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OPTIMIZATION OF CARDING PROCESS FOR MICROMODAL AND BLENDS.

A PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

Microfibres, used alone or in blends, have created considerable interest in the apparel industry because of their potentially greater comfort and functionality. Additionally, their lower diameter, greater surface area and flexibility offer many applications in areas of non-wovens such as filtration, man-made leather, protective clothing, and wipes. Unfortunately the properties of microfibres that make them attractive for the above applications are also the same properties that lead to difficulties in processing.

The project is an account of systematic experimental investigation into the processing of Modal microfibres on a semi high production flat card. The effects of the carding process parameters such as Doffer Speed, Flat Speed and Delivery Hank on the output sliver quality were determined by assessing the Mean fibre length, Short Fibre Content and Neps after carding using the USTER Advanced Fibre Information System (AFIS) instrument and the Manual analysis by the standard Baer Sorter method with the results from both the tests showing a strong correlation. Statistical analysis of the data for optimization of the carding process incorporating the Box Behnken Model for three variables using the Systat Software indicate that all the main parameters studied have an influence on web quality. Furthermore it is shown that there is a strong correlation between the incidence of Neps and the increase in Doffer Speed during carding and between the incidence of Short Fibre Content and the increase in Flat Speed. The optimum process conditions for the study for Micromodal-Cotton blends are revealed as Moderate Doffer Speed with Finer Hank and Medium Flat Speed or Moderate Doffer Speed with Medium Hank and Higher Flat Speed. Similarly for 100% Micro Modal, the optimum process conditions are derived as Minimum Doffer Speed with Medium Hank and Maximum Flat Speed or Maximum Doffer Speed with Finer Hank and Maximum Flat Speed.

சாராம்சம்

கார்டிங் பொறியில் நுண்ணிய மொடால் மற்றும் மொடால் பருத்தி இழைகளின் தரம் அபிவிருத்தி செய்ய அதன் செயற்காரணிகளை உச்சப்படுத்துதல்.

உலக சந்தையில் மாறிவரும் தேவைகளுக்கு ஏற்ப ஆடை வடிவமைத்தல் இன்றியமையாதது. அதில், சந்தையில் புதியதாக தோன்றியிருக்கும் நுண்ணிய ரக இழைகள் (Microfibres) குறிப்பிடத்தக்க அளவில் ஆடை வடிவமைத்தலில் இடம் பெற்றுள்ளது. இவ்வகை நுண்ணிய இழைகள் இழை வலிமை, நீளும் தன்மை, உராய்வு தன்மை, வளையும் தன்மை போன்ற பண்புகளில் சிறந்து விளங்குவதால் நல்ல சீரான தன்மையுடைய (uniformity) நூற்களை உருவாக்க ஏதுவாக உள்ளது. இவ்வாறு நல்ல அடிப்படை பண்புகளை இந்த நுண்ணிய இழைகள் கொண்டுள்ளதால் இவற்றை கொண்டு தேவைக்கு ஏற்ற பண்புகளோடு ஆடை வடிவமைக்கலாம். மேற்கூறிய பல நல்ல பண்புகள் இவ்வகை நுண்ணிய ரக இழைகள் கொண்டிருந்த போதிலும் அதனை கொண்டு நூல் நூற்கும் போது இழையில் இருக்கும் அதே நல்ல பண்புகள், மிகுந்த சிரமத்தை உண்டு செய்கின்றன.

நூற்பாலையைப் பொறுத்தவரை கார்டிங் (carding) நூற்பு நுட்பத்தின் இதயமாகக் கருதப்படுவதாகும். இத்தகைய கார்டிங் பொறியில் இவ்வகை நுண்ணிய இழைகலை பயன்படுத்தும் போது நல்ல தரமான சிலைவர் (Sliver, முறுக்கப்படாத தொடர் இழைத் தொகுப்பு) தயாரிக்க குறிப்பிடத்தக்க அளவில் உற்பத்தி வேகம் குறைய நேரிடுகின்றது. எனவே இத்திட்ட நோக்கத்தில் கார்டிங் பொறியின் செயற்காரணிகளை மேம்படுத்த நல்ல தரமான சிலைவரை உற்பத்தி வேகம் குறையாமல் எடுக்க முயற்சி மேற்கொள்ளப்பட்டது. சிலைவரின் தரம், சராசரி இழை நீளம், குட்டை இழை விழுக்காடு, மற்றும் இழை முடிச்சு எண்ணிக்கை போன்றவற்றை அடிப்படையாக கொண்டு நிர்ணயம் செய்யப்பட்டது. மேலும் நர

நிர்ணயத்திற்கு பேயர் சார்டர். மற்றும் தானியங்கி கருவியான அதி நவீன இழை தகவல் இயந்திரம் பயன்படுத்தப்பட்டது. கார்டிங் பொறியின் செயற்காரணிகளாக டாபர் உருளை வேகம். (Doffer speed) முள் அட்டை வேகம் (Flat Speed) மற்றும் சிலைவர் ஹேங்க் (Sliver Hank) தேர்ந்து எடுக்கப்பட்டு மூன்று மாறிலி பாக்ஸ் - பென்ஹன் முறைப்படி புள்ளி விபர ஆராய்வு செய்யப்பட்டது.

ஆராய்வின் முடிவுகளின் படி 100% மொடால் நுண்ணிய ரக இழைகள் குறைந்த டாபர் உருளை வேகத்துடன். சராசரி ஹேங்க். மற்றும் உச்ச முள் அட்டை வேகத்துடன் இருப்பின் நல்ல தரமான சிலைவர் தயாரிக்க ஏதுவாகிறது. அதே போல் உச்ச டாபர் உருளை வேகம். பைன் ஹேங்க் (Fine Hank) மற்றும் உச்ச முள் அட்டை வேகமும் நல்ல தரமான சிலைவரை உருவாக்கும்.

மொடால் பருத்தி இழைகளின் ஆராய்வு முடிவுகளாக மிதமான டாபர் உருளை வேகம். பைன் ஹேங்க். மிதமான முள் அட்டை வேகம் ஆகியவை இருப்பின் நல்ல தரமான சிலைவரை தயாரிக்க முடிகிறது. அதே போல். மிதமான டாபர் உருளை வேகம். சராசரி ஹேங்க் மற்றும் உச்ச முள் அட்டை வேகம் ஆகியவை தரமான சிலைவரை உருவாக்கும்.

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1. INTRODUCTION

Generally, microfibre is defined as a fibre of less than 1.0 denier. In the early 1930's, man-made fibres of less than 1.0 dpf were produced even though they did not have properties that were then considered suitable for conventional textile applications. More recently, fine man-made fibres were developed with the intent to simulate silk. Microfibres less than half size of the finest silk are now available commercially and furthermore microfibres as small as 0.001 dpf are produced by Toray of Japan. US fibre producers have decided not to manufacture microfibres of lower denier than 0.5 due to the difficulties involved in converting finer fibres to yarns.

Over the last 30 years numerous developments have taken place with the cotton card. The production rate has risen by factor of 5 with the main rotating components running at significantly higher speeds. Triple taker-in rollers and modified feed systems are in use, additional carding segments are fitted for more effective fibre opening, and improved wire clothing profiles have been developed for a better carding action. Advances in electronics have provided much improved monitoring and process control. Most of these developments have resulted in enhanced cleaning of cotton fibres, reduced neppiness of the card web and better sliver uniformity.

While there are many researches concerning the processing of normal denier synthetic fibres (denier >1) in flat cards, a very few deal with microfibre processability, the evenness of their fibre webs and the requirements of the design of the machine components.

Microfibre properties are influenced in many interesting ways, as dpf (denier per filament) is reduced. These changes of properties may affect both processing conditions and potential end uses. A reduction in dpf has an immediate impact on fiber flexibility which in turn increases difficulties in processing as there are more chances of nep formation and fibre breakage at each stage where fibres are manipulated and requires a reduction in number of steps in processing. This increase of flexibility due to the reduction of dpf is related to the reduction of bending rigidity. The reduced bending rigidity of microfibres might allow fibres to be easily damaged in carding process. The bending rigidity of the fibre considerable decreases as the fibre denier is reduced.

The number of fibres per unit mass increases significantly as dpf decreases. From the view of this change, a given card should accommodate the increase in the number of fibres. As the number of fibres increase, the openness of feed stock should be improved as the lack of openness of fibres deteriorates the web quality with an increase of nep count and fibre breakage. In order to efficiently handle the increase in the number of fibres in the card, wires with high point density, high speed of card elements and proper settings becomes a necessity.

As dpf decreases, the fibre surface area per unit mass increases enormously. This in turn causes fibre to fibre and fibre to wire friction to increase, and it leads to difficulty in the fibre transfer from one element to another during carding. To avoid or reduce this problem, it was suggested that certain critical processing parameters be controlled such as the use of low throughput, wires with high point density and or high speeds of elements.

In order to overcome the above mentioned difficulties and to optimize the process parameters to achieve maximum productivity and quality in carding, there arises the necessity to investigate into the cardability of the microfibres.

2. LITERATURE SURVEY

'Carding... The heart of the spinning'

'Well Carded... is half-spun'

2.1 Introduction

There are several advantages of producing fabrics from micro denier fabrics as far as fabric properties are concerned. But due to extra fineness of fibres, critical problems are faced during processing of these fibres.

When fibres are subjected through a series of machines employed for spinning, they experience various types of stresses and strains of different magnitude.

As we go to micro level in terms of fineness (denier), the immediate dimensional change that can be foreseen is a reduction in diameter. But to what extent it gets affected can only be realized if the diameter is plotted as a function of denier covering the denier range from micro to normal level. The diameter-denier relationship, assuming circular cross-section would be

$$\frac{\sqrt{den}}{\text{fibre density}}$$

ie., $d(\mu m)$ $9.6464\sqrt{den}$ (for viscose, modal etc.)

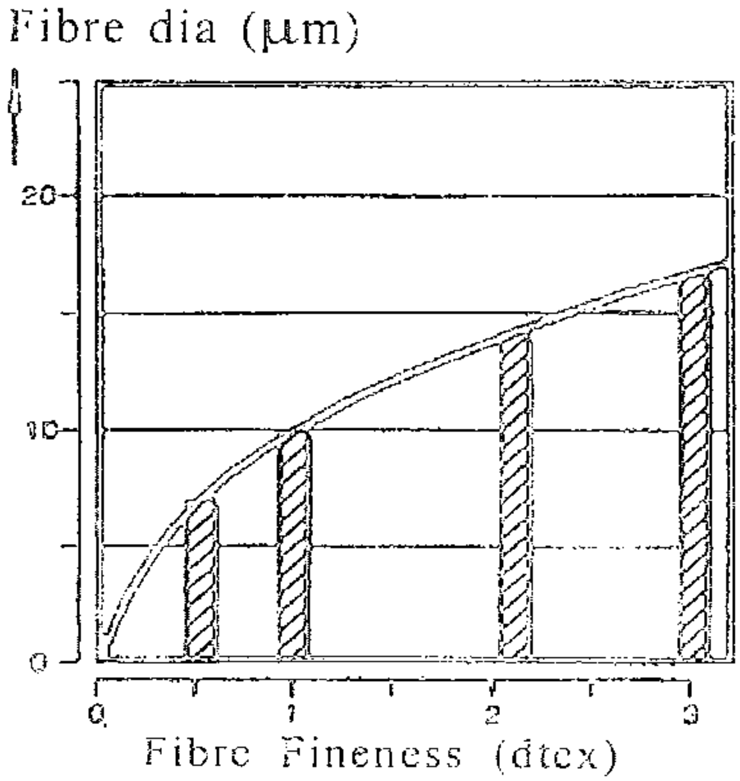


Fig 1. Relation between Fibre Diameter and Fibre Fineness.

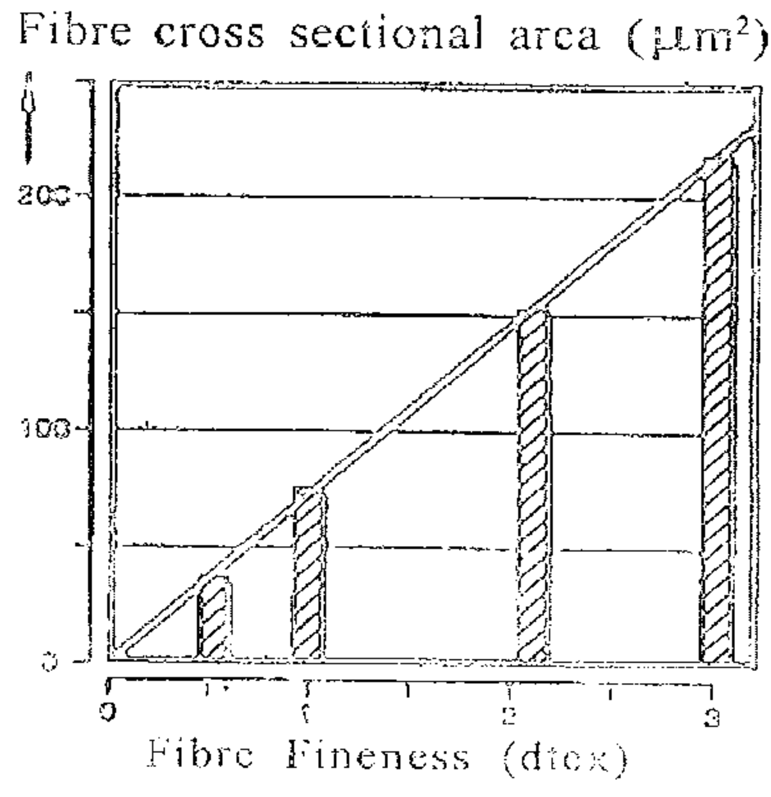


Fig 2. Relation between Fibre Cross-Section and Fibre Fineness

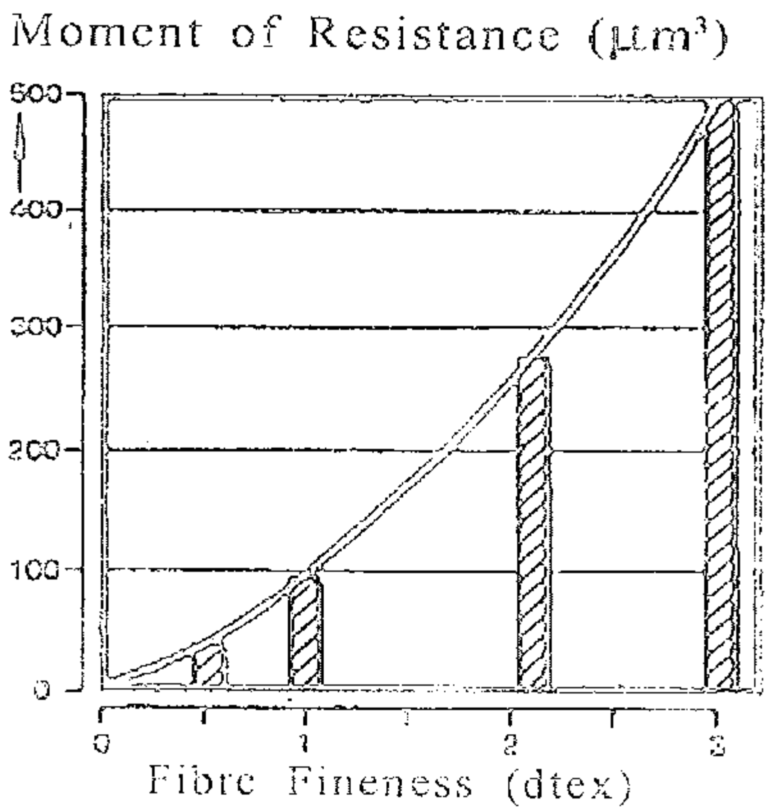


Fig 3. Relation between Moment of Resistance and Fibre Fineness

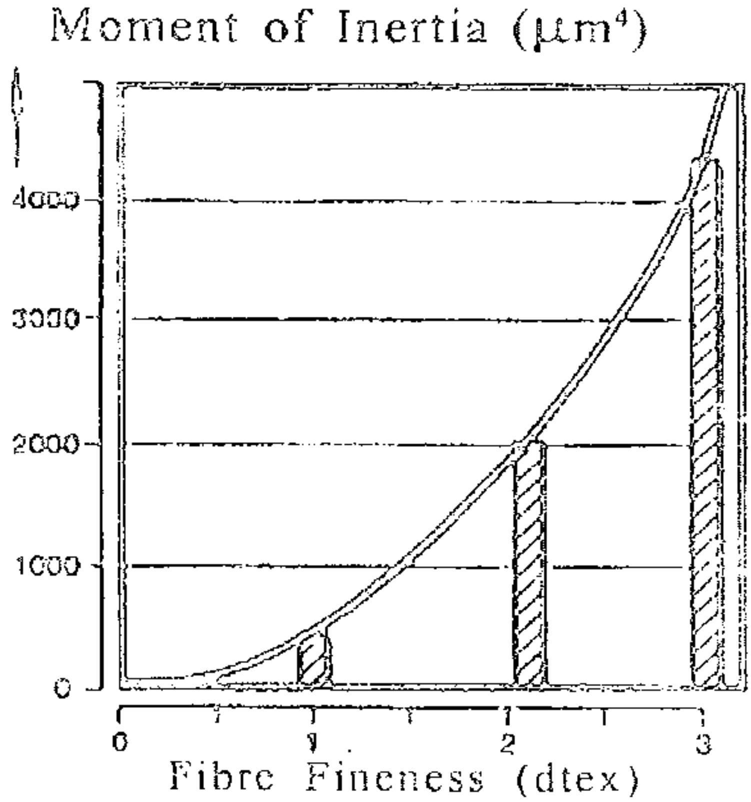


Fig 4. Relation between Moment of Inertia and Fibre Fineness.

