower pre-drafting zone.

### *2.2. Hardware and Communication*

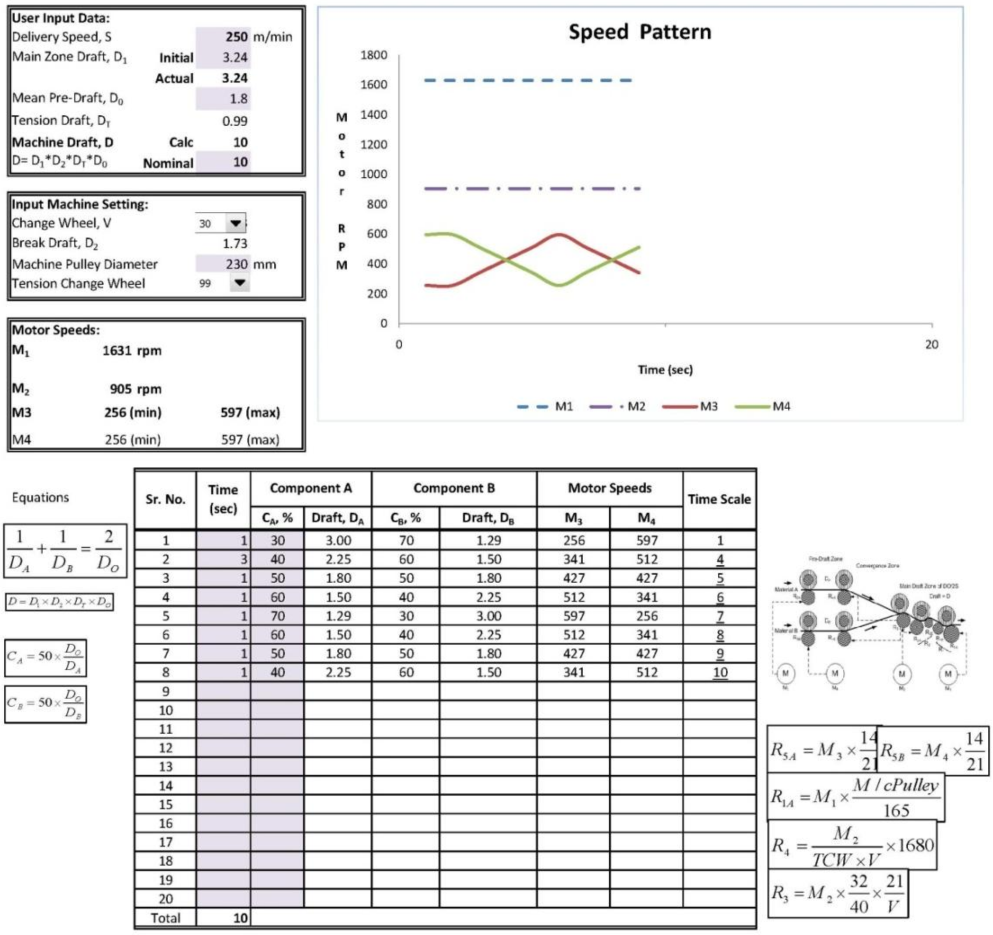
The complete pre-draft assembly is supported on a flat bed mounted at the back of the drawframe. Bottom rollers are supported on the roller saddle with needle bearings, while top rollers are mounted on needle bearing bushes with appropriate pneumatic loading arrangements. This was to make sure that the pre-draft system suits the performance requirements of the main drafting system. Alterations in the original mechanical drive of the drawframe were made to implement the new drive scheme as given in Figure 1 . New helical gear trains were designed to drive the rollers $R_{5A}$, $R_{5B}$ and $R_{3,}$ for which one extra frame was erected on the machine side. Care was taken in designing the mechanical system such that least alterations in the original system could be made.

To drive the bottom rollers through appropriate gear trains, four adjustable speeds drives each using Space vector modulation direct torque control (SVPWM DTC) sensor-less technique to control the speeds of 3-phase induction motor were used. The technique has advantages of constant switching frequency and less torque ripple over the conventional DTC [3].

The motors $M_3$ and $M_4$ operate in complementary speed mode such that the Equation (2) holds true. The other two motors $M_1$ and $M_2$ operate in differential mode such that a constant main-zone draft is maintained. The intelligence to the motor in complementary mode for colour pattern effect is provided by two-layer computer control. The background software in the personal computer (Pentium-IV), processes the required drive speed depending upon the specific colour requirements. Speed references for different motors are computed using the values of the corresponding gear ratios, roller dimensions, delivery speed of the machine, mean pre-draft, main draft and the instantaneous pre-draft requirements. Various machine parameters can be set on-line through the GUI based software seen from the screen grab in Figure 3.

