EVALUATION OF EGYPTIAN COTTON CLEANING EFFICIENCY BY ANALYSIS OF TRASH PARTICLE SIZE DISTRIBUTION

تقييم كفاءة تنظيف الأقطان المصرية بواسطة تحليل توزيع الشوائب والأتربه

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ملخص البحث

الهدف من هذا البحث هو تقييم قابلية الأقطان المصرية للتنظيف أثناء مرحلة التفتيح والتنظيف. من خلال تحليل توزيع الشوائب والأتربه ، حيث تم تشغيل احدى عشرة نوعا من الأقطان المصريه طويلة التيله وفائقة الطول فى خط التفتيح والتنظيف.تم اختبار نسب وعدد وتوزيع الشوائب فى كل من بالات القطن و الأقطان الخارجه من الماكينات المتتاليه فى خط التفتيح والتنظيف و من خلال حساب كفاءة تنظيف الأقطان المختلفه وطبقا لنسب الاحتواء على الشوائب تم تصنيف الأقطان على حسب درجة مقاومتها للتنظيف إلى ثلاثة مجموعات من الأقطان بدرجات مقاومة تنظيف مختلفه . وقد أضحت النتائج أن كفاءة التفتيح والتنظيف للأقطان المستخدمه تتراوح من ٣٩% إلى ٨٤% . وأن تتابع ماكينات التفتيح والتنظيف تؤثر على توزيع الشوائب والأتربه.

Abstract

The aim of this work is evaluation of Egyptian cottons cleanability by blowroom . Where eleven Egyptian cotton varieties were processed through blowroom line. Cotton samples from bale and from output of successive opening and cleaning machines were tested using Advanced Fibre Information System (AFIS) for thrash content. Trash content and as cunt/g are considered. Blowroom cleaning efficiency of the different cottons is calculated and the different cotton varieties are classified to three groups: low, medium and high resistance to cleaning. For the three groups of different cleaning resistance trash particle size distribution for the different cotton samples is analyzed as two distributions . The first is dust size distribution (size<500 μ m) and the second is SCI size distribution (size >500 μ m). Effect of successive opening and cleaning machines on the two distributions is discussed. The results showed that Blowroom cleaning efficiency of the investigated cottons ranged from 39% to 84% and cotton cleanability is an effective factor amomgst the factors affecting blowroom cleaning efficiency. Data showed that successive blowroom machines have an effect on particle size distribution

1.Introduction

During the technological process in the spinning mill, there are a number of stages, which cause the significant changes of characteristics of the processed fiber stream. The number and kind of operations, to which cotton is exposed, depend on the quality of raw material as well as of the used spinning system. As a result a significant changes of fiber stream parameters can be observed. The most significant reduction of trash and dust content in cotton takes a place in blowroom and next during the carding and combing processes.

The primary function of blowroom is opening and cleaning. Different trash categories have different influences on the textile processing of cotton and the quality of the finished products. Brashears et al. [1] reported that the yarn breakage during the spinning increased by approximately 60% with a 1% increase in the bark content when cottons were processed only with regular cleaning and carding. Veit et al [2] found that a correlation existed between the number of seed coat fragments and uster imperfection of the yarn, and proved that the seed coat particles were more difficult to separate from cotton in the cleaning process than nep, leaf, and wooden fragments. It has been indicated [3,4] that seed coat fragments are disrupt the spinning process and decrease the quality of the yarn produced, where they are the main reason for end breaks and increase in neps and other problems.

Klein [5] stated that a blow room installation removes approximately 40 to 70% of the impurities. Shahid et al [12] reported that cleaning efficiency of the blowroom would rise 50 to 80%..

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Blowroom machines eliminate foreign matter, this is done simultaneously with good fibre elimination. Leifield [6] reported that fiber straightening in the blow room occurs at the point where hard beats occurred. Mechanical cleaning damages the fibres and degrading their quality. All mechanical processings are a compromise between quality improvement, such as disentanglement or straightening and cleaning of fibres and damage such as fibre entanglement, breakage or loss [7]. The most obvious example is in cleaning, where removal of impurities is usually accompanied by shortening of the length distribution, fiber loss, dust, and other damage [8, 9, 10, 11]

El-Bealy [13] indicated that the behaviour of different Egyptian cotton fibre qualities through different blowroom installations followed by carding process the intial trash content affects significantly on the cleaning efficiency, cottons with a higher trash content can easily cleaned than little and also with lower micronaire value, the more diffcult it is to eliminate impurities from fibres. El-Bealy [13 reported that for Egyptian cotton fibres differences in intial trash content; blowroom line removes 65% to 85% of impuritie and over 10% of dust from it. Also a substantial differences in CE% are observed when different bloroom lines were employed for the same cotton fibres

The main objective of this work is to recognize the effect of opening and cleaning machines on the distribution and elimination of trash and dust for different Egyptian cotton fibres.

2.Experimental work

2.1.Maferial and measurements

Eleven Egyptian cotton varieties, long staple and extra long staple, were processed through blowroom line with the machine sequence: Bale opener-Automixer - Porcupine – RST cleaner – Dust separator (Dustex). Cotton samples were taken from bale and from output of successive opening and cleaning machines were tested using Advanced Fibre Information System (AFIS) with 5 replications for the trash content. Particle size distribution of cotton fibre stream during processing is considered, where a histogram of 41 particle size categories from 0 to 2050 μm with increment of 50 μm and frequency (as a count/g) as well as a cumulative frequency (%) were taken into consideration. Summary of trash and dust results are given in Table (1) to (3).

2.2.Evaluation

▪ Influence of cotton resistance to cleaning on the cleaning efficiency of blowroom machines is studied. Cleaning efficiency of blowroom machines and totally of blowroom is calculated for the different eleven Egyptian cottons as the following:

$$CE = \frac{T(\%)_{input} - T(\%)_{output}}{T(\%)_{input}} \times 100\%$$

where

CE = cleaning efficiency (%)

$T(\%)_{input}$ = *trash content (%) of the feed material*

$T(\%)_{output}$ = *trash content (%) of the delivered material*

Degree of cleaning of different cotton varieties by different blowroom machines is plotted against cotton trash content (%) and introduced in Fig (1) and (2). Where: zone I including high resistance to cleaning cottons (difficult to clean) , zone II including medium resistance to cleaning cottons and zone III including low resistance to cleaning (easy to clean).

▪ from each of the above zones one cotton was chosen to study the behavior of these three cottons during opening and cleaning. Where first cotton : low resistance to cleaning cotton (LR cotton), second: medium resistance to cleaning cotton (MR cotton) and third: high resistance to cleaning cotton (HR cotton).

▪ For the three chosen cottons particle size distribution of cotton fibre stream during processing by opening and cleaning machines is divided to dust size distribution (particle size <500 μm) and seed coat impurities (SCI) size distribution (particle size >500 μ m).

- Effect of different opening and cleaning machines on dust and SCI at different size categories is calculated as:

difference in particles (dust or SCI) count= output content - input content. So positive number means the added particles and negative number means the eliminated particles by a specific machine. Since there is no dust content in the size category 0-50 μ m, for bale cotton and output of successive opening and cleaning machines , so dust size categories were started with the category <100 μ m followed by 100-150 μ m and so on with increment of 50 μ m.