Due to the reduction in diameter, the following properties get affected significantly.

- Flexural Rigidity.
- Tensile Strength.
- Surface Friction.

All these properties are extremely important since flexural rigidity relates to easiness with which deformation may lead to nep generation or incidence of lapping. Tensile Strength resists damage that may accrue to the fiber during processing and Surface friction influences cohesion.

The bending stress is inversely proportional to diameter^3 and bending deformation is inversely proportional to diameter^4. Hence, a small reduction in diameter through changing denier will cause a fine fiber to get deformed easily, leading to nep formation.

If the Tenacity value remains same, the absolute Tensile strength will be lower for microdenier fiber. According to some authors the actual Tenacities are sometimes lower than normal (probably due to manufacturing difficulties) fibres. This compounds the problems of processing microfibres.

Type of Fiber	Polyester			Acrylic		
Denier	1.3	0.8	0.5	0.5	0.8	1.3
Length (mm)	38	32	32	32	40	40
Tenacity (g/d)	6.32	5.53	4.92	2.8	3.8	3.6
Elongation %	19.5	19.5	24.9	20-30	30	32

Table 1. Physical Properties of Polyester and Acrylic Micro denier Fibres.

Also, it has to be taken into account that increasing fineness of fibre count is associated with

- Greater efforts in opening the fibre stock.
- Lower carding performance and
- Higher sensitivity to unfavorable spinning conditions.

2.2. Mechanical processing of Microfibres

2.2.1. Blow Room and Carding

Being sensitive fibres, the microfibres must be treated gently. Short machines, short pipe connections, short air transport and less number of machines rightly selected show the way for the solution of the problem. Since a self controlled stroke is necessary for a good opening, the components which pull out the fibres from the fiber tuft must be so shaped that the load on fiber is minimum. The ideal components may be pins and needles on the pin roller and needle on the licker-in. There is no other gentler component as the needles which because of their fine points penetrate practically with no resistance in the lap. The round needle obstructs the sharp cutting on the edges and or bending of the fibre. Properly selected and properly processed saw tooth are harmless, especially when they only convey or take over fibres in an opened condition.

With the cleaners as well as with the cards the stresses in the fibres can be influenced through the setting. In openers and cards, the machine and settings are be selected as used in the case of finest cotton. For fine cotton, cylinders of 865 teeth per sq inch are selected. For processing microfibres, either the above or cylinders with 1080 teeth per sq inch can be used. The wire breast angle 25 degrees may be used for fibres with less number of neps. The flat wire density would be 450-500 PPSI. As far as the card cylinder speed is concerned, it must be assumed that because of the lower centrifugal force of the microfibres the speed should be somewhat higher in order to prevent the fibres from lodging at the base of the clothing. In this case the number of carding points on the card cylinder should not be excessive if fibre damage is to be kept within reasonable limits.

Most modern cards (Trutzschler DK 760, Rieter C4 etc) with presently available facilities are capable of handling microdenier fibres. In 1980s it was possible to produce 30 - 40 kgs/hr. The success can be shared by the fiber and machinery manufacturers. The new and accurate machines, which have the modern metallic clothing have a remarkable share in this development.

2.2.2. Drawing

On modern drawframe, it may be necessary to reduce the delivery speed to 400m/min in order to reduce the incidence of roller lapping which is likely to be more because of larger area of contact with the rollers and its low bending rigidity. Higher top roller load may be used (around 20-25%). More frequent grinding or buffing is required. Whenever the drawframes are stopped the pressure on the top rollers should be in released condition. Prolonged holding of fibres under pressure may cause thermal damage.

2.2.3. Roving Frame

Due to higher cohesive force between the fibres the twist level used may be a little less as compared to normal denier fibre (ie., TM 0.85-0.9). Higher top roller pressure should be used. The top rollers need to be buffed more frequently. Flyer with highly polished surface may lead to more fly generation and hence a matt finish would be preferable. Fly top with more number of ribs may be more advantageous.

2.2.4. Ring Frame

The sliver and drafted fiber web being very thin care has to be taken so that proper drafting takes place. Use of softer cots may be useful as the fibres will be gripped better, thereby reducing slippages. Higher break draft or wider setting (back zone) may be required due to higher cohesiveness of roving. For fibres finer than 0.5 denier very high spindle speed may be avoided as it is likely to damage the fiber. The traveler speed should be restricted to 30 – 35 m/sec along with smaller ring and shorter lift. For 0.8 denier polyester fiber the experience shows that the yarns can be spun at same spindle speed as conventional fibres. In addition, it is possible to reduce twist of the yarn due to presence of higher number of fibres per cross-section. (Arindam Basu)[1]

2.3. Related Research on Microfibre Carding

Distribution of tuftlet sizes by taker in action seems to be a normal mass distribution and author report that further research is required on the effect of taker in parameters, fibre properties and blowroom process on the tuftlet size distribution. A better understanding is required of the fibre mass transfer from takerin to cylinder and on the benefits of combing segments, and triple licker in systems. Each flat acquires 2/3rd of its load at the beginning of the cycle of contact with cylinder and separation of given tuftlet occurs over few flats. High teeth densities and low cylinder speeds per gram however, it still remained in good working condition. Some of the results are shown in the Table 2. (Arindam Basu)[1]

Fiber	Fineness	Length	Prodn.	Nep	Card Sliver Values		
					Avg Len Before – After	**Weight CV%**	**Uster U%**
Acryl Bayer Dralon	0.6	32	35	4	28-27.9	1.2	3.9
Polyester Diolen44	0.8	40	30	1	34-32	1.5	3.4
Polyester NN	0.7	38	35	3	32.29	1.5	3.8
Polyester Skyron	0.8	38	40.1	1	33-31	1.3	3.4
Polyester Montefibre	0.85	38	35	3	29-28	1.5	2.7

Table 2. Carding Results for Microfibre processing.

3.OBJECTIVES

- Optimization of process parameters in carding machine for the processing of Micromodal and blends in order to achieve better productivity and quality.

- Optimization of process parameters involves a study on the Doffer Speed, Flat Speed and Delivery Hank.

- Optimization of quality is done through a study on parameters like Mean Fibre Length, Short Fibre Content and Neps in the carded sliver.

- Optimization of the results of the study will be done using Box-Behnken design of statistical analysis (for three variables) using the Systat software as an interface for interpretation.

4. PROJECT METHODOLOGY

4.1. Work Plan

Procuring the required raw materials for conducting the study

↓

Design of Experiments

↓

Conducting experiments on carding m/c by varying process parameters.

↓

Testing

↓

Analysis of the results and interpretation for optimization

↓

Conclusion

4.2. Experimental Design

4.2.1. Combinations of the process parameters

According to the experimental design to be used for the statistical interpretation, ie., the Box Behnken Model of Statistical Interpretation, 15 combination runs were selected. The run codes and combination runs are tabulated below in Table 3 and Table 4 respectively.

Run Code	Doffer Speed	Delivery Hank	Flat Speed
	X1	X2	X3
1	9	0.155	6
0	7.5	0.17	4
-1	6	0.185	2

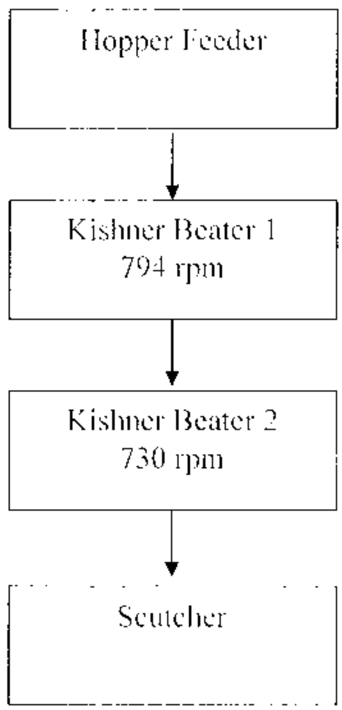
Table 3. Run Code for Various Factors.

Run No	Doffer Speed (rpm)	Delivery Hank (Ne)	Flat Speed (in/min)
1	6(-1)	0.185(-1)	4(0)
2	9(+1)	0.185(-1)	4(0)
3	6(-1)	0.155(+1)	4(0)
4	9(+1)	0.155(+1)	4(0)
5	6(-1)	0.170(0)	2(-1)
6	9(+1)	0.170(0)	2(-1)
7	6(-1)	0.170(0)	6(+1)
8	9(+1)	0.170(0)	6(+1)
9	7.5(0)	0.185(-1)	2(-1)
10	7.5(0)	0.155(+1)	2(-1)
11	7.5(0)	0.185(-1)	6(+1)
12	7.5(0)	0.155(+1)	6(+1)
13	7.5(0)	0.170(0)	4(0)
14	7.5(0)	0.170(0)	4(0)
15	7.5(0)	0.170(0)	4(0)

Table 4.Combination Runs for the three parameters

4.3. Process Flow and Machinery Settings

4.3.1. Blow Room



- Arms attachment - 3 arms
- Arms back pin density - 3.5mm [Thickness]
- Setting between parts - Feed Roller to Beater 8mm
- Lap weight - 13.50 kg [Both 100% & Blend]
- Lap length - 45 yards
- Hank - 0.0017 Ne
- Calendar roller pressure - 1500 Kg

4.3.2. Carding

- Lickerin speed - 550 rpm
- Cylinder speed - 260 rpm
- Flat Speed - 4 inches minute
- Wire points
    1. Cylinder - 720 PSI
    2. Doffer - 588 PSI
    3. Lickerin - 3 inch

4. Flat - 420 PSI

- Type of wire - Metallic wire
- Settings:
  1. Cylinder to Doffer - 4/1000"
  2. Lickerin to Cylinder - 7/1000"
  3. Cylinder to Flat - 12/1000" , 12/1000" , 12/1000" 10/1000" , 10/1000"
- Waste %
  1. 100% Modal - Actual 3.22% Std 2.5%
  2. 70/30 Micromodal-Cotton - Actual 2.52% Std 3.2%

4.4. Testing Details

For evaluating Mean Length, Short Fibre Content and Neps, both manual and Automatic machine mode (AFIS) were used.

Test	Instrument	Sample Size	Readings	Parameters Measured
Machine Mode	Uster AFIS Multidata Module	0.450 g per Sample	4 Readings per sample	Mean Length in mm. Short Fibre Content %. Neps Per Gram.
Manual Testing Mode	Baer Sorter	2 samples of 15mg each	Average of values from 2 patterns per sample	Mean Length mm. Short Fibre Content in %.
	Manual Counting	5 samples of 1 g each	Average of values from 5 countings.	Neps Per Gram.

Table 5: Details of Machine mode and Manual mode Testing.

4.4.1 Machine Testing:

Advanced Fibre Information System (AFIS) is based on aeromechanical fibre processing followed by electro optical sensing and then by high speed micro processor based computing and data reporting. The fibres penetrate a collimated beam of light and scatter and block the light in proportion to their optical diameter and direct relation to their time of flight through the sampling volume. From the wave forms which are micro seconds in deviation, the pertinent data are acquired, analyzed and stored in the host computer for interpretation.

The AFIS Nep classification module counts and sizes seed coat neps. The Classification module is able to identify the distinct electrical wave forms produced by fibres, fibre clumps and seed coat neps etc. It uses digital signal processor to classify all incoming wave forms and calculate nep size.

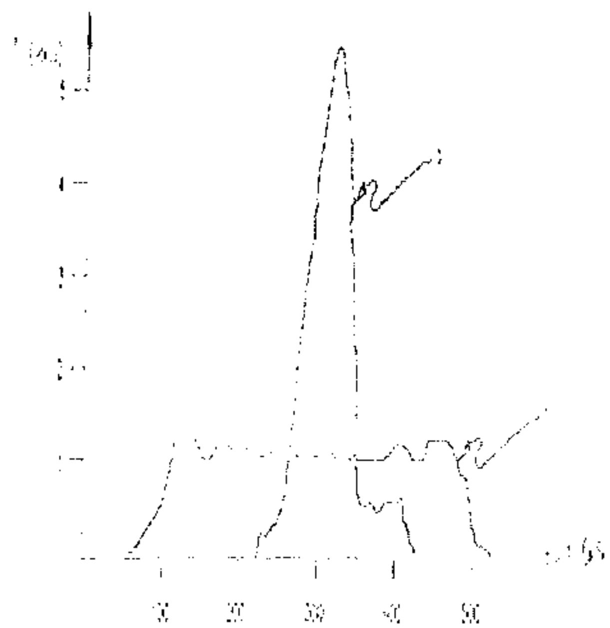


Fig 5: AFIS Waveforms for Neps and Normal Fibre

4.4.2. Manual Testing:

For estimation of the Mean Length and Short Fibre Content. Baer Sorter instrument was used. In this method of length measurement, we can evaluate different length groups of fibres both visually and numerically. The basic procedure used in comb sorters is implemented to construct the comb sorter diagrams from which the fibre length parameters are estimated. (SITRA)[5]

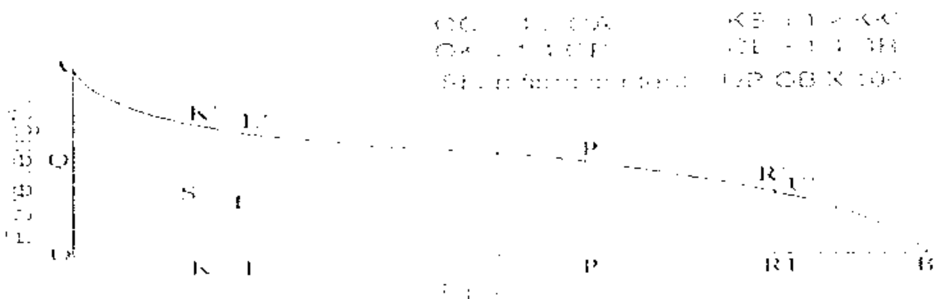


Fig 6 : Staple Length Diagram from Baer Sorter Testing

4.5. Statistical Interpretation

Box Behnken Model Of Statistical Inference is the Statistical Model Used for Interpretation. Box-Behnken designs are used to estimate quadratic Contour Plots. These designs combine a two-level factorial design with an incomplete block design. They are efficient, requiring fewer runs than the corresponding full factorial design. They can be somewhat easier to implement than the corresponding central composite design. They require factors to be measured at only three points (instead of five) and they avoid using points that are extreme on all factors. Box-Behnken designs can be created for several different experiments involving between 3 and 16 factors. Many Box-Behnken designs are rotatable (or nearly rotatable),meaning that the variance of estimates is constant (or nearly constant) for all points equidistant from the center of the design.

5. RESULTS AND DISCUSSIONS

5.1. Fibre Test Results

[As per BISFFA 1998 & ASTMD-3822-01 Testing Standards]

Fibre Tested: Micromodal Fibre Samples

5.1.1. Fibre Denier and Single Fibre Tenacity

Mean Denier	0.96
CV% of Denier	10.8

5.1.2. Single Fibre Strength And Elongation

Tenacity g/ Denier	3.71
CV% of Tenacity	8.3
Elongation %	14.7
CV% of Elongation	9.6

5.2. Results and inferences for Micromodal-Cotton Blend

The detailed mean test results of the previously referred characteristics for the Micromodal-Cotton blend samples are given in the Table 6.