For foreground processor dsPIC30F6010 is used. For initiating a change in the speeds of motor $M_3$ and $M_4$, a speed transition command is provided by the background processor to all the drivers. The background processor will set the new speed transition selectively based upon which colour has to be prominent in the delivered sliver. By adjusting the length of each colour various pattern designs can be obtained. The speed control commands from the background processor are communicated to a foreground dsPIC controller by a serial port. The foreground dsPIC controller generates PWM signals for the inverter, which feeds the current/voltage magnitude at the desired frequency based upon speed command. The schematic representation of the motor drive is shown in Figure 4. The PWM channel of the dsPIC30F6010 motor control board are used to provide triggering signals to the inverter through the gate driver circuit. Constant slip condition is set for obtaining the desired running speed. One dsPIC controller is needed for each variable speed drives. The robustness and low cost of the induction motor are the attractive features of this system.

Four dsPIC controllers, one each for four drives in the front end, controls the speed of individual motor based upon the command received from the background processor. The background processor sends the command signals based upon the real-time/manual input fed to it for the design of blended sliver.




| Sr. No. | Time (sec) | Component A | | Component B | | Motor Speeds | | Time Scale |
|---|---|---|---|---|---|---|---|---|
| | | $C_A$, % | Draft, $D_A$ | $C_B$, % | Draft, $D_B$ | $M_3$ | $M_4$ | |
| 1 | 1 | 30 | 3.00 | 70 | 1.29 | 256 | 597 | 1 |
| 2 | 3 | 40 | 2.25 | 60 | 1.50 | 341 | 512 | 4 |
| 3 | 1 | 50 | 1.80 | 50 | 1.80 | 427 | 427 | 5 |
| 4 | 1 | 60 | 1.50 | 40 | 2.25 | 512 | 341 | 6 |
| 5 | 1 | 70 | 1.29 | 30 | 3.00 | 597 | 256 | 7 |
| 6 | 1 | 60 | 1.50 | 40 | 2.25 | 512 | 341 | 8 |
| 7 | 1 | 50 | 1.80 | 50 | 1.80 | 427 | 427 | 9 |
| 8 | 1 | 40 | 2.25 | 60 | 1.50 | 341 | 512 | 10 |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
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| 16 | | | | | | | | |
| 17 | | | | | | | | |
| 18 | | | | | | | | |
| 19 | | | | | | | | |
| 20 | | | | | | | | |
| Total | 10 | | | | | | | |

**Figure 3 Background software screen grab**

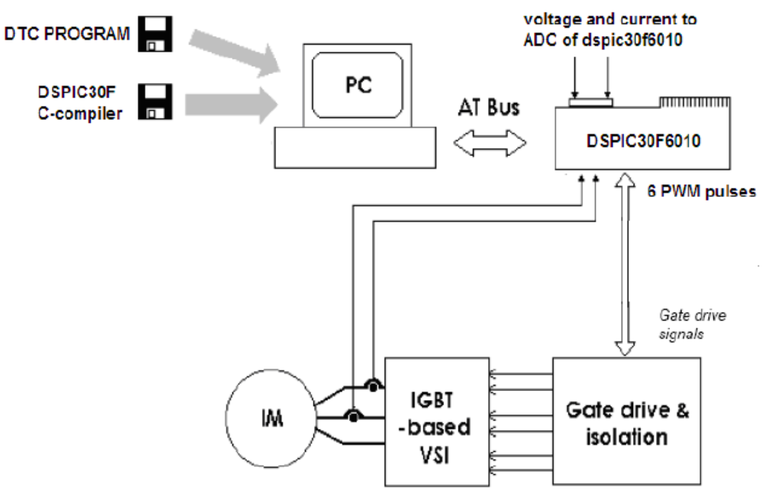


**Figure 4 System layout**

## 2.3. *Testing and Evaluation*

The machine along with the control systems has been fabricated and various slivers at different combinations of mean pre-draft and blend ratio on the uniformity of produced sliver. These are been tested for sliver quality parameters. Yarns were prepared out of the sliver produced on rotor open end system and ring frame. These yarns were tested for their unevenness and strength. Figure 5 shows the pattern visible in the ring spun yarn wound on the cone.

**Figure 5 Pattern visible in yarn**

In order to see the influence on the aesthetic look in fabric, fabrics were produced on air-jet loom and circular knitting machine. Fabrics with two different weave namely; plain and weft satin weaves were produced to see the appearance effects in fabrics. Fabric was also prepared on circular knitting machine from a single yarn with pattern to see the pattern in the knitted fabric. Figure 6 shows the stripe effect visible in the plain woven fabric produced on air-jet loom with pattern yarn in weft.

**Figure 6 Pattern yarn used as weft in plain weave fabric**

## 3. Conclusions

System of pattern blending has been developed using a commercial drawframe that is capable of producing the sliver with varying proportion of colour along the sliver length, while maintaining a constant linear density. SVPWM DTC technique has been successfully implemented which has resulted in very low torque ripples, even at low speeds of bottom rollers. The quality of the sliver and yarn produced out of the system are satisfactory.

The system has opened new dimensions in the production of the fancy yarns. System can produce wide range of colour blend ratio in single yarn and desired yarn colour patterning along the length of the yarn. Colourful fancy effect can be produced in the fabrics made even on a simple plain loom without any weft mixing arrangement. The system will provide a cost effective way of producing desired pattern effect in the fabrics, value added garments and made ups.

## 4. Acknowledgements

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