- Cleaning intensity of blowroom is calculated for dust and SCI as the following :

$$CI = \frac{T(cnt)_{input} - T(cnt)_{output}}{T(cnt)_{input}} \times 100\%$$

where

CI = cleaning intensity (%)

$T(cnt)_{input}$ = trash content (count/g) of feed material

$T(cnt)_{output}$ = trash content (count/g) of the delivered material

3.Results and discussion

Table (1) shows summary of trash content data ofr the eleven different cottons. Data showed that dust content of Egyptian cotton ranges from 88% to 97% of total trash content.

3.1Cotton resistance to cleaning

Fig (1) the relationship between cleaning efficiency of blowroom machines and trash content of the input material. Zone I is the zone of high resistance to cleaning. Zone II is the zone of medium resistance to cleaning. Zone III is the zone of low resistance to cleaning.

For bale opener, as shown in Fig (1-1). It can be noticed that with the same trash content of about 2% different cleaning efficiencies of 11.8 %, 15.3% and 32.3% are obtained. Where the cotton of the first CE% is HR to cleaning cotton, of the second is MR to cleaning cotton and of the third is LR to cleaning cotton. Cleaning efficiency of about 9% and 41% are obtained with 4% and 1.89% trash content respectively For porcupine as shown in Fig (1-2) for the same tarsh content there are different CE%.

It can be noticed that for porcupine the slope (centerline) is steeper than those for the bale opener. The same was found for the successive machines, as shown in Fig (2). For dustex the slope is steeper than for RST and this of RST is steeper than porcupine. Consequently, the steepness of the curve is a measure for the cleaning efficiency of the machine. Where for bale opener cleaning efficiency (as a mean) of 12% is obtained with trash content 1% trash content. for the same cotton cleaning efficiency of porcupine is 15%, for cleaner RST is 17% and and for dustex. Is 23%. Where by successive machines degree of opening increases leading to increasing degree of cleaning.

Fig.(2) Relationship between cleaning efficiency of blowroom line and trash content of the input material. It ranges form 39% (at trash content 1.89%) to 84% (at trash content 2.07%). For trash content of abobut 2.1% different cleaning efficiencies of 57 %, 72% and 84% are obtained. A cleaning efficiency of 63% is obtained with 0.88% trash content, and 59% with 4% trash content So cleaning efficiency is dependent to a large extent on cotton cleanability

3.2.Effect of blowroom machine on cleaning efficiency and trash size distribution

Table (2) to (3) show summary of trash content of fibre stream of three cottons (LR cotton, MR cotton and HR cotton) in fibre stream during opening and cleaning. Where dust particles are the particles of size <500 μ m, seed coat impurities (SCI) are those of size >500 μ m and total trash particles are the summation of both. It was noticed that, for the cottons used in investigation, there in no or very little count/g of dust in the size category 0-50 μ m , so dust size categories are started from <100 μ m followed by 100-150 μ m and so on.

Dust and SCI size distribution and difference in size distribution of cotton fibre stream during opening and cleaning during opening and cleaning are shown in Fig (3) to Fig (10).

Effect of bale opener on dust size distribution is shown in Fig (3). It can be noticed that the LR cotton has the higher dust elimination. the higher elimination was found for the dust in the size category < 100 μ m (reduced from 848 to 169 count/g) which is about 53% of the eliminated dust. Eliminated dust in the size <150 μ m is about 78% of the eliminated dust. While 87% of the eliminated dust are of size <200 μ m and 93% are < 250 μ m.

For HR cotton the higher elimination was found for the dust in the size category < 100 μ m which represent about 34% of the bale cotton. where dust content is reduced from 430/g to 257/g representing about 40% of total eliminated dust. While for MR cotton there is an increment in the dust content for the same size category and the elimination in the other size categories is smaller.

Effect of bale opener on the difference in SCI size distribution is shown in Fig (3). LR cotton has the largest difference in the distribution before and after bale opener. Fig. (3-1) demonstrates that the most of trash eliminated by bale opener are of size <1150 μ m. Eliminated SCI of size from 550 μ m to 750 μ m represents about 66% of the eliminated SCI Total eliminated SCI is about 23 particle/g and increment is about 3.2 particle/g.

For MR cotton It can be noticed that trash count elimination as well as trash count increment are carried out. Increment in some SCI categories may be related to fragmentation of trash particles of larger sizes increasing dust and smaller SCI content. For HR cotton trash elimination is carried out at most trash size categories as shown in Fig (3-3).

Fig.(4) shows particle size distribution after bale opener of the three cottons. It can be noticed that LR cotton has the lower frequency of dust particles at different sizes and MR cotton has the higher. Regarding to SCI MR cotton has the higher content up to 1250 μ m.

Fig (5) shows the effect of porcupine on particle size distribution. The effect of porcupine in reducing dust and SCI content at the different size categories is higher for MR cotton followed by LR cotton.

As shown in Fig (6) after porcupine MR cotton has higher content up to particle size 150 μ m. HR cotton has higher SCI content for most size categories.

Fig (7) shows the effect of RST fine opener on particle size distribution. For LR cotton, as shown in Fig (7-1), reduction in dust and SCI content is carried out for some size categories.. Effect of RST is clear for MR cotton in elimination of dust particles in the size categories up to 200 μ m. Where about 67% of eliminated dust are of size up to 100 μ m and 89% of eliminated dust are in the size categories up to 200 μ m. For HR cotton elimination of small dust particles up to150 μ m is very low and increment is carried out in dust content for the other size categories. Increment in SCI content in some size categories after RST is higher for HR cotton and lower for LR cotton.. After RST, as shown in Fig (8) Dust and SCI content at different sizes is higher for HR cotton.

From data in Table (1) dust content represents about 90 to 93% of total trash content. Dust cleaning intensity by dustex ranges from 30 to 33%.

Fig (9) shows the effect of dustex on particle size distribution. Dust particles eliminated by dustex as a count are higher for the higher dust content before dustex. Dust eliminated of the size up to 100 μ m, which has the higher content, represents about 30% (HR cotton) and 47% (LR and MR cottons) of the total eliminated dust by dustex. The eliminated of the size up to 150 μm represents 69% (LR and MR cottons) and 51% (HR cotton) of the total eliminated. While about 83% (LR cotton), 75% (MR cotton) and 72% (HR cotton) of the eliminated dust by dustex are in the size category up to 200 μm. Since cotton before dustex contain high percent of dust, so the effect of dustex in reducing trash content is obvious.

As shown in Fig (9-1) to (9-3) elimination of SCI in different size categories by dustex is carried is combined with increment in SCI content in some size categories. This increment is higher for HR cotton and lower for LR cotton. The effect of dustex on the three cotton is clear as shown in Fig (10) as compared by Fig (8). Where a reduction in dust content at different sizes is found for the three cottons and HR cotton still has the higher dust content. For SCI the reduction is founed for size categories up to 850 μm.