Run No	X1	X2	X3	Neps AFIS	Neps Manual	Mean Length mm AFIS	Mean Length mm Manual	Short Fibre Content % AFIS	Short Fibre Content % Manual
1	-1	-1	0	14.67	13.3	25.4	30.6	12.45	6.522
2	1	-1	0	17.5	15.5	25.63	29	12.65	7.285
3	-1	1	0	18.75	21.75	25.68	29.24	11.93	5.596
4	1	1	0	19	26.8	25.33	29.02	11.67	7.027
5	1	0	-1	25.75	20	25.38	29.82	12.35	5.994
6	-1	0	-1	17.75	19.5	26.65	29.57	9.23	4.629
7	1	0	1	18.67	20.8	26.53	29.86	9.73	6.317
8	0	-1	-1	17.5	16.2	26.97	30.5	7.78	4.65
9	0	1	-1	18.5	18.2	26.15	30	10.65	6.329
10	0	-1	1	13.5	18.5	25.63	29.98	11.53	6.301
11	0	1	1	15.33	20.75	26.48	30.23	10.08	6.181
12	-1	0	1	11.5	13.25	27.5	31.47	9.5	5.671
13	0	0	0	20.33	19.25	25.53	30.6	11.35	6.268
14	0	0	0	16.5	17.5	26.45	30.96	10.48	6.593
15	0	0	0	17.33	19	25.4	29.66	11.5	6.515

Run Code	Doffer Speed X1	Delivery Hank X2	Flat Speed X3
1	9	0.155	6
0	7.5	0.170	4
-1	6	0.185	2

Table 6. Mean Results of Sliver Quality for Micromodal-Cotton Blend

Using Software such as Systat, subsequent to feeding of all the main results of fifteen runs for each Response (Quality Parameters), the coefficients of response surface polynomial second order equation given below is derived along with the Regression Coefficient (R^2)

$$Z = B_0+B_1X_1+B_2X_2+B_3X_3+B_{12}X_1X_2+B_{13}X_1X_3+B_{23}X_2X_3+B_{11}X_1^2+B_{22}X_2^2+B_{33}X_3^2$$

The polynomial equation and regression constant found are tabulated in Table 7 given below.

Parameter	Testing	Quadratic Equation	Correlation Coefficient - R^2
Neps Per Gram	**AFIS**	$17.812-2.344X_1+1.112X_2-2.563X_3+0.786X_1^2-1.424X_2^2-0.770X_2X_1$	0.789
Neps Per Gram	**Manual**	$18.312+1.912X_1+3.394X_2-0.906X_3+1.230X_1^2-1.358X_3^2+0.713X_2X_1-1.763X_3X_1-0.850X_3X_2$	0.872
Mean Length	**AFIS**	$25.833-0.295X_1+0.124X_3-0.058X_1^2-0.265X_2^2+0.740X_3^2-0.145X_2X_1+0.075X_1X_3+0.417X_2X_3$	0.650
Mean Length	**Manual**	$30.047-0.701X_1-0.206X_2+0.188X_3-0.518X_1^2-0.408X_2^2-0.179X_3^2+0.330X_1X_2+0.188X_3X_2$	0.761
Short Fibre Content	**AFIS**	$11.175+0.511X_1+0.491X_2-0.152X_3-0.332X_2^2-0.829X_3^2-0.530X_3X_1-1.035X_2X_3$	0.746
Short Fibre Content	**Manual**	$6.439+0.526X_1-0.359X_3-0.183X_2^2-0.772X_3^2+0.167X_1X_2-0.180X_1X_3-0.450X_2X_3$	0.867

Table 7 : Quadratic equations and Regression Constants for Micromodal-Cotton Blend.

The Response Surfaces are drawn for the above mentioned quadratic equations. The Contour Plots for the Response Surfaces are plotted. The Optimum process conditions towards minimizing Neps Per Gram and Short Fibre Content and maximizing Mean Length are derived by overlapping the Contour Plots to find the common area of the Contour meeting the above requirements. The common area gives the most Optimum process condition required.

5.2.1. Effect of Process Parameters on Neps per gram.

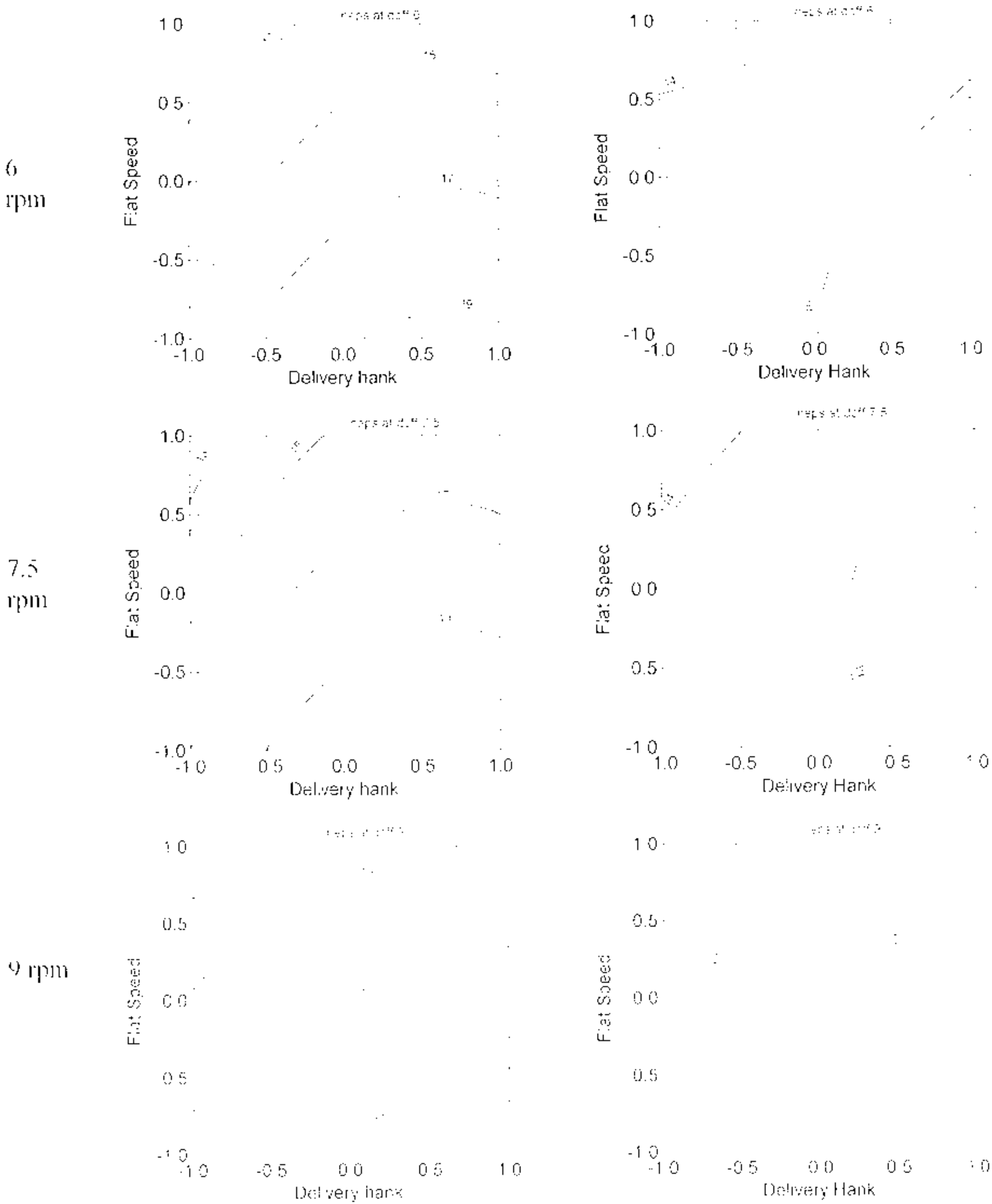


Fig 7: Contour Plots for Neps Per Gram at Different Doffer Speeds

Fig 7(a): AFIS Testing **Fig 7(b): Manual Testing**

0.155 Ne

0.170 Ne

0.185 Ne

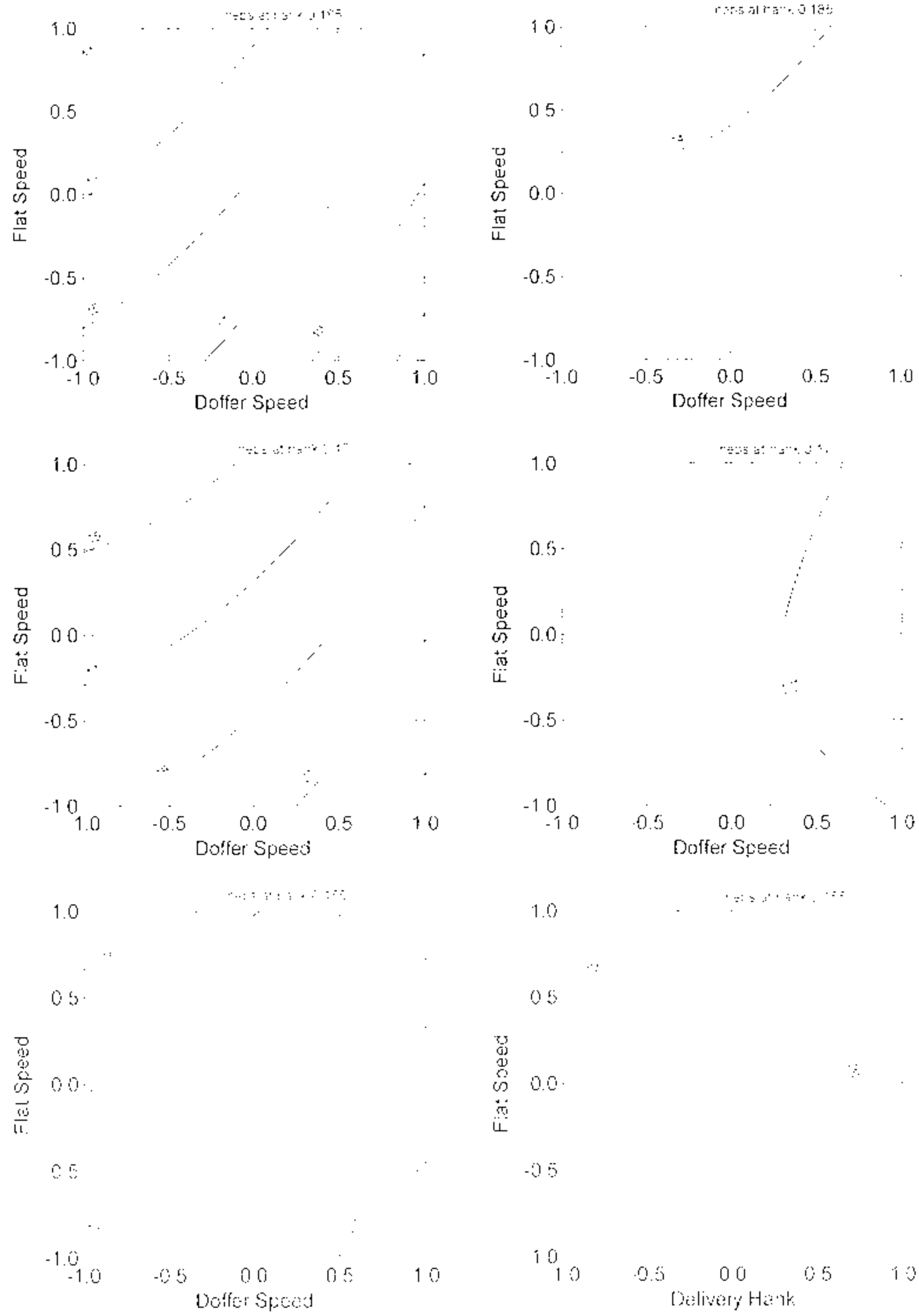


Fig 8: Contour Plots for Neps Per Gram at different Sliver Hanks

Fig 8 (a): AFIS Testing **Fig 8 (b): Manual Testing**

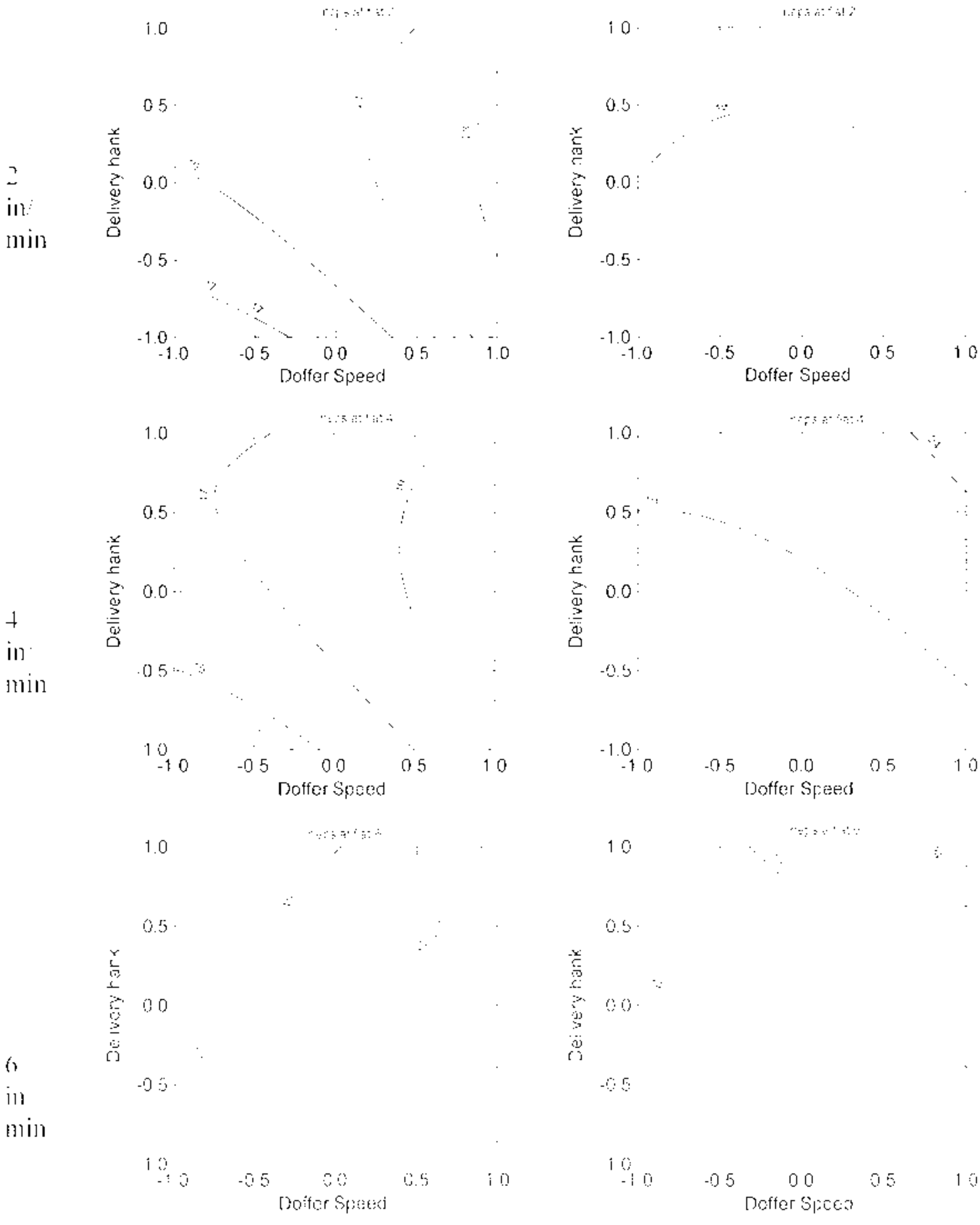


Fig 9: Contour Plots for Neps Per Gram at Different Flat Speeds

Fig 9(a): AFIS Testing **Fig 9(b): Manual Testing**

5.2.1.1. Effect of Delivery Hank and Flat Speed on Neps Per Gram at different Doffer Speeds:

- Graphs are depicted in fig 7 (a,b) for the AFIS and Manual Testing. On Studying the graphs, the following can be observed
- Irrespective of the Doffer Speed, minimum Neps Per Gram is observed for higher Flat Speed and finer Delivery Hank.
- There is an overall increase in Neps Per Gram noticed, with increase in Doffer Speed, for any given Flat Speed or Delivery Hank (38% increase for AFIS results and 35% increase for Manual results)
- For the results from the Manual Testing, the variations observed for higher Doffer Speed is slightly more significant and for other cases, there is no significant change.
- These inferences are in line with the general expectations for this parameter as the increased Doffer Speeds increases the throughput giving less time for carding action to perform the disentanglement of neps.

5.2.1.2. Effect of Doffer Speed and Flat Speed on Neps Per Gram at different Delivery Hanks:

- Graphs are presented in fig 8(a,b) for the AFIS and Manual Testing.
- Irrespective of the Delivery Sliver Weight, minimum value of 11-15 Neps Per Gram is noticed for lowest Doffer Speed and highest Flat Speed and maximum value of 21-22 Neps Per Gram is observed for higher Doffer Speed and lower Flat Speed.
- The increase in weight of Delivery Sliver results in increase in Nep level to the tune of 2-4 Neps Per Gram for AFIS and 4-7 Neps Per Gram for manual due to increased quantity of material to be handled in unit time by the carding elements.
- For the increase in Delivery Sliver Weight, manual testing shows a higher values for all the ranges of Doffer and Flat Speeds.

5.2.1.3. Effect of Doffer Speed and Delivery Hank on Neps Per Gram at different Flat Speeds:

- Graphs are given in fig 9 (a,b) for the AFIS and Manual Testing
- As observed in earlier cases, irrespective of the Flat Speed, lower values of Neps are obtained for lower Sliver Weights and lower Doffer Speed (12-19 Neps Per Gram for both AFIS and Manual Results).
- For the highest Doffer Speed and Sliver weight, in comparison with the lowest, there is an increase of around 7 Neps Per Gram in AFIS testing and 4-13 Neps Per Gram for Manual Testing for the range of Flat Speeds used in the study.

5.2.1.4. Optimum Parameters (Neps Per Gram – Blend)

The following are the optimum process parameter combinations derived from the procedure explained earlier.

	Doffer Speed	Delivery Hank	Flat Speed	Neps Per Gram (AFIS)	Neps Per Gram (Manual)
1.	Medium (7.5 rpm)	Fine (0.185 Ne)	Medium (4 in min)	14.75	15.25
2.	Medium (7.5 rpm)	Medium (0.170 Ne)	Maximum (6 in min)	15.20	15.50

Table 8: Optimum process conditions derived for Neps Per Gram (Blend).

5.2.2. Effect of Process Parameters on Mean Length.

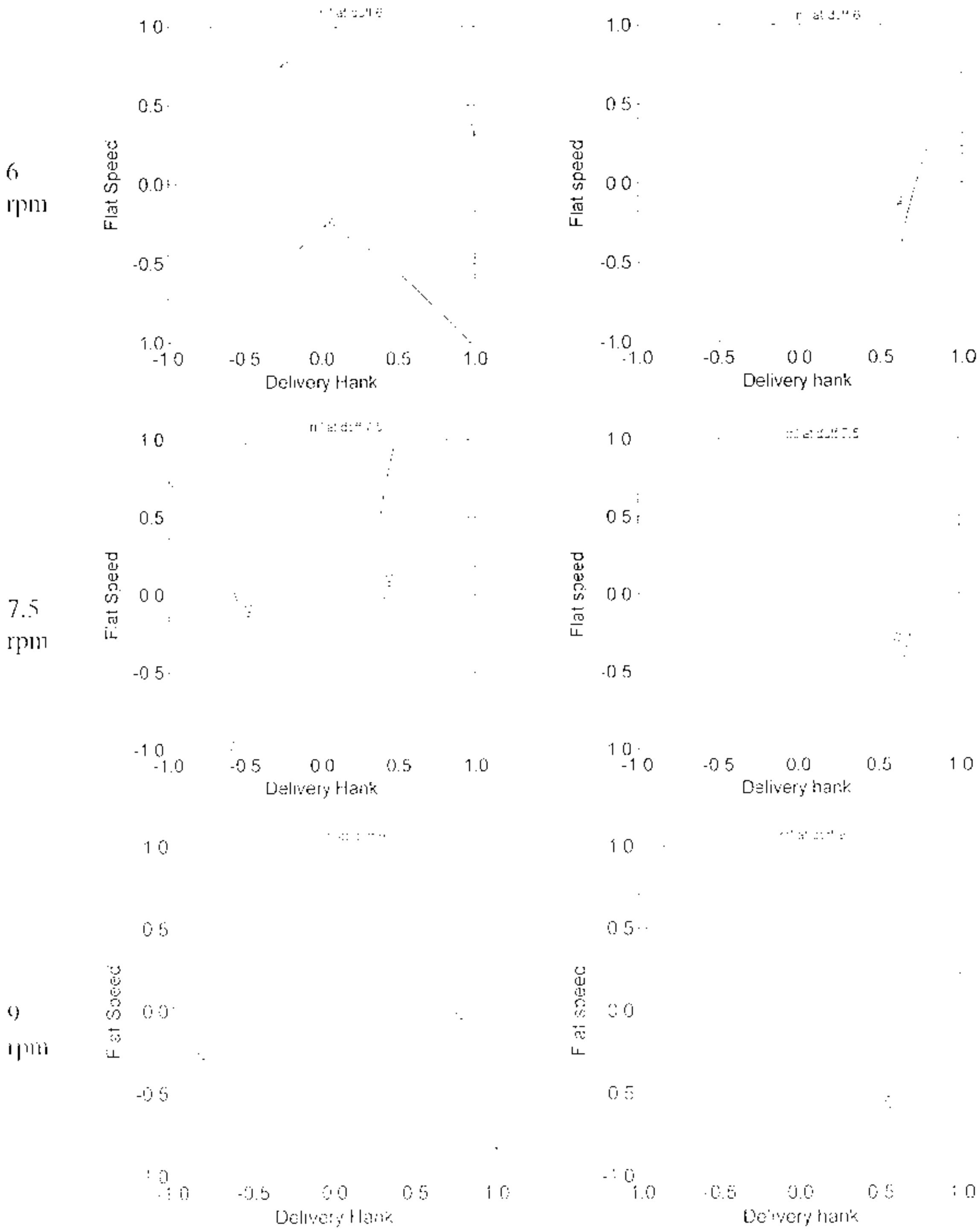


Fig 10: Contour Plots for Mean Length at Different Doffer Speeds

Fig 10(a): AFIS Testing

Fig 10(b): Manual Testing

0.185 Ne

0.170 Ne

0.155 Ne

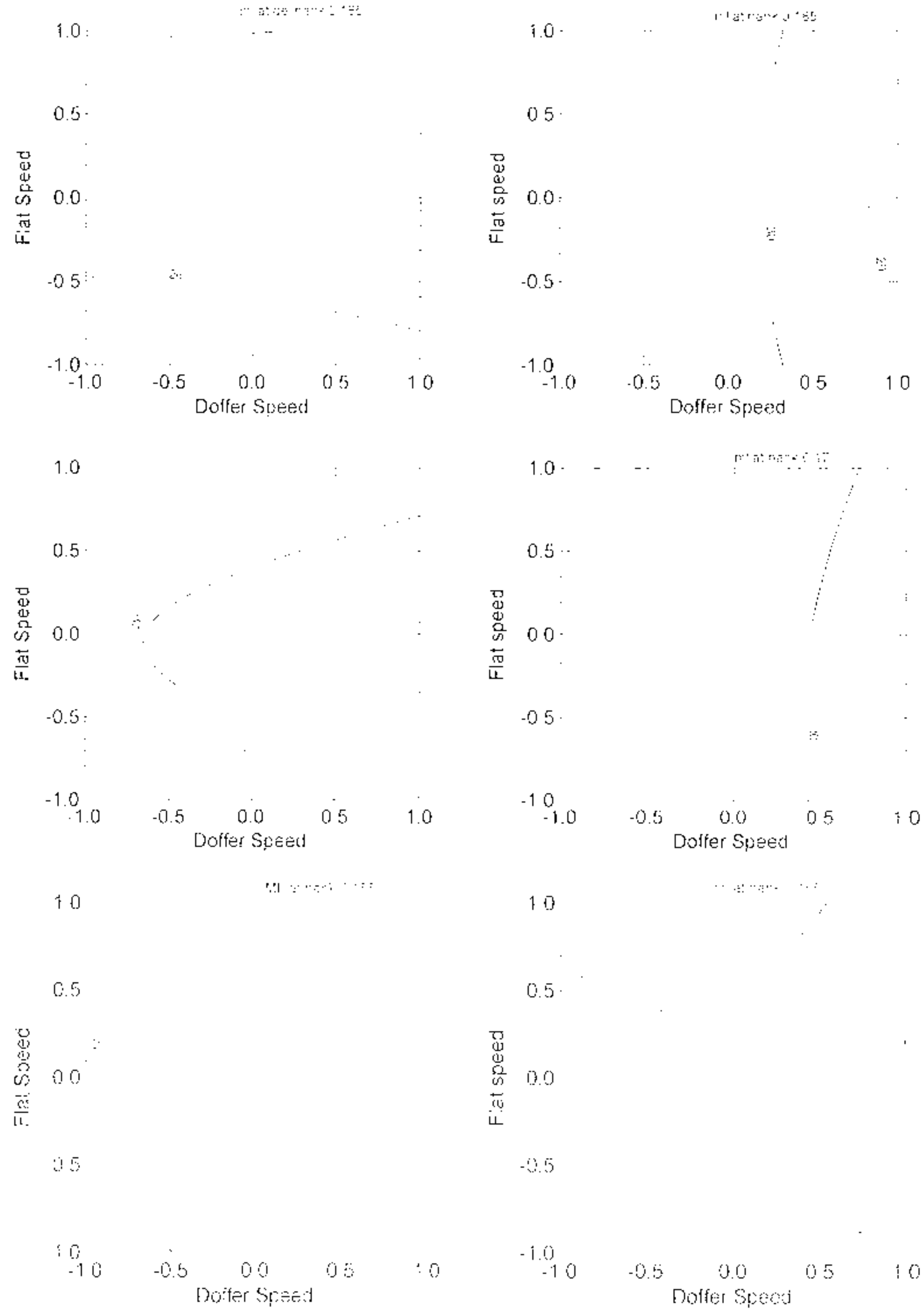


Fig 11: Contour Plots for Mean Length at Different Delivery Hanks

Fig 11(a): AFIS Testing **Fig 11(b): Manual Testing**

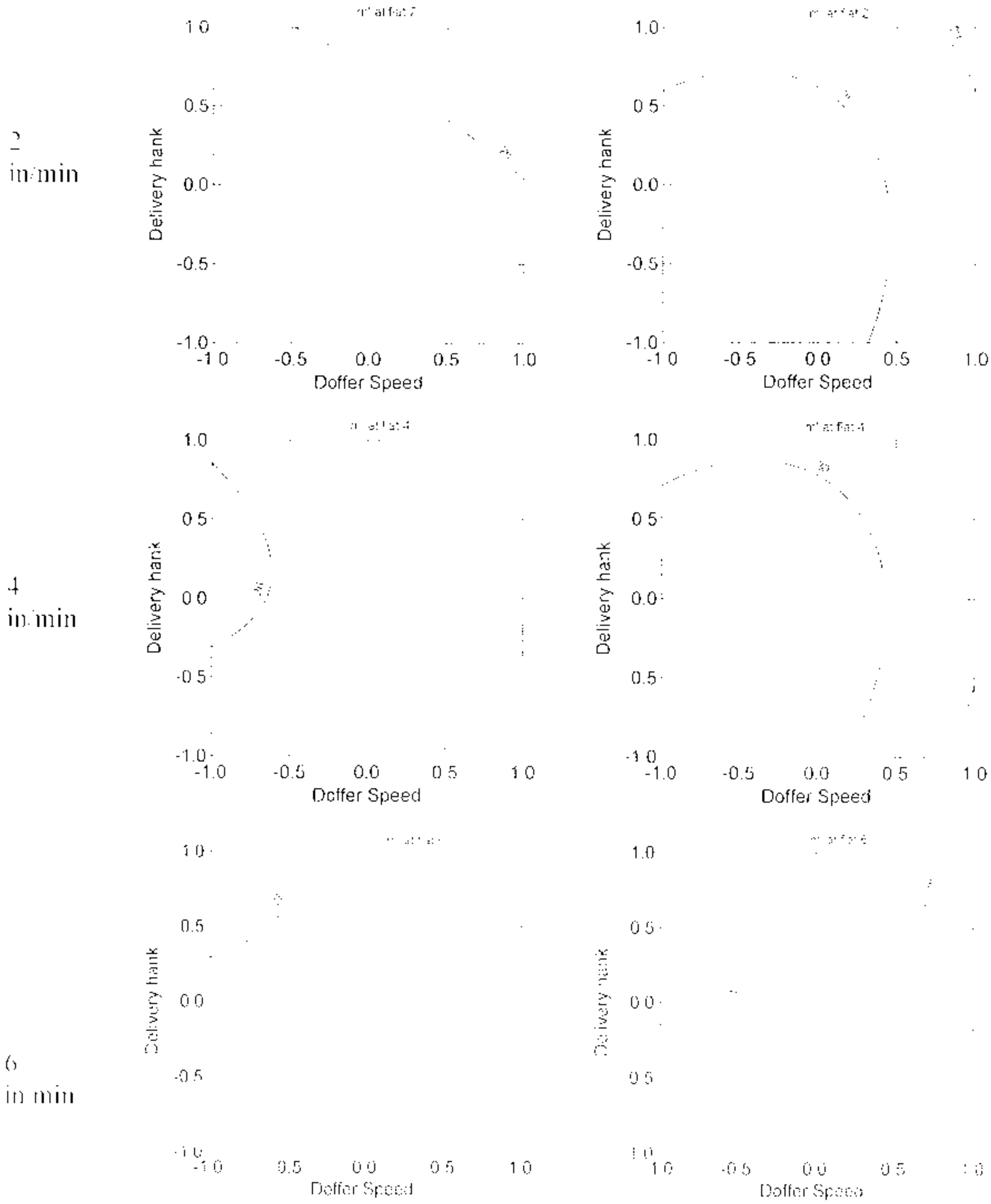


Fig 12: Contour Plots for Mean Length at Different Flat Speed

Fig 12(a): AFIS Testing **Fig 12(b): Manual Testing**

5.2.2.1. Effect of Delivery Hank and Flat Speed on Mean Length at different Doffer Speeds:

- Graphs are provided in fig 10 (a,b) for the AFIS and Manual Testing
- The Mean Length of the delivery sliver obtained is higher for lower Doffer Speed (values of the range 26-27mm for AFIS results and 29.5-30.9mm for Manual results) than for higher Doffer Speed (25.1-26.4mm for AFIS results and 28.8-29.2mm for Manual results) for the full range of Flat Speeds and Sliver Weights.
- The influence of Flat Speed on Mean Length is insignificant compared to the delivery Sliver Weight.

5.2.2.2. Effect of Doffer Speed and Flat Speed on Mean Length at different Delivery Hanks:

- Graphs are produced in fig 11 (a,b) for the AFIS and Manual Testing .
- The results from the AFIS testing show a significant Mean Length reduction for heavier Sliver Weight than for lower when the Doffer Speed is high.
- Mean Length reduction is more pronounced (about 1.5 mm, about 5%) in the case of increase in Doffer Speed compared to reduction in Flat Speed (about 0.5mm, around 2%).
- From the manual readings it is observed that, for heavier weight of sliver, in comparison to lesser weight, there is an overall reduction in Mean Length for the full range of Flat and Doffer Speeds.

5.2.2.3. Effect of Doffer Speed and Delivery hank on Mean Length for different Flat Speeds:

- Graphs are compiled in fig 12 (a,b) for the AFIS and Manual Testing .
- There is an overall reduction in Mean Length (about 1 mm, around 4%) for a lower Flat Speed compared to high speeds for the full range of Doffer Speeds and Sliver Weights.
- However, the reduction in Mean Length is more pronounced for a lower Flat Speed (about 2mm, around 5%).

- The readings of AFIS, at high Flat Speed, show a significant reduction in Mean Length for a very low Sliver Weight and Doffer Speed (about 1.5mm, around 7%).
- Very low Flat Speed increases the fibre loading on it resulting in the increase in force of carding and consequent reduction in Mean Length.

5.2.2.4. Optimum Parameters (Mean Length – Blend)

The following are the optimum process parameter combinations derived from the procedure explained earlier.

	Doffer Speed	Delivery Hank	Flat Speed	Mean Length (AFIS)	Mean Length (Manual)
1	Maximum (9 rpm)	Coarse (0.155 Ne)	Maximum (6 in/min)	30.2 mm	27 mm
2.	Maximum (9 rpm)	Fine (0.185 Ne)	Minimum (2 in/min)	30.2 mm	27 mm
3.	Medium (7.5 rpm)	Fine (0.185 Ne)	Medium (4 in/min)	30 mm	27 mm
4.	Medium (7.5 rpm)	Medium (0.170 Ne)	Maximum (6 in/min)	30 mm	27 mm

Table 9: Optimum process conditions derived for Mean Length (Blend).