Fig (11) shows the effect of blowroom on particles size distribution. The higher reduction in dust content at different size categories is found for LR cotton and the lower is found for HR cotton. The same was found for SCI at the same time increment in SCI content at some size categories is higher for HR cotton and lower for LR cotton. This increment is due to fragmentation of particles of larger sizes.

Comparison between Particle size distribution before and after blowroom for the three cotton is shown in Fig (12) and (13). As shown in Fig (12-1) LR cotton has the higher dust content up to particle size 200 μm. After blowroom dust content of this cotton is dropped to the lower degree of the three cottons followed by MR cotton.

Fig (13) shows the cumulative trash size distribution before and after blowroom.

Fig (14) shows the difference between particle size frequency before and after blowroom. It can be noticed that the difference between trash content(i.e. the elimination) at different size categories is higher for LR cotton followed by MR cotton and the lower is for HR cotton. This mean that dust cleaning intensity is higher than trash cleaning intensity. Data in Table (2) confirms this result.

Data in Table (2) shows that CE% is 77%, 57% and 39% for LR, MR and HR cotton respectively. Particles cleaning intensity as shown in Table (3) is 86% , 75% and 56% for the three cottons. After blowroom LR cotton has the lower trash residual% and HR cotton has the higher trash residual% as shown in Tables (2) and (3).

4. Conclusions

From the experimental work and discussion the following conclusions can be drawn for the Egyptian cottons used in investigation:

(i) In terms of particle size content and distribution

- Dust content ranged from 88% to 97%. For all cottons there is no micro dust content i.e. of size <50 microns.
- Dust particle size is exponentially distributed

(ii) *In terms of obtainable cleaning efficiency*

- Blowroom cleaning efficiency for the is ranged from 39% to 84%.
- Amongst the factors influencing Blowroom cleaning efficiency is cotton cleanability . Since different different cleaning efficiencies are obtained for different cottons with the same level of trash content (%).
- For the same trash content(%) cleanig efficiency of successive opening and cleaning machines increases.

(iii) In terms of cotton cleaning resistance

For the chosen three groups of cottons law resistance (LR), medium resistance

(MR) and high resistance (HR) to cleaning :

- Cleaning efficiency is 77% , 57%and 36% for LR, MR and HR cottons respectively.
- particles cleaning intensity is 86%, 75%and 56% for LR, MR and HR cottons respectively.
- Fragmentation of trash particles is the higher for high resistance to cleaning cotton and the lower is for low resistance to cleaning cotton.
- Low resistance to cleaning cotton has the higher trash elimination at the start of opening and cleaning process (at bale opener). Where 70% of dust and 31% of SCI are eliminated for this cotton.
- By dust separator, for LR cotton about 83% of the eliminated dust are in the size categories up to 200 μm. While for MR and HR cottons the eliminated dust of the same size represented about 75% and 72% of total eliminated dust respectively.
- By opening and cleaning process, low resistance to cleaning cotton is the higher in dust and SCI elimination at different size categories while high resistance to cleaning cotton is the lower
- By blowroom fragmentation of SCI is higher for high resistance to cleaning cotton and lower for low resistance to cleaning cotton.

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Table (1) Summary of trash content of fibre stream during opening and cleaning

		From bale	After opener	After porcupinr	After RST	After Dustex
VFM (%)	min	0.88	0.78	0.63	0.49	0.33
	max	4.05	3.7	2.86	2.2	1.65
	mean	2.2	1.66	1.23	1.064	0.797
Dust (count/g)	min	270	294	248	241	137
	max	2760	2748	1568	903	771
	mean	1357	1041	689	430	416
SCI (count/g)	min	42	34	30	15	22
	max	180	135	104	65	54
	mean	87	73	52	39	36

Table (2) Trash content of fibre stream during opening and cleaning

	Dust content (count/g)			SCI content (count/g)			VFM (%)		
	LR cotton	MR cotton	HR cotton	LR cotton	MR cotton	HR cotton	LR cotton	MR cotton	HR cotton
bale cotton	1889	1160	1262	65	90	77	1.83	2.16	1.89
After bale opener	574	1126	824	45	84	50	1.22	1.83	1.11
After porcupine	406	666	690	40	42	50	0..95	1.01	1.17
After RST	364	403	737	27	44	54	0.68	1.06	1.41
After Dustex	241	279	546	27	36	44	0.43	0.93	1.16
Residual%	13	24	43	42	40	57	34	43	.61
Total cleaning Intensity	87%	76%	57%	58%	60%	43%			
Total cleaning efficiency							77%	57%	39%

LR cotton = low resistance to cleaning cotton
MR cotton = medium resistance to cleaning cotton
HR cotton = high resistance to cleaning cotton

Table (3) Total trash content and particle mean size of fibre stream during opening andcleanig

	Total trash particles(count/g)			Mean size (μm)		
	LR cotton	MR cotton	HR cotton	LR cotton	MR cotton	HR cotton
Bale cotton	1954	1250	1339	181	228	209
After Bale opener	618	1210	875	231	223	209
After Porcupine	446	709	741	250	192	218
After RST	391	447	791	236	251	233
After Dustex	268	315	590	271	267	241
Residual%	14	25	44			
Total cleaning Intensity	86%	75%%	56%			