5.2.3. Effect of Process Parameters on Short Fibre Content.

6 rpm

7.5 rpm

9 rpm

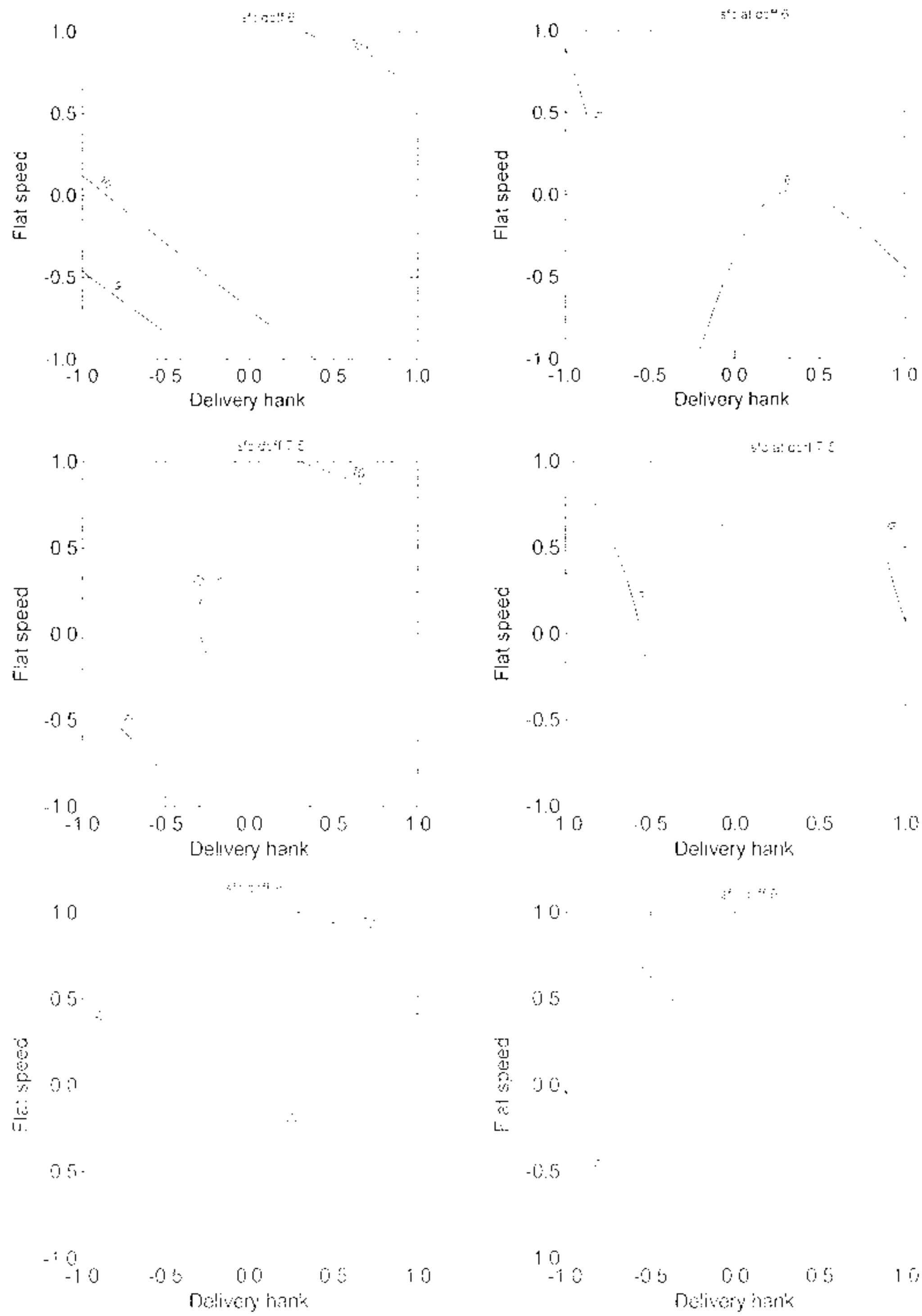


Fig 13: Contour Plots for Short Fibre Content at Different Doffer Speeds

Fig 13(a): AFIS Testing   Fig 13(b): Manual Testing

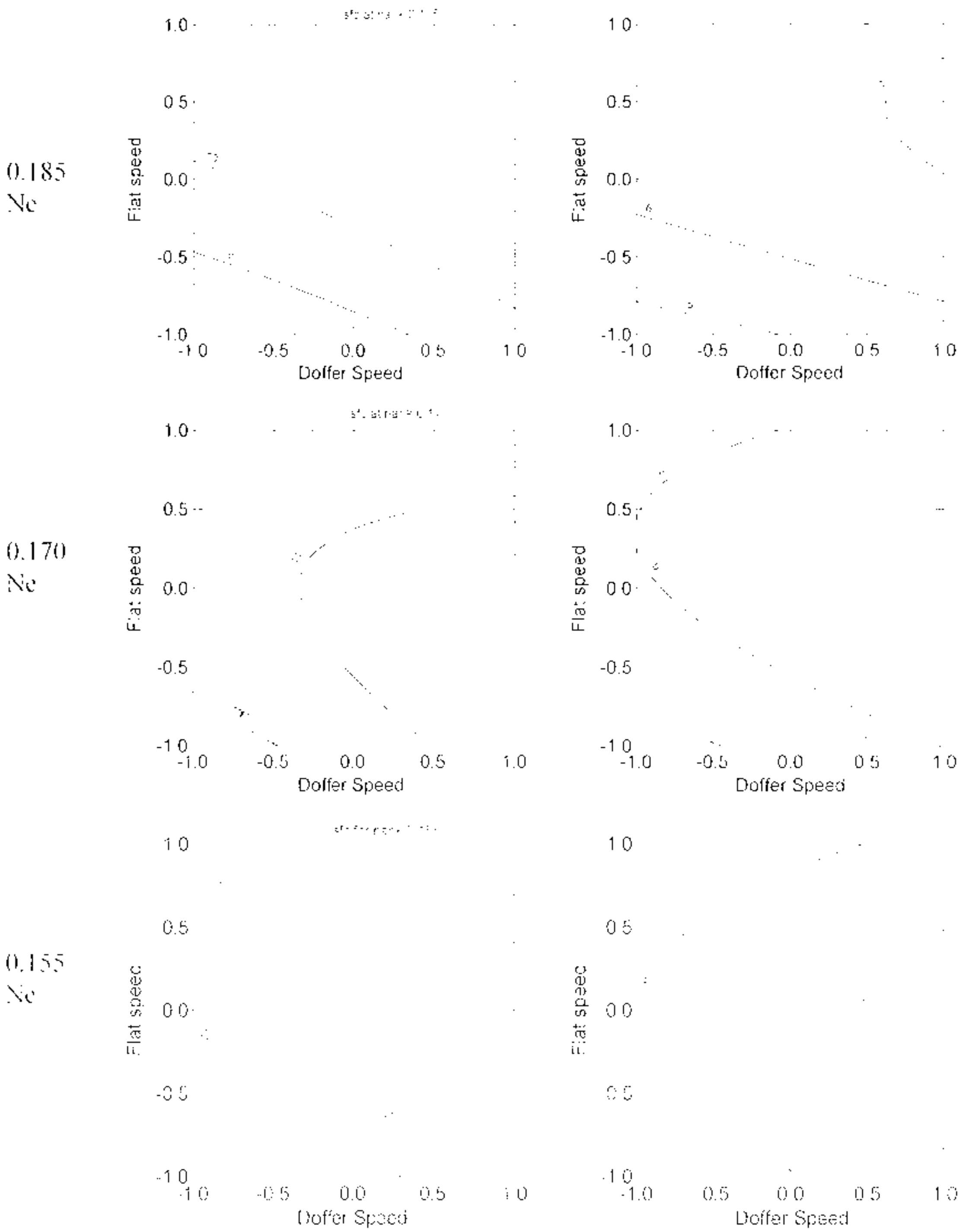


Fig 14: Contour Plots for Short Fibre Content at different Delivery Hanks

Fig 14(a): AFIS Testing **Fig 14(b): Manual Testing**

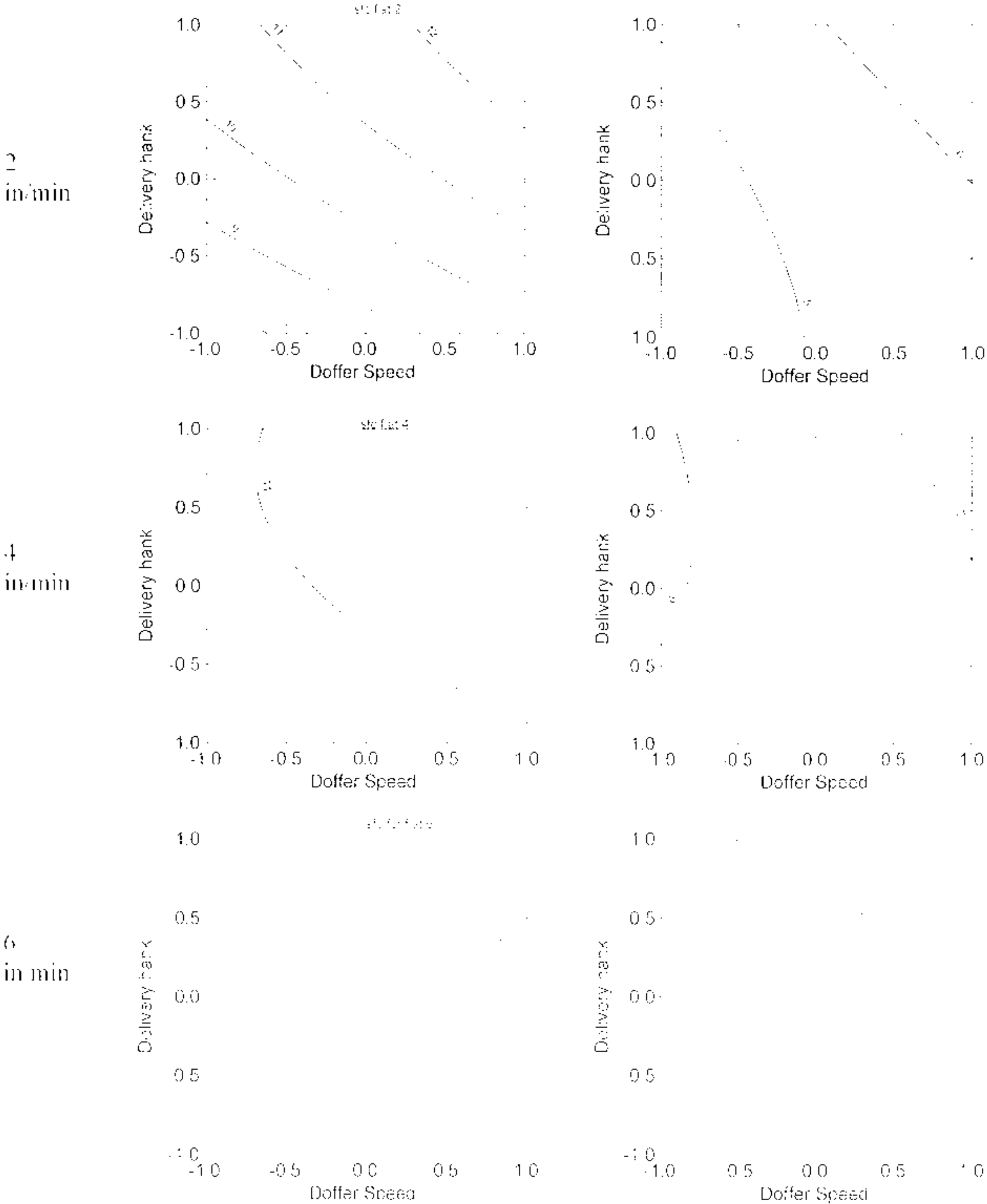


Fig 15: Contour Plots for Short Fibre Content at Different Flat Speeds

Fig 15(a): AFIS Testing

Fig 15(b): Manual Testing

5.2.3.1. Effect of Delivery Hank and Flat Speed on Short Fibre Content at different Doffer Speeds:

- Graphs are compiled as fig 13 (a,b) for the AFIS and Manual Testing .
- Irrespective of Delivery Hanks and Flat Speeds, there is an overall increase in Short Fibre Content for higher Doffer Speeds (Short Fibre Content of around 2%) compared to the lower speeds as far as the manual results are concerned.
- As per the AFIS test results, Short Fibre Content is more for higher Flat Speed with the combination of lower Sliver Weight and lower Flat Speed in combination with higher Sliver Weight.
- From these results, the following inference could be drawn that, the increase in Flat Speed when the Sliver Weight is kept higher help to reduce the load on the flat and consequent reduction in carding process helping in reducing Short Fibre Content.

5.2.3.2. Effect of Doffer Speed and Flat Speed on Short Fibre Content for Different Delivery Hanks:

- Graphs are represented as fig 14 (a,b) for the AFIS and Manual Testing.
- For all given Sliver Weights, increase in Doffer Speed increases the Short Fibre Content.
- However, for the very low Sliver Weights, increase in Doffer Speeds and Flat Speeds increases the Short Fibre Content (around 1.5%) and this trend gets reversed when the Sliver Weight is higher.
- The inferences are inline with the previous case.

5.2.3.3. Effect of Doffer Speed and Deliver Hank on Short Fibre Content for different Flat Speeds:

- Graphs are represented as fig 15 (a,b) for the AFIS and Manual Testing.
- At low Flat Speed, increase in Sliver Weight and Doffer Speed produces marked increase in Short Fibre Content (around 7-13% in AFIS Testing and 4-7% in Manual Testing) whereas at medium and higher Flat Speed, influence of Doffer Speed and Sliver weight on Short Fibre Content is marginal.

5.2.3.4. Optimum parameters (Short Fibre Content – Blend)

The following are the optimum process parameter combinations derived from the procedure explained earlier.

	Doffer Speed	Delivery Hank	Flat Speed	Short Fibre Content (AFIS)	Short Fibre Content (Manual)
1	Medium (7.5 rpm)	Fine (0.185 Ne)	Minimum (2 in/min)	9%	5%
2	Medium (7.5 rpm)	Coarse (0.155 Ne)	Maximum (6 in/min)	10%	6%
3	Maximum (9 rpm)	Coarse (0.155 Ne)	Maximum (6 in/min)	10%	6%

Table 10: Optimum process conditions derived for Short Fibre Content (Blend).

5.3. Results and inferences for 100% Micro Modal

The detailed mean test results of the previously referred characteristics for the 100% Micro Modal blend samples are given in the Table 11. below

Run No	X1	X2	X3	Neps AFIS	Neps Manual	Mean Length mm AFIS	Mean Length mm Manual	Short Fibre Content % AFIS	Short Fibre Content % Manual
1	-1	-1	0	7	3.4	29.4	31.05	5.31	4.47
2	1	-1	0	7.3	4.4	27.83	29.71	7.93	5.49
3	-1	1	0	8.8	5.2	28.95	30.78	6	4.67
4	1	1	0	9.3	6	27.6	28.76	8.3	6.2
5	1	0	-1	10.5	7.2	26.63	27.9	9.6	7.04
6	-1	0	-1	9.5	6.3	28.53	29.93	6.77	4.79
7	1	0	1	7.8	4	29.1	30.72	5.82	4.72
8	0	-1	-1	10.8	6.8	28.25	29.44	7.23	5.69
9	0	1	-1	10.5	6.6	27.35	28.38	8.73	6.49
10	0	-1	1	6.8	3.4	28.53	30.45	6.77	4.92
11	0	1	1	7.2	4.5	28.05	29.67	7.52	5.52
12	-1	0	1	6.5	2.6	29.73	31.67	4.77	4.03
13	0	0	0	8	5.2	28	29.47	7.5	5.69
14	0	0	0	8.3	5.6	28.2	29.72	7.3	5.66
15	0	0	0	8.3	4.8	28.13	29.67	7.6	5.6

Run Code	Doffer Speed X1	Delivery Hank X2	Flat Speed X3
1	9	0.155	6
0	7.5	0.17	4
-1	6	0.185	2

Table 11. Mean results of Sliver Quality for 100% Micro Modal

Using Software such as Systat, subsequent to feeding of all the main results of fifteen runs for each Response (Quality Parameters), the coefficients of response surface polynomial second order equation given below is derived along with the Regression Coefficient (R^2)

$$Z = B_0+B_1X_1+B_2X_2+B_3X_3+B_{12}X_1X_2+B_{13}X_1X_3+B_{23}X_2X_3+B_{11}X_1^2+B_{22}X_2^2+B_{33}X_3^2$$

The polynomial equation and regression constant found are tabulated in Table 12 given below.