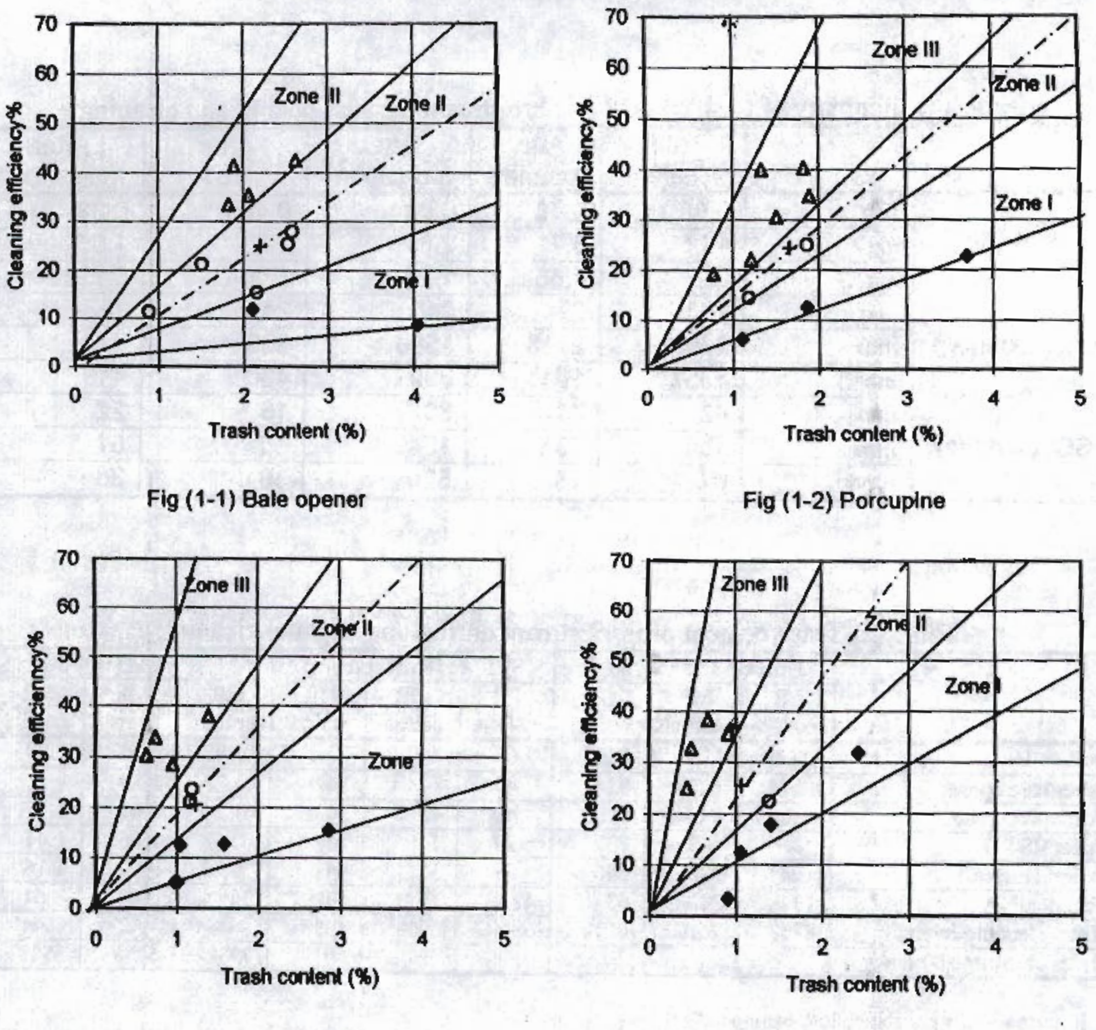


Fig (1-1) Bale opener

Fig (1-2) Porcupine

Fig. (1-3) Cleaner RST

Fig (1-4) Dustex

Fig. (1) Relationship between cleaning efficiency of blowroom machines and trash content of the input material

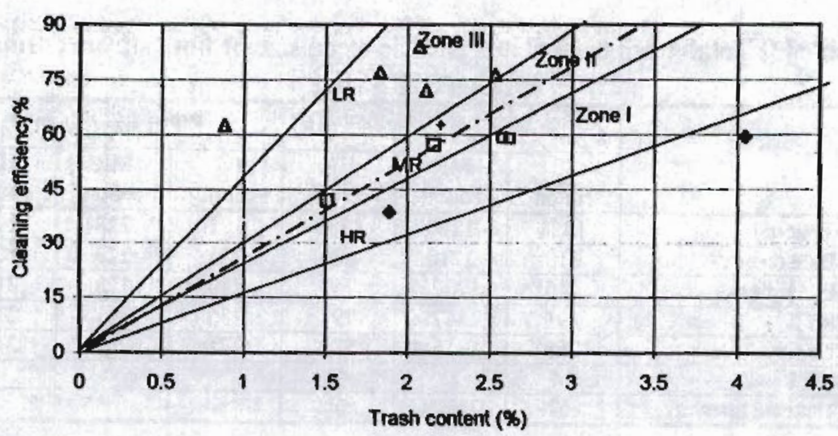


Fig. (2) Relationship between cleaning efficiency of blowroom line and trash content of the input material

Zone I high resistance to cleaning cottons

Zone II medium resistance to cleaning cottons

Zone III low resistance to cleaning cottons

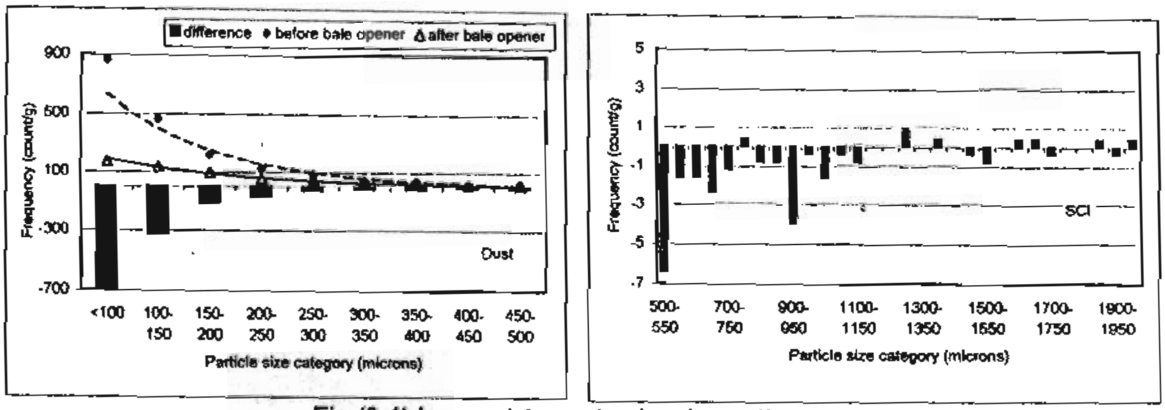


Fig (3-1) Low resistance to cleaning cotton

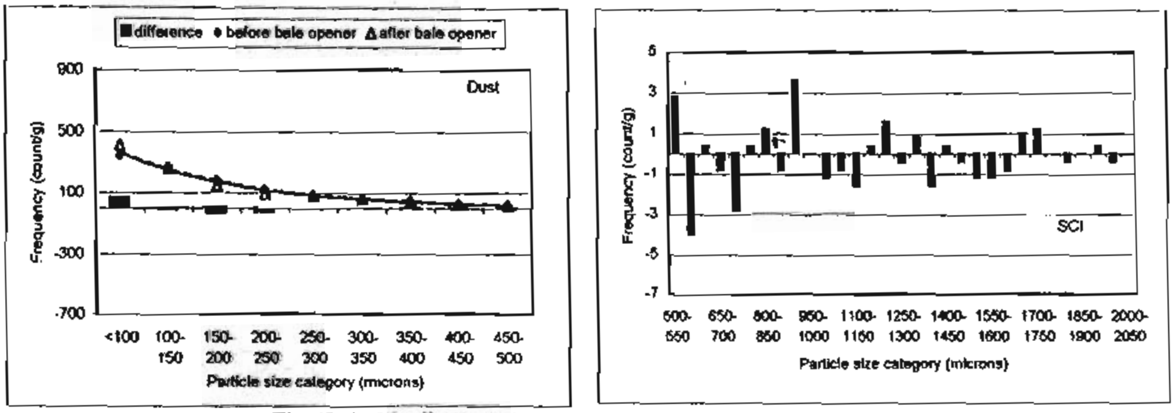


Fig (3-2) Medium resistance to cleaning cotton

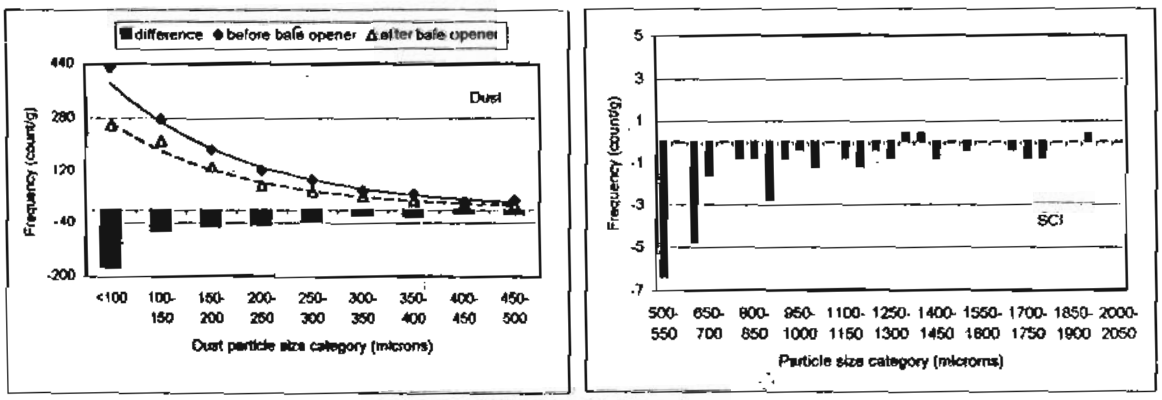


Fig (3-3) High resistance to cleaning cotton

Fig (3) effect of bale opener on prticles size distribution

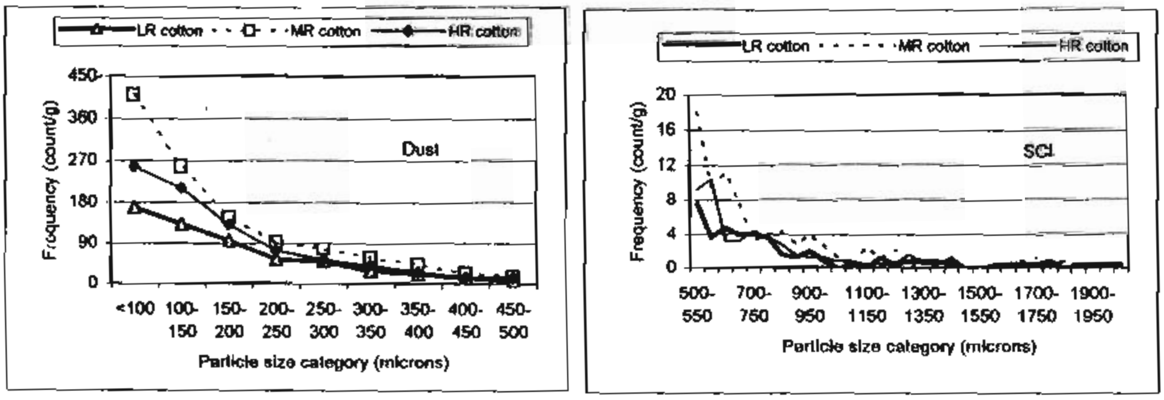