Parameter	Testing	Quadratic Equation	Correlation Coefficient - R^2
Neps Per Gram	AFIS	$8.246+0.387X_1+0.488X_2-1.625X_3-0.181X_1^2+0.544X_3^2-0.175X_2X_3$	0.914
Neps Per Gram	Manual	$5.154+0.513X_1+0.538X_2-1.550X_3-0.369X_1^2+0.206X_3^2+0.125X_3X_1+0.325X_2X_3$	0.946
Mean Length	AFIS	$28.073-0.681X_1-0.257X_2+0.581X_3+0.398X_1^2+0.318X_3X_1+0.105X_3X_2$	0.886
Mean Length	Manual	$29.543-0.793X_1-0.383X_2+0.857X_3+0.522X_1^2-0.170X_1X_2-0.270X_1X_3$	0.945
Short Fibre Content	AFIS	$7.521+1.1X_1+0.414X_2-0.931X_3-0.709X_1^2-0.445X_3X_1-0.187X_2X_3$	0.891
Short Fibre Content	Manual	$5.653+0.686X_1+0.298X_2-0.603X_3-0.477X_1^2+0.128X_2X_3-0.390X_1X_3$	0.968

Table 12. Quadratic equations and Regression Constants for 100% Micro Modal

The Response Surfaces are drawn for the above mentioned quadratic equations. The Contour Plots for the Response Surfaces are plotted. The Optimum process conditions towards minimizing Neps Per Gram and Short Fibre Content and maximizing Mean Length are derived by overlapping the Contour Plots to find the common area of the Contour meeting the above requirements. The common area gives the most Optimum process condition required.

5.3.1. Effect of Process Parameters on Neps Per Gram.

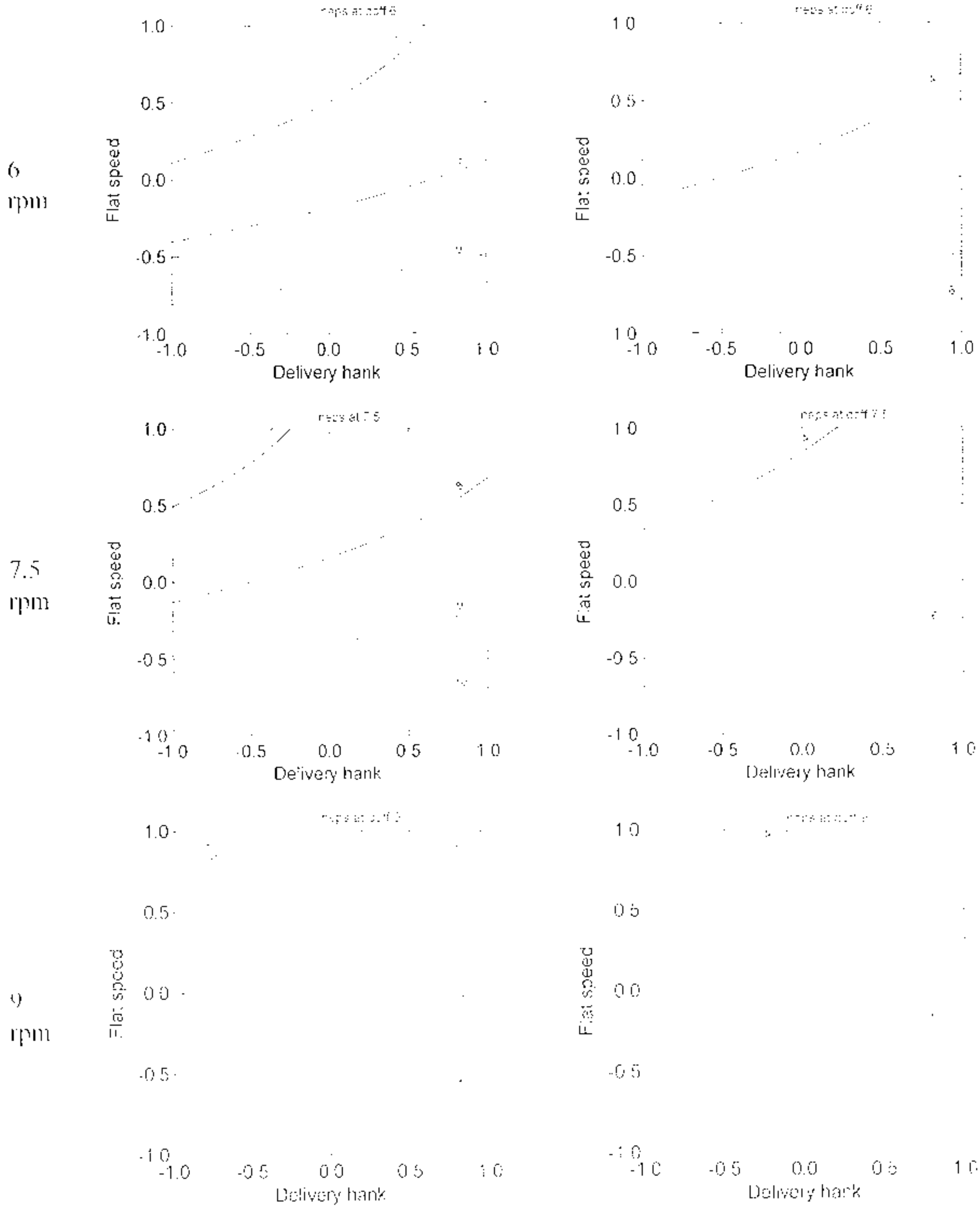


Fig 16: Contour Plots for Neps Per Gram at Different Doffer Speeds

Fig 16(a): AFIS Testing **Fig 16(b): Manual Testing**

0.185 Ne

0.170 Ne

0.155 Ne

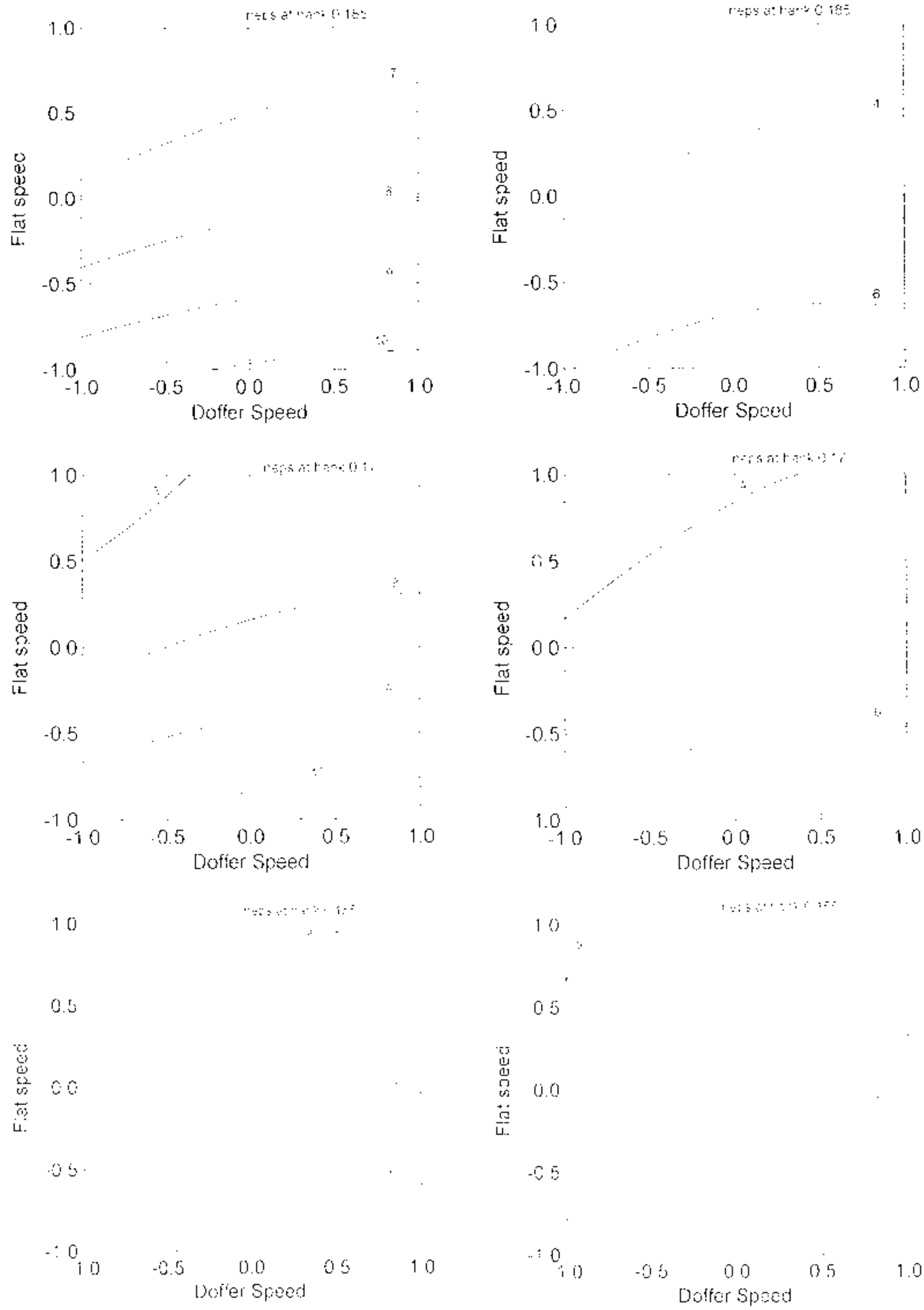


Fig 17: Contour Plots for Neps Per Gram at different Delivery Hanks

Fig 17(a): AFIS Testing **Fig 17(b): Manual Testing**

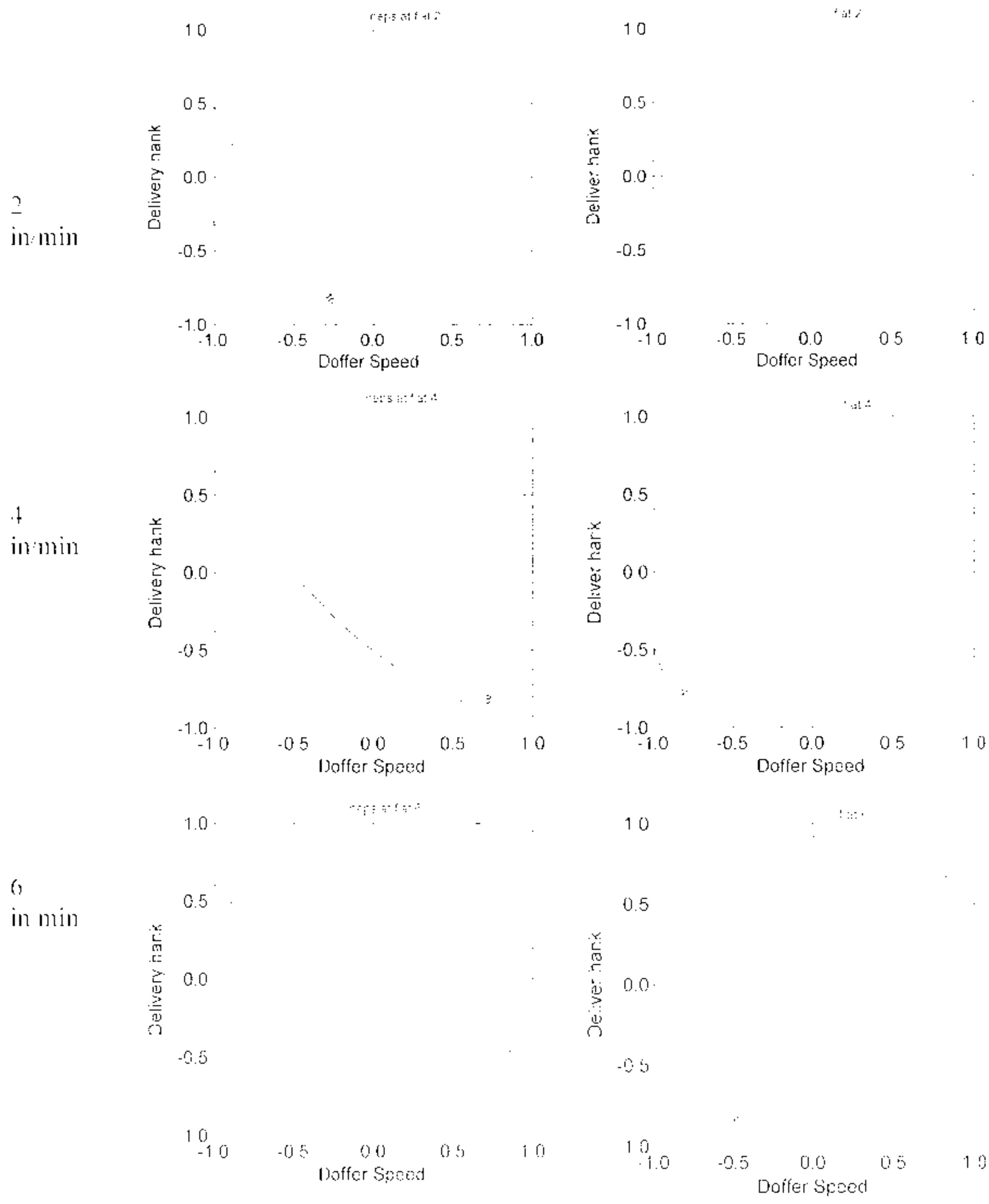


Fig 18: Contour Plots for Neps Per Gram at Different Flat Speeds

Fig 18(a): AFIS Testing **Fig 18(b): Manual Testing**

5.3.1.1. Effect of Delivery Hank and Flat Speed on Neps Per Gram for different Doffer Speeds:

- Graphs are compiled in fig 16(a.b) for the AFIS and Manual Testing
- The Neps Per Gram is observed to be higher at lower Flat Speeds and higher Sliver Weight for all the different Doffer Speeds.
- There is an overall increase in Neps Per Gram with every level of increase in the Doffer Speed irrespective of Flat Speed and Sliver Weight.
- When the Flat Speed is reduced from higher speeds to lower speeds, there is an increase of 3 Neps Per Gram and also, with the increase of the Sliver Weights, there is an increase of 2 Neps Per Gram.
- The results from the AFIS and Manual testing show similar trends and the Manual Testing results seem to be more pronounced.
- These results show that carding effectiveness of the nep removal efficiency is lesser (around 16%) for higher output rate through increased Doffer Speed and lower Flat Speed and waste.

5.3.1.2. Effect of Doffer Speed and Flat Speed on Neps Per Gram for different Delivery Hanks:

- Graphs are represented in fig 17 (a.b) for the AFIS and Manual Testing
- Irrespective of the Delivery Sliver Weight, minimum Neps Per Gram is noticed for the lowest Doffer Speeds and highest Flat Speeds (around 6-8 Neps Per Gram for AFIS results, around 2.5-4 Neps Per Gram for Manual Results) and a maximum Neps Per Gram is observed for highest Doffer Speeds and lowest Flat Speed (around 10-11 Neps per Gram for AFIS results, around 6.5-7.2 Neps per Gram for Manual results)
- An increase of Delivery Sliver Weight causes an increase in Neps Per Gram of from 8 to 9.5 in AFIS readings and from 4.5 to 5.5 in Manual readings.
- These results show that heavier Sliver Weights have reduced carding effectiveness as the cylinder has to handle more fiber for an unit time resulting in the increase in Neps Per Gram.

5.3.1.3. Effect of Doffer Speed and Delivery Hank on Neps Per Gram for different Flat Speeds:

- Graphs are produced in fig 18 (a,b) for the AFIS and Manual Testing
- Irrespective of Flat Speeds, lower values of neps is obtained at lower Doffer Speeds and Sliver Weights.
- For the highest Doffer Speeds and Sliver Weights compared to that of the lowest, and increase of 1.5-3.5 Neps Per Gram for AFIS results and an increase of 1-2.5 Neps Per Gram for Manual results is observed.
- Higher Flat Speed reduces the Neps from 10-11 to 6-8 Neps Per Gram for AFIS results and from 6.5-7 to 3.5-6 for Manual readings.
- High Flat Speed provide more cleaner flat for better carding thereby increasing the nep removal efficiency.

5.3.1.4.Optimum Parameters (Neps Per Gram–100% Micro)

The following are the optimum process parameter combinations derived from the procedure explained earlier.

	Doffer Speed	Delivery Hank	Flat Speed	Neps Per Gram (AFIS)	Neps Per Gram (Manual)
1	Minimum (6 rpm)	Medium (0.170 Ne)	Medium (4 in min)	7.5	4
2.	Minimum (6 rpm)	Medium (0.170 Ne)	Maximum (6 in/min)	6.75	3.5
3.	Maximum (9 rpm)	Finer (0.185 Ne)	Maximum (6 in min)	7	3.5

Table 13: Optimum process conditions derived for Neps per Gram (100% Micro).