Fig (4) Particle size distribution after bale opener

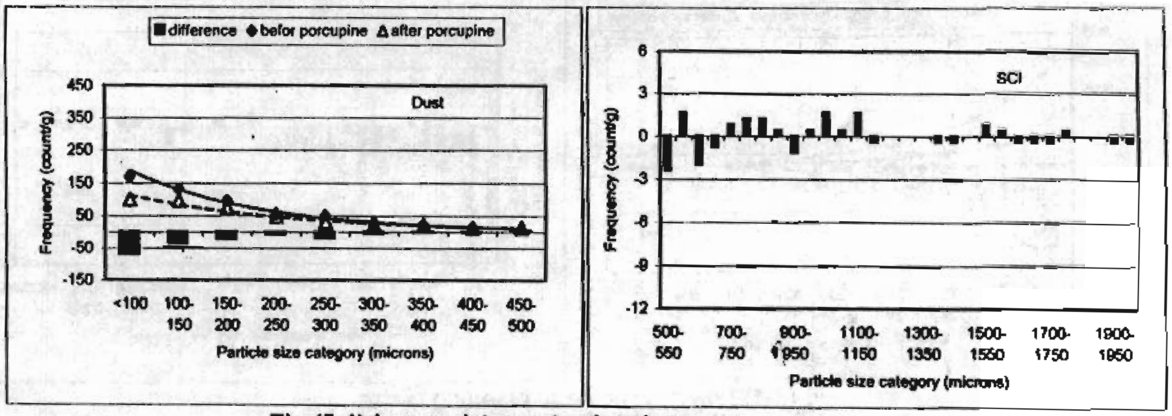


Fig (5-1) Low resistance to cleaning cotton

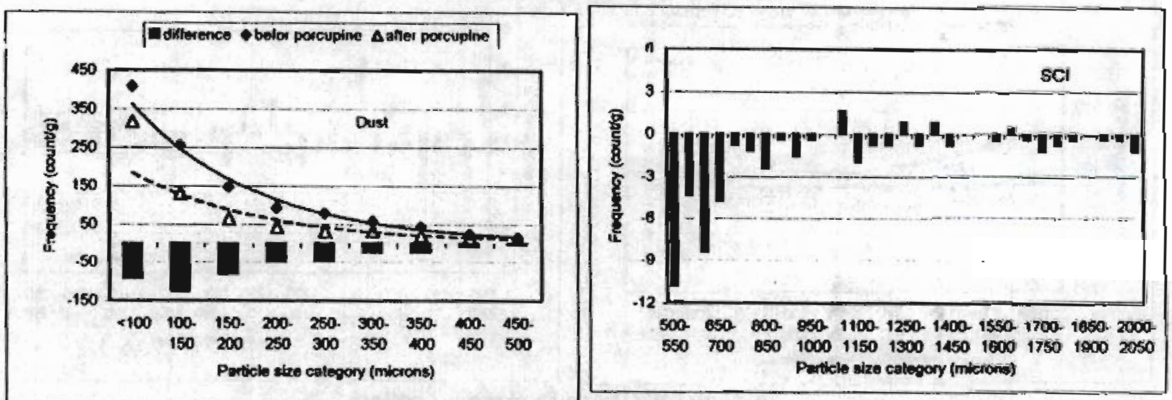


Fig (5-2) Medium resistance to cleaning cotton

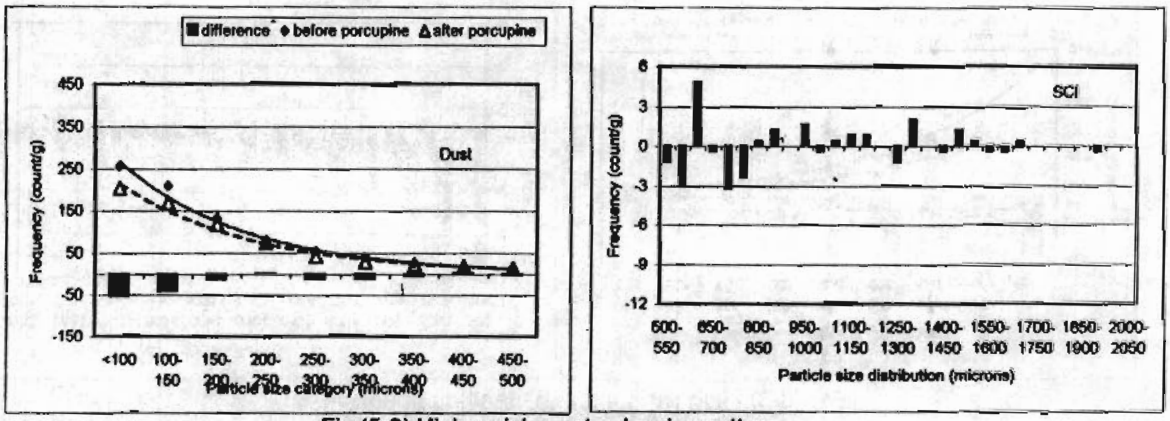


Fig (5-3) High resistance to cleaning cotton

Fig (5) effect of porcupine on prticles size distribution

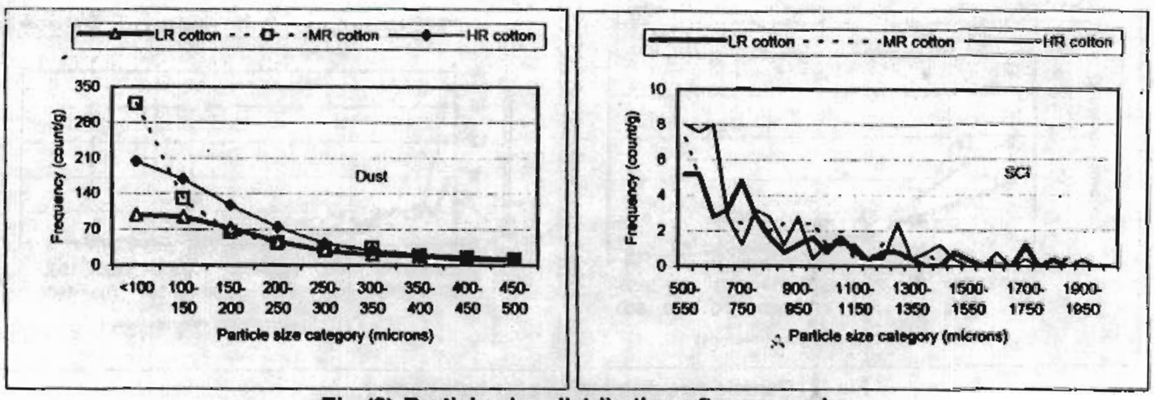


Fig (6) Particle size distribution after porcupine

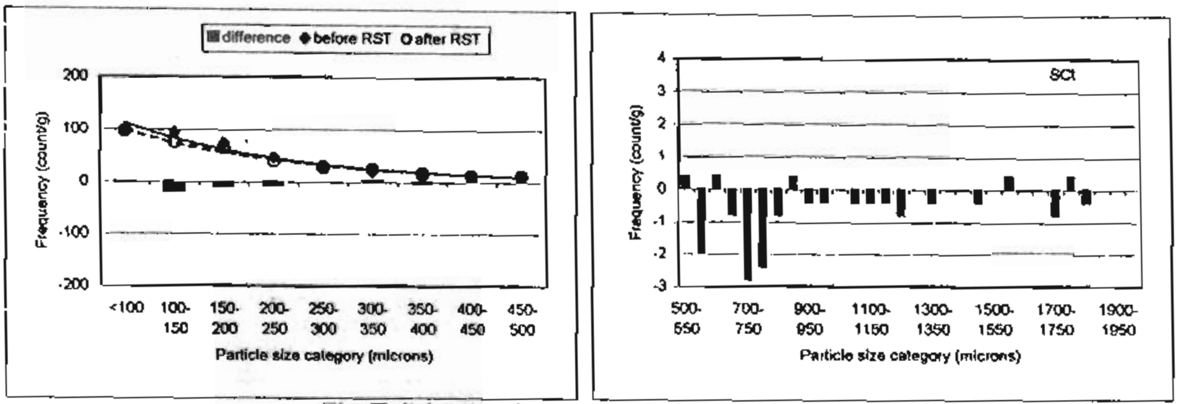