5.3.2. Effect of Process Parameters on Mean Length.

6 rpm

7.5 rpm

9 rpm

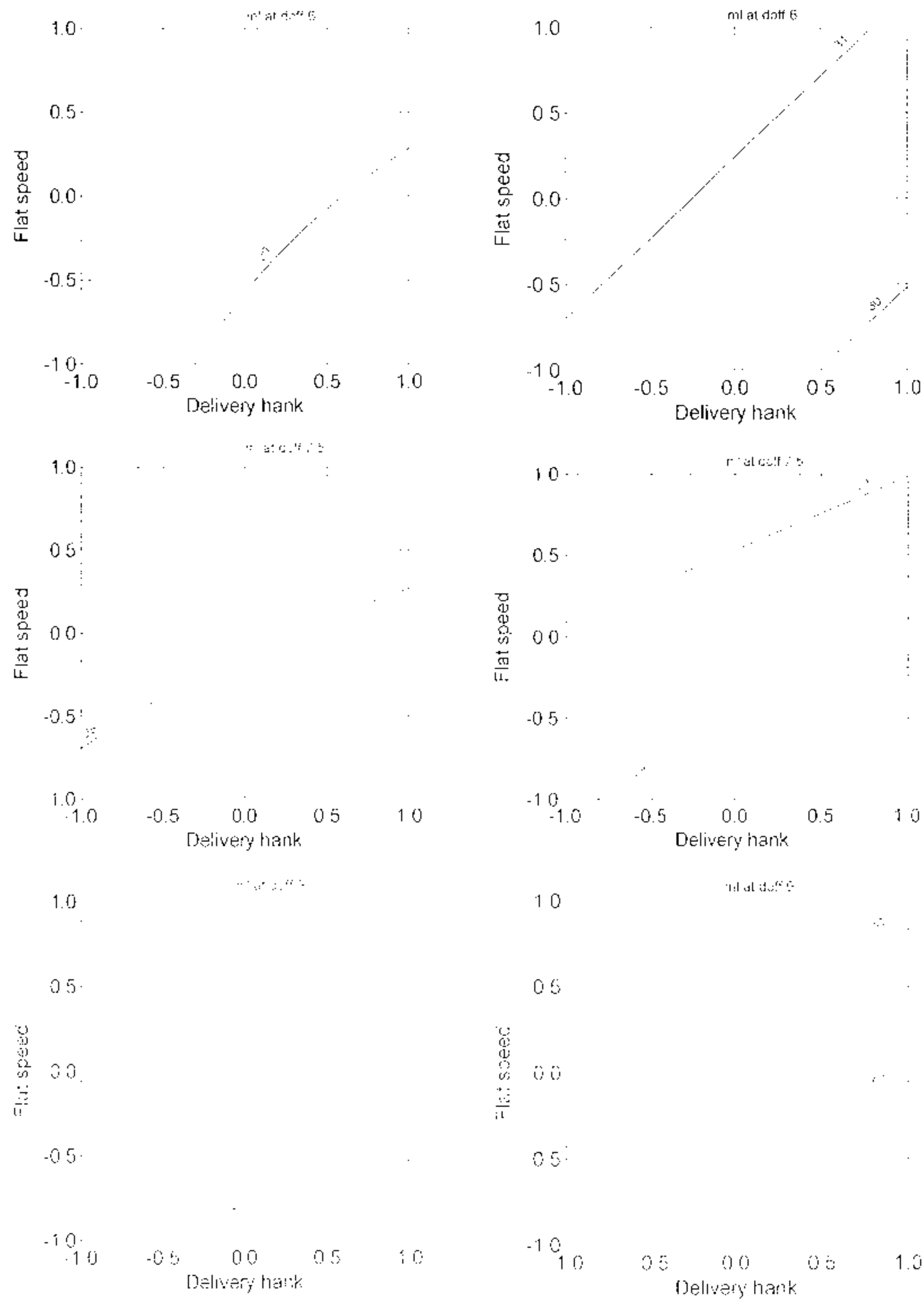


Fig 19: Contour Plots for Mean Length at Different Doffer Speeds

Fig 19(a): AFIS Testing

Fig 19(b): Manual Testing

0.185 Ne

0.170 Ne

0.155 Ne

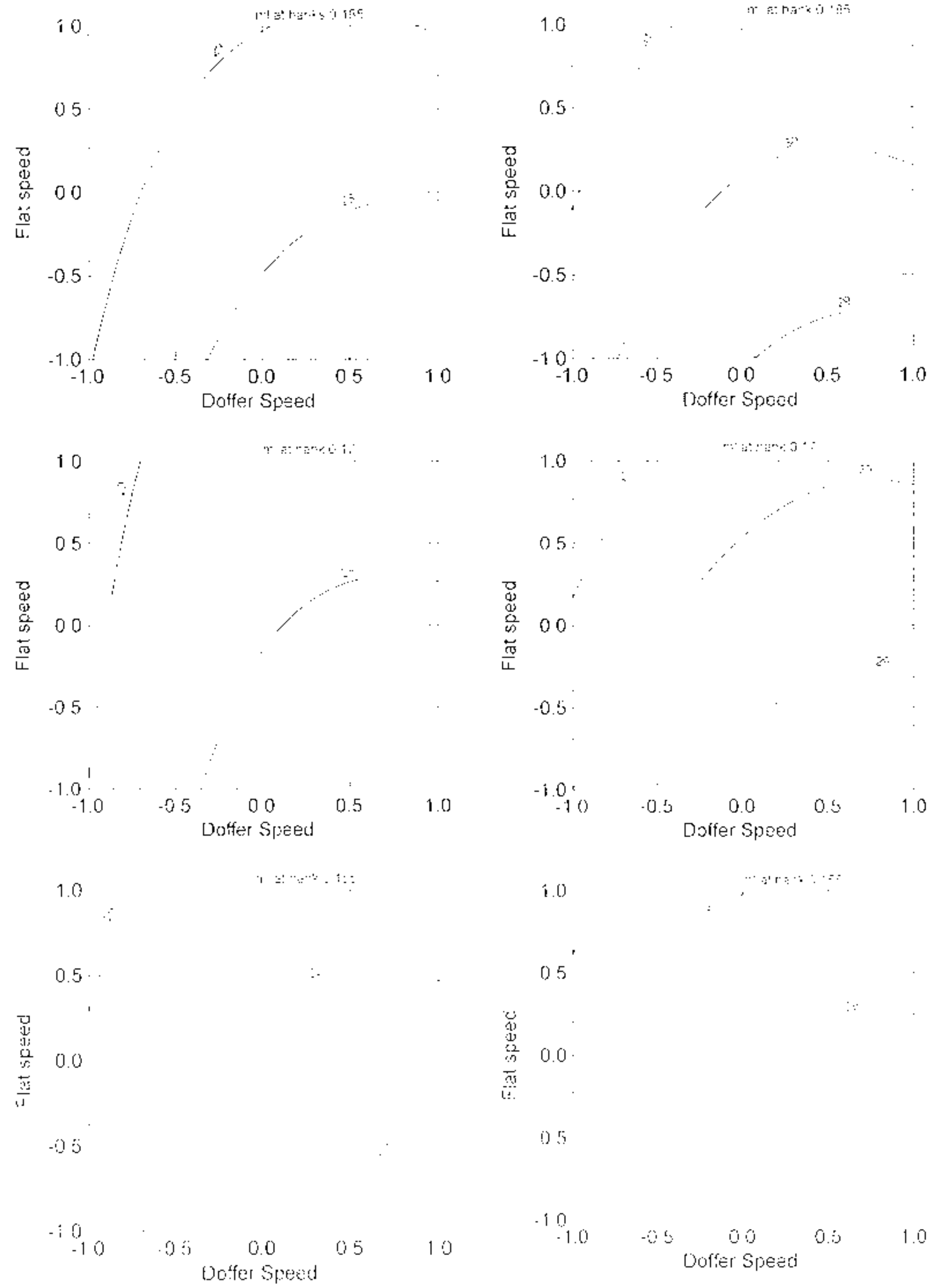


Fig 20: Contour Plots for Mean Length at different Delivery Hanks

Fig 20(a): AFIS Testing **Fig 20(b): Manual Testing**

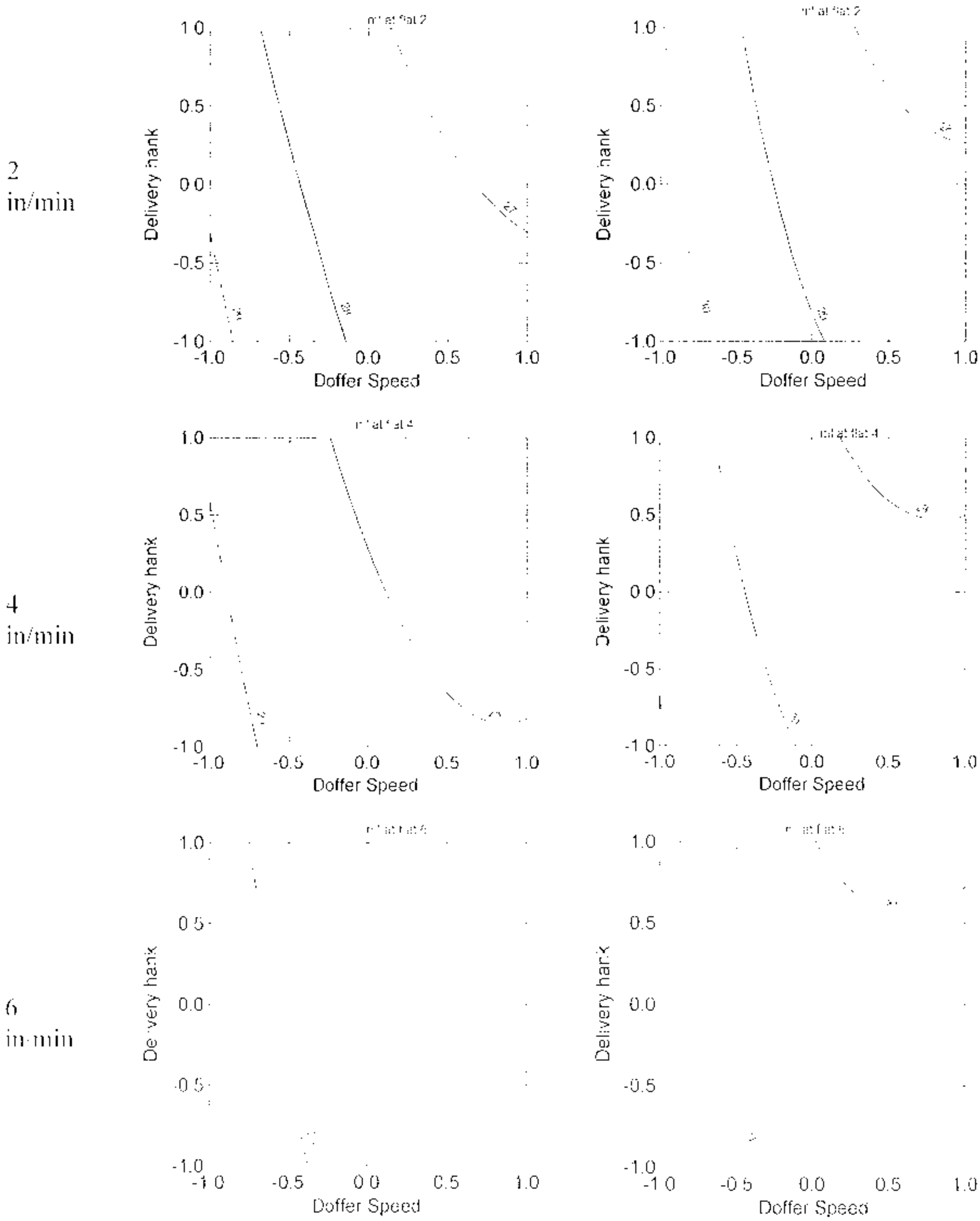


Fig 21: Contour Plots for Mean Length at different Flat Speeds

Fig 21(a): AFIS Testing **Fig 21(b): Manual Testing**

5.3.2.1. Effect of Delivery Hank and Flat Speeds on Mean Length for different Doffer Speeds:

- Graphs are provided in fig 19 (a,b) for the AFIS and Manual Testing
- Irrespective of the Doffer Speeds, there is a decrease of Mean Length with the decrease in Flat Speeds and a similar effect is noted for an increase in the Sliver Weights.
- The AFIS results show a reduction of Mean Length in the order of 1-2.5 mm while the Manual readings show a reduction in the order of 2-2.5 mm for any given Flat Speed and Deliver Hank for changes from lower Doffer Speed to higher Doffer Speed.
- Higher Doffer Speed increases the carding load thereby increasing the fibre rupture and reducing the Mean Length by 4-12%.

5.3.2.2. Effect of Doffer Speed and Flat Speed on Mean Length for different Delivery Hanks:

- Graphs are provided in fig 20 (a,b) for the AFIS and Manual Testing
- Irrespective of the Sliver weights, there is a decrease in Mean Length for decrease in Flat Speed and increase in Doffer Speed.
- The Mean Length reduction (around 2.5 mm AFIS Testing and 2.5-3.5 mm in Manual Testing) is noted over the ranges of Doffer Speeds and Flat Speeds.
- The trend seems to be similar for both the AFIS and Manual testing results.
- The higher Sliver Weight increase the carding load, thereby causing more reduction in Mean Length (around 12-14%)

5.3.2.3. Effect of Doffer Speed and Delivery Hank on Mean Length for different Flat Speeds:

- Graphs are provided in fig 21 (a,b) for the AFIS and Manual Testing
- An overall reduction of the Mean Length (around 0.9-1.5mm) for a lower Flat Speed in comparison with higher Flat Speeds is observed irrespective of the Doffer Speeds and Delivery Hanks.

- The reduction in Mean Length is more pronounced for the lower Flat Speed setting due to more loading of the wire points.
- The AFIS and Manual Testing show a similar inference on the trends.

5.3.2.4. Optimum Parameters (Mean Length – 100% Micro)

The following are the optimum process parameter combinations derived from the procedure explained earlier.

	Doffer Speed	Delivery Hank	Flat Speed	Mean Length (AFIS)	Mean Length (Manual)
1.	Minimum (6 rpm)	Medium (0.170 Ne)	Medium (4 in/min)	29.25 mm	30.75 mm
2.	Minimum (6 rpm)	Medium (0.170 Ne)	Maximum (6 in/min)	29.3 mm	31.5 mm
3.	Maximum (9 rpm)	Fine (0.185 Ne)	Maximum (6 in/min)	28.9 mm	30.7 mm

Table 14: Optimum process conditions derived for Mean Length (100% Micro).