Fig (7-1) Low resistance to cleaning cotton

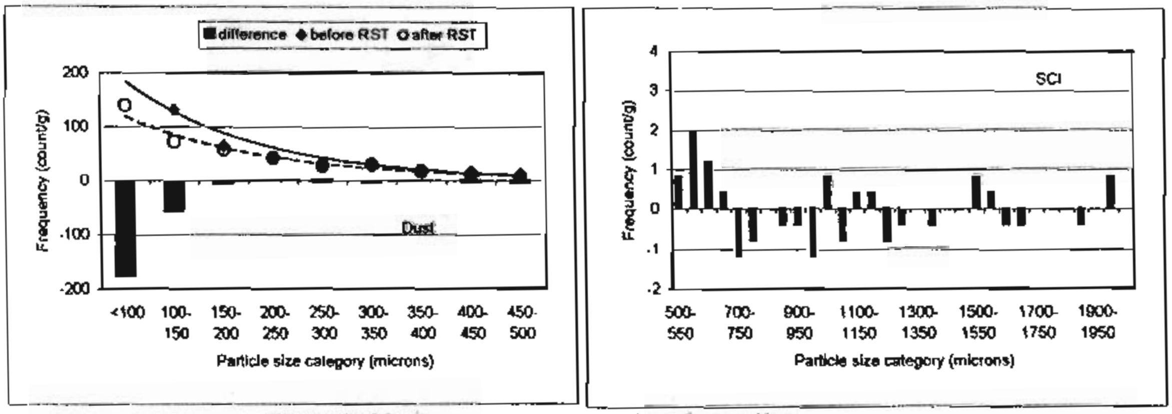


Fig (7-2) Medium resistance to cleaning cotton

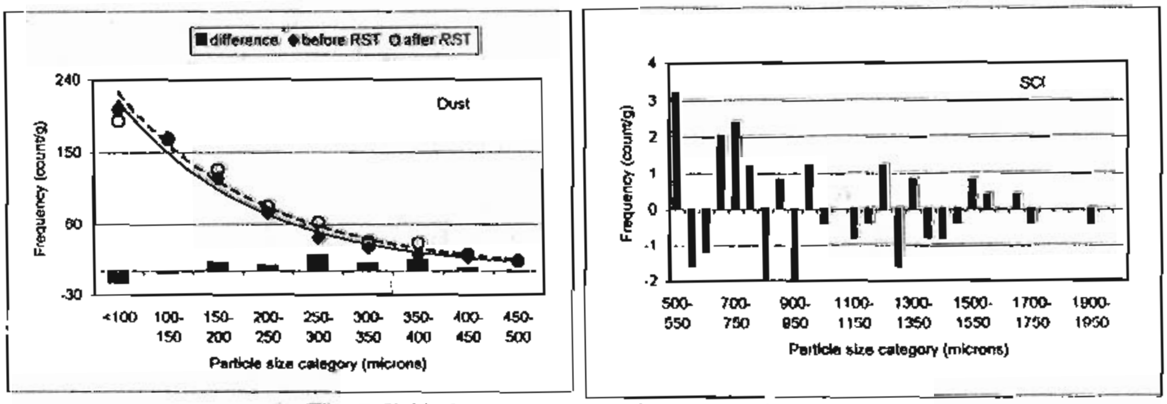


Fig (7-3) High resistance to cleaning cotton

Fig (7) Effect of RST on prticles size distribution

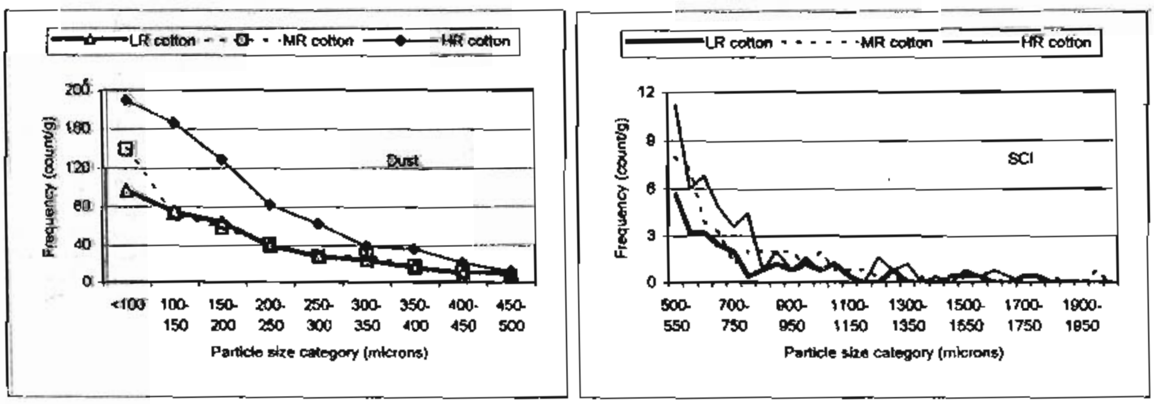


Fig (8) Particle size distribution after RST

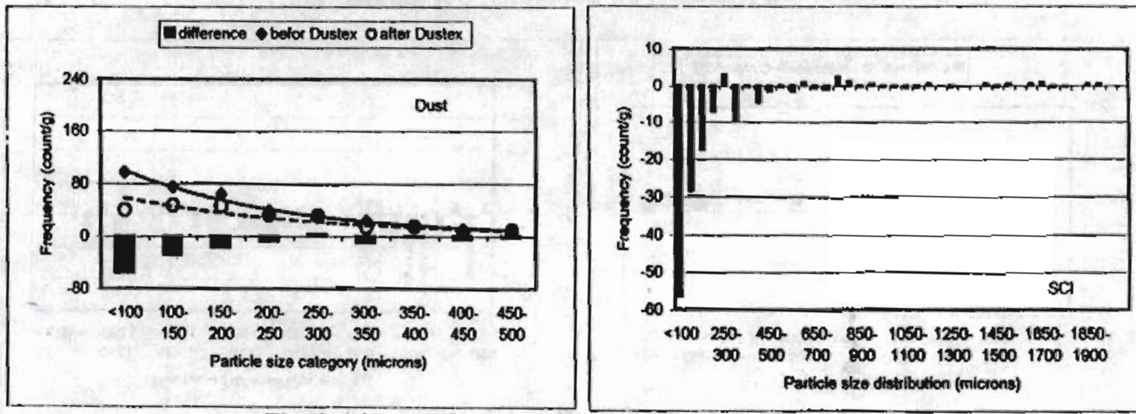


Fig (9-1)Low resistance to cleaning cotton

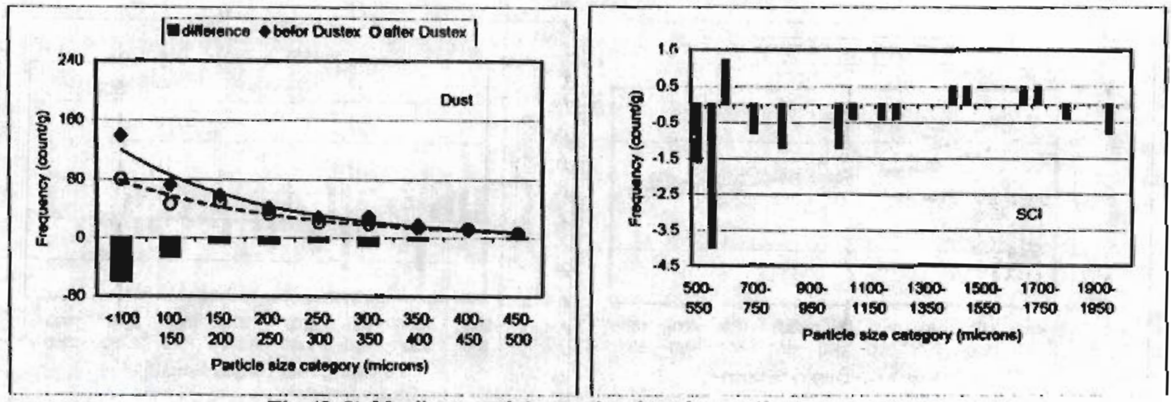


Fig (9-2) Medium resistance to cleaning cotton

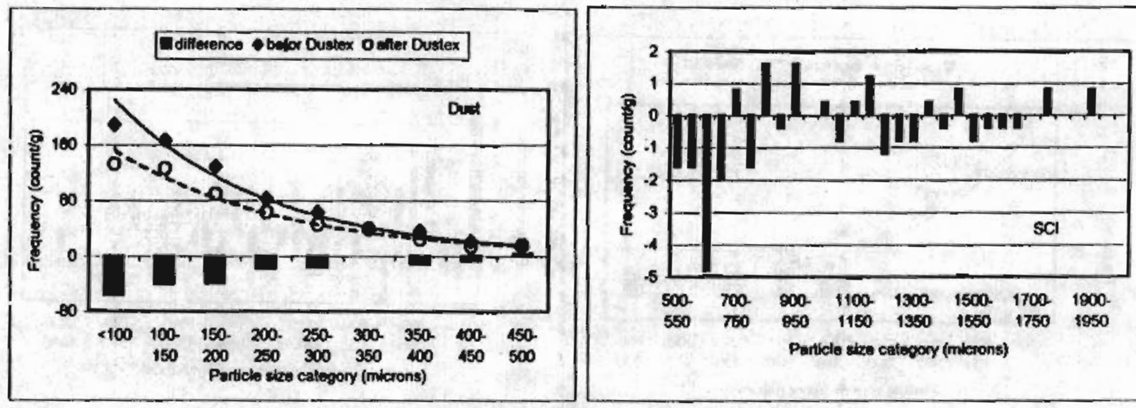


Fig (9-3) High resistance to cleaning cotton

Fig (9) effect of Dustex on prticles size distribution

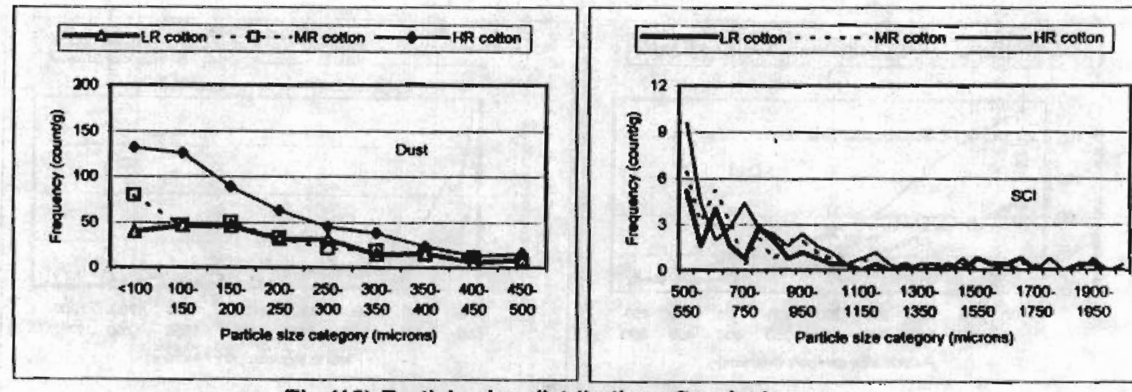


Fig (10) Particle size distribution after dustex

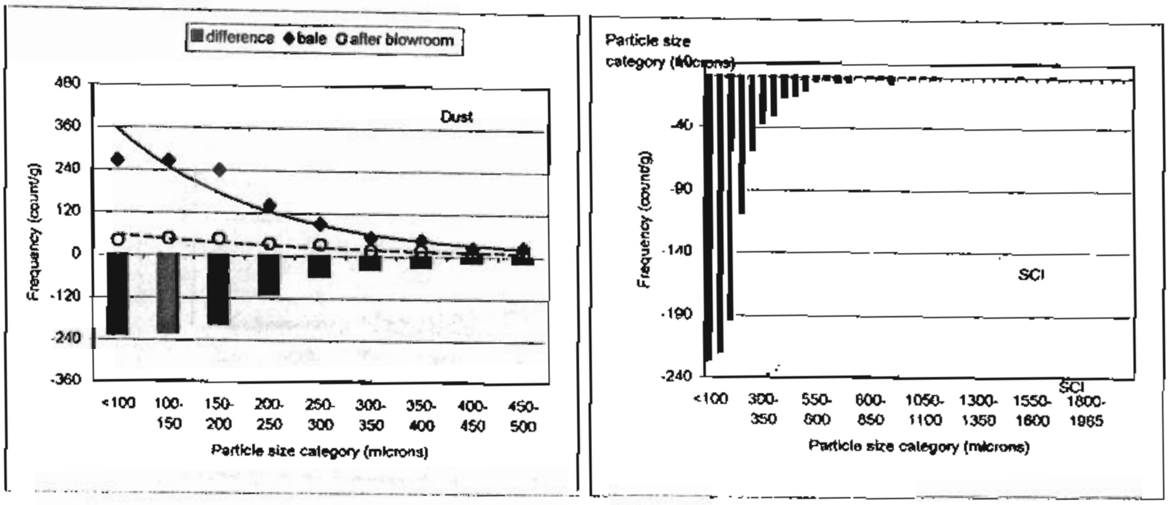


Fig (11-1) Low resistance to cleaning cotton

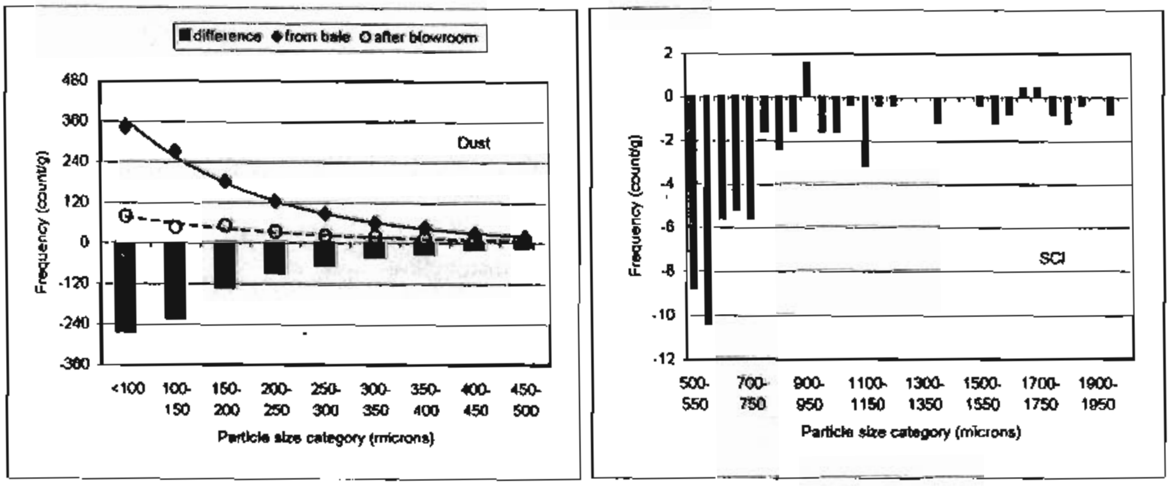


Fig (11-2) Medium resistance to cleaning cotton

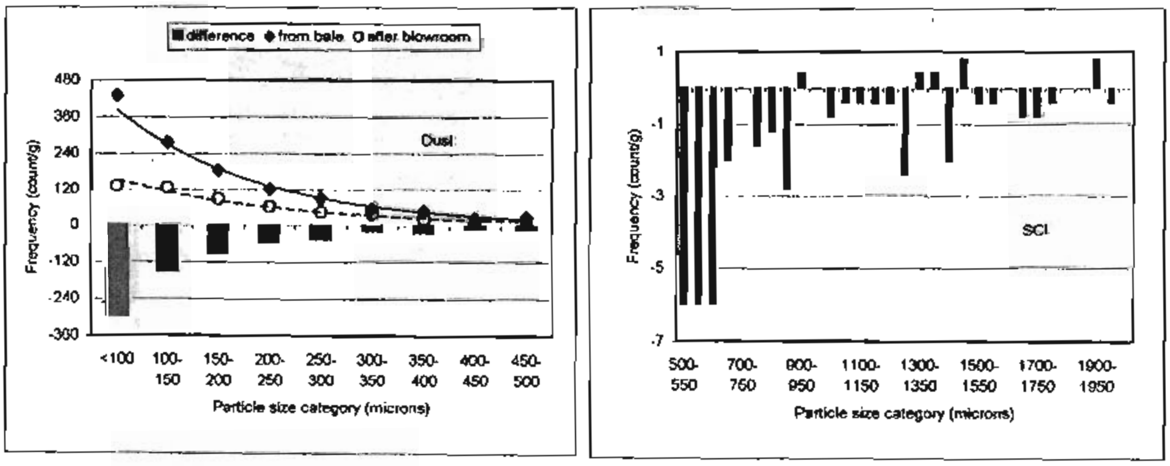