5.3.3. Effect of Process Parameters on Short Fibre Content.

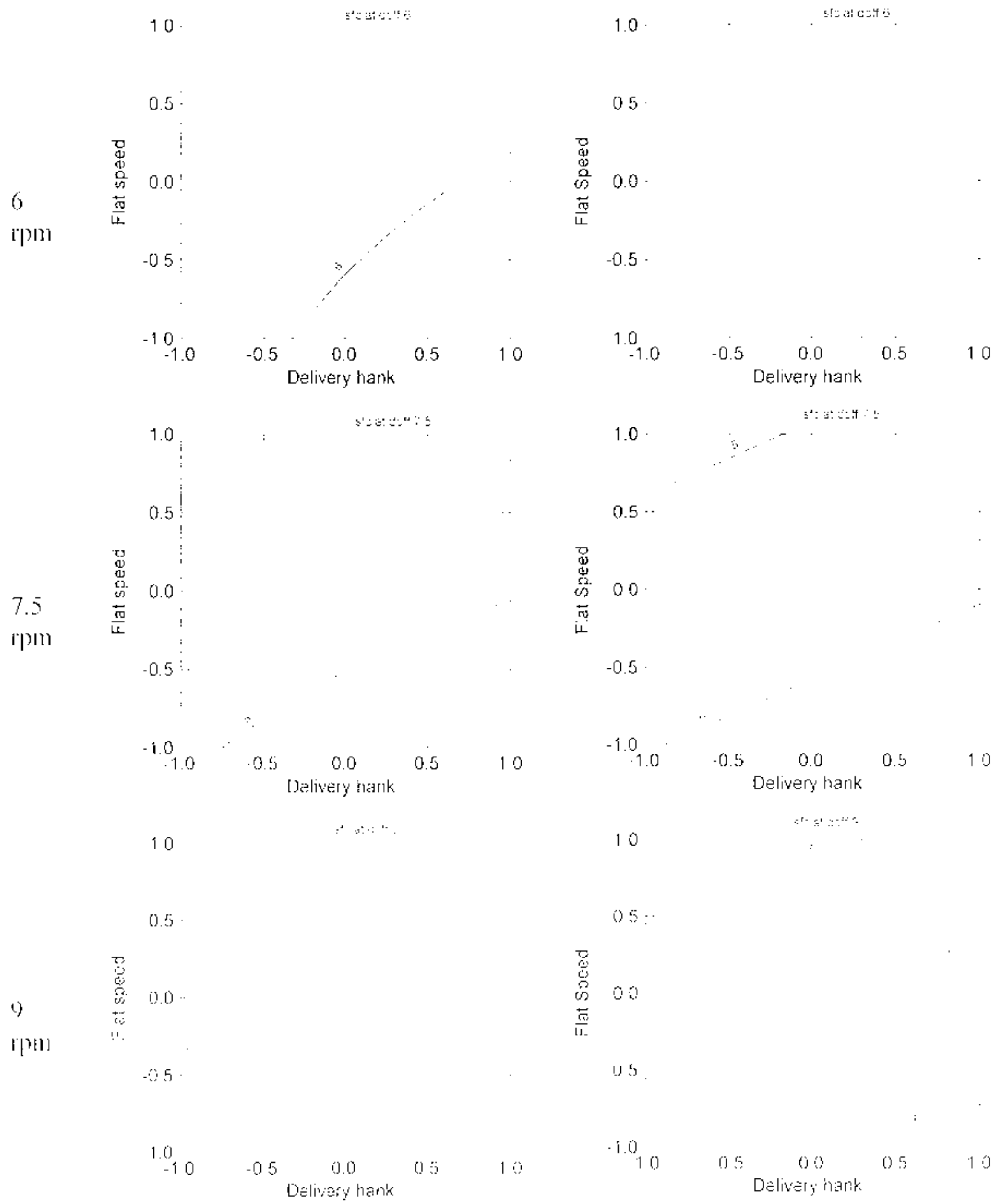


Fig 22: Contour Plots for Short Fibre Content at Different Doffer Speeds

Fig 22(a): AFIS Testing   Fig 22(b): Manual Testing

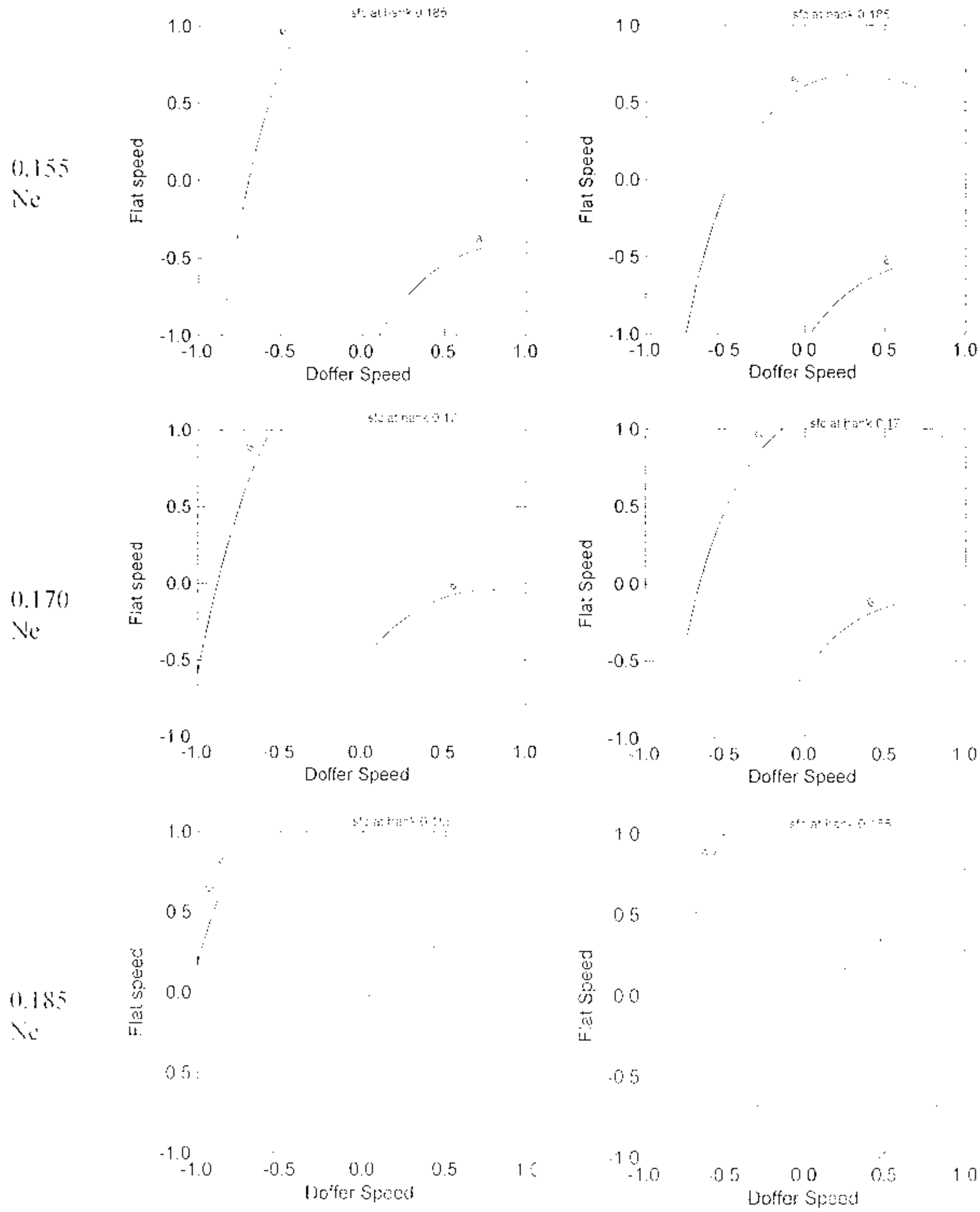


Fig 23:Contour Plots for Short Fibre Content at different Delivery Hanks

Fig 23(a): AFIS Testing **Fig 23(b): Manual Testing**

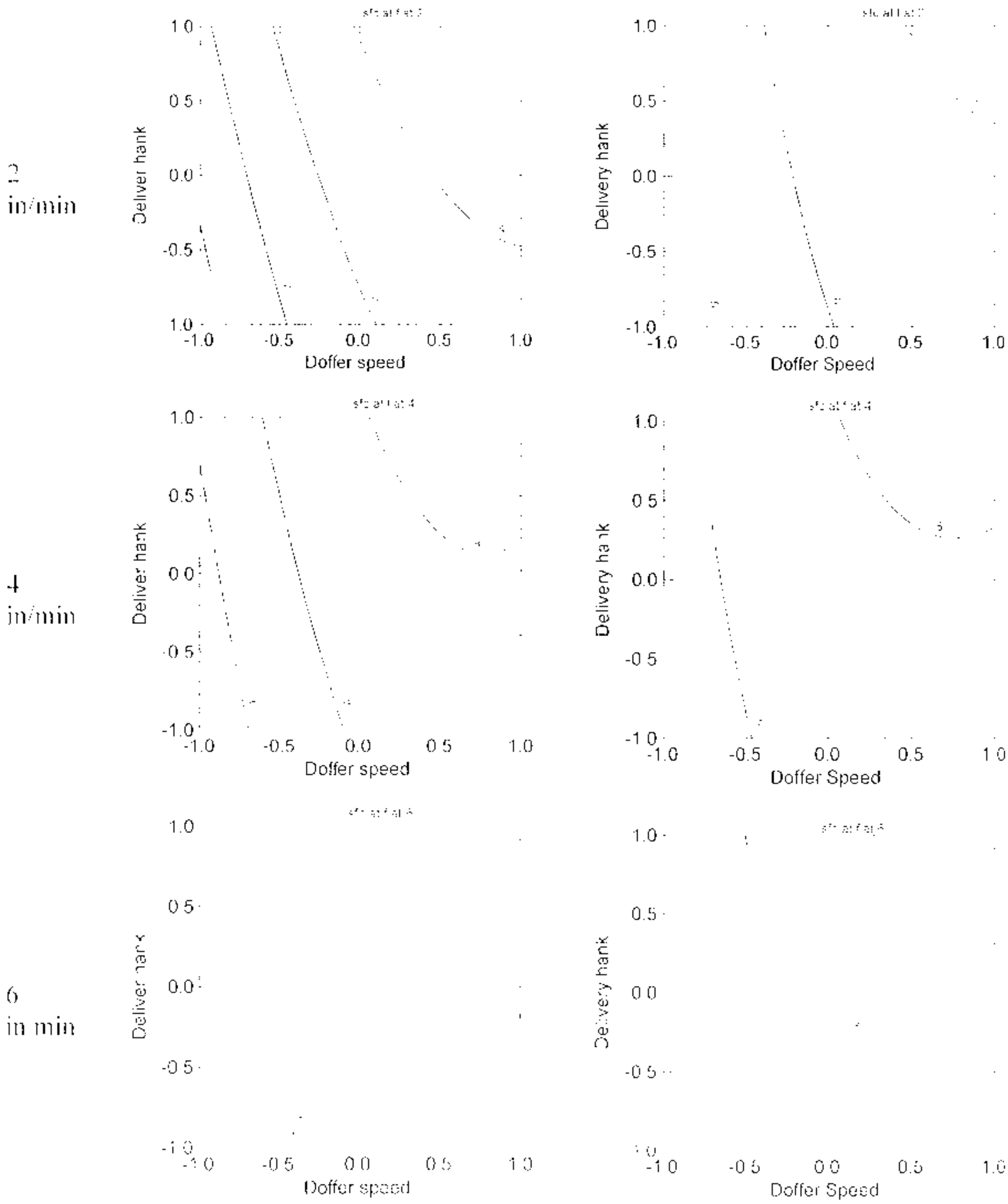


Fig 24: Contour Plots for Short Fibre Content at Different Flat Speeds

Fig 24(a): AFIS Testing **Fig 24(b): Manual Testing**

5.3.3.1. Effect of Delivery Hank and Flat Speed on Short Fibre Content for different Doffer Speeds:

- Graphs are in fig 22 (a,b) for the AFIS and Manual Testing
- Irrespective of the Delivery Hanks and Flat Speeds, there is an increase in the Short Fibre Content for higher Doffer Speeds than lower Doffer Speeds for both manual and AFIS readings.
- An increase from Short Fibre Content of 5 % to 9% is noticed in the AFIS testing and from Short Fib Content 4.25% to 7% is notice in the Manual testing.
- Higher Throughput rate through increased Doffer Speed increases the carding stress and thereby increasing fibre rupture resulting in more Short Fibre Content.

5.3.3.2. Effect of Doffer Speed and Flat Speed on Short Fibre Content for different Delivery Hanks:

- Graphs are given in fig 23 (a,b) for the AFIS and Manual Testing
- The change in the Short Fibre Content for the changes in the Sliver Weights is less (0.25%) for a given Doffer Speed and Flat Speed.
- For all Sliver Weights, increase in Doffer Speed increases Short Fibre Content (Short Fibre Content increase of 2.5-3% in both cases of testing).
- Irrespective of Sliver Weights, decrease in Flat Speed increases the Short Fibre Content for all a given Doffer Speed.

5.3.3.3. Effect of Doffer Speed and Deliver Hank on Short Fibre Content for different Flat Speeds:

- Graphs are depicted in fig 24 (a,b) for the AFIS and Manual Testing
- Irrespective of the Flat Speeds, there is an increase in Short Fibre Content for higher Doffer Speed (an increase of around 2 to 4%) and a decrease in Short Fibre Content for lower Sliver Weights (a decrease of around 2 to 4%)
- The above mentioned trend is more pronounced for the lower Flat Speed settings.

5.3.3.4. Optimum Parameters (Short Fibre Content – 100% Micro)

The following are the optimum process parameter combinations derived from the procedure explained earlier.

	Doffer Speed	Delivery Hank	Flat Speed	Short Fibre Content (AFIS)	Short Fibre Content (Manual)
1.	Minimum (6 rpm)	Medium (0.170 Ne)	Medium (4 in/min)	5.75%	4.5%
2.	Minimum (6 rpm)	Medium (0.170 Ne)	Maximum (6 in/min)	5.5%	4.25%
3.	Maximum (9 rpm)	Finer (0.185 Ne)	Maximum (6 in/min)	6.5%	4.5%

Table 15: Optimum process conditions derived for Short Fibre Content (100% Micro).

5. CONCLUSION

From the foregone results and discussions, the following conclusions are drawn with regards to optimum process conditions for the Micromodal-Cotton blend and 100% Micro Modal processing.

Micromodal-Cotton Blend Processing:

Towards achieving optimum values of Neps Per Gram, Mean Length and Short Fibre Content as 15.3 , 27 mm and 9% respectively for AFIS Testing and 4.5 , 30.2 mm and 6% respectively for Manual Testing, the following process parameter combinations could be chosen for Micromodal-Cotton blend processing.

	Doffer Speed	Delivery Hank	Flat Speed
1.	Medium (7.5rpm)	Fine (0.185 Ne)	Medium (4 in/min)
2.	Medium (7.5 rpm)	Medium (0.170 Ne)	Maximum (6 in/min)

Table 16: Optimum Settings for Micromodal-Cotton Blend processing.

100% Micro Modal Processing:

Towards achieving optimum values of Neps Per Gram, Mean Length and Short Fibre Content as 6.5 , 29 mm and 7% respectively for AFIS Testing and 3.5, 31 mm and 4.7% respectively for Manual Testing, the following process parameter combinations could be chosen for 100% Micro Modal processing.

	Doffer Speed	Delivery Hank	Flat Speed
1.	Minimum (6 rpm)	Medium (0.170 Ne)	Maximum (6 in/min)
2.	Maximum (9 rpm)	Fine (0.185 Ne)	Maximum (6 in/min)

Table 17: Optimum Settings for 100% Micro Modal processing.

Different Optimum process conditions are derived for 100% Micro Modal and Micromodal-Cotton blend processing because of the changes in the Fibre properties such as Fineness, Flexural Rigidity and Frictional characteristics of the natural and regenerated fibres which have influence on the carding factors.

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ANNEXURE

Cross Sectional View of the fibres.

Cotton.

Modal.

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION
SITRA PHYSICAL LABORATORY

P.B.No. : 3205, Coimbatore Aerodrome Post, Coimbatore - 641 014, INDIA
Grams : SITRA Ph : (0422) 2574367-9 Fax : (0422) 2571896
Email: sitra@vsnl.com Website:http:// www.sitra.org.in
Address all correspondence to the Director ISO/IEC 17025:1999 NABL ACCREDITED

Cert. Number:T-358

PHYSICS DIVISION

Fibre Test Report No. : 4621

Date : 14/02/2006

Our Ref No. : V/3/ 3755/06

No. of Samples : 1

Your Ref No. : 13.02.2006

Received on : 04/02/2006

To

Kumaraguru College of Technology,
Chinnavedampatti
Coimbatore - 641 006
Tamilnadu

Dear Sirs,

We are pleased to give our results (enclosed) on your above samples.

Yours faithfully,

Head of the Textile Physics Division

Encl. : Bill & M/c Printouts wherever applicable

IMPORTANT

This report is strictly CONFIDENTIAL. Its use for publicity, arbitration or as evidence in legal disputes is forbidden. The results relate to the sample supplied by the mill. The report shall not be reproduced except in full, without the written approval of the laboratory.

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION
SITRA PHYSICAL LABORATORY
P.B.No. : 3205, Coimbatore Aerodrome Post, Coimbatore - 641 014, INDIA
Grams : SITRA Ph : (0422) 2574367-9 Fax : (0422) 2571896
Email: sitra@vsnl.com Website:http:// www.sitra.org.in
Address all correspondence to the Director ISO/IEC 17025:1999 NABL ACCREDITED Cert. Number:T-358

Fibre Test Report No.:4621 Kumaraguru College of Technology,

Samples Tested at : R.H. 65% +/- 2% and Temp. 21 Degree C +/- 1 Degree C

Lab Code No. F_26806

Sample Particulars.: MODAL
FIBRE SAMPLE

Fiber Denier & Single Fibre Tenacity
(As per BISFA 1998 & ASTM D-3822-01)

Denier

Mean Denier	0.96
CV% of Denier	10.80

Single Fibre St. & Elongation

Tenacity g/Denier	3.71
CV% of Tenacity	8.30
Elongation %	14.70
CV% of Elongation	9.60

End of Report

LENZING TECHNIK INSTRUMENTS

2006.07.06 14:34

File Name : F-260306
Particulars: MODAL
Comment :
Longterm Code : MOD
Gauge Length [mm] : 20
Tension Weight [mg] : 100
Testing Speed [mm/min]: 20
Procedure (ASTM D-3822 & D1577'98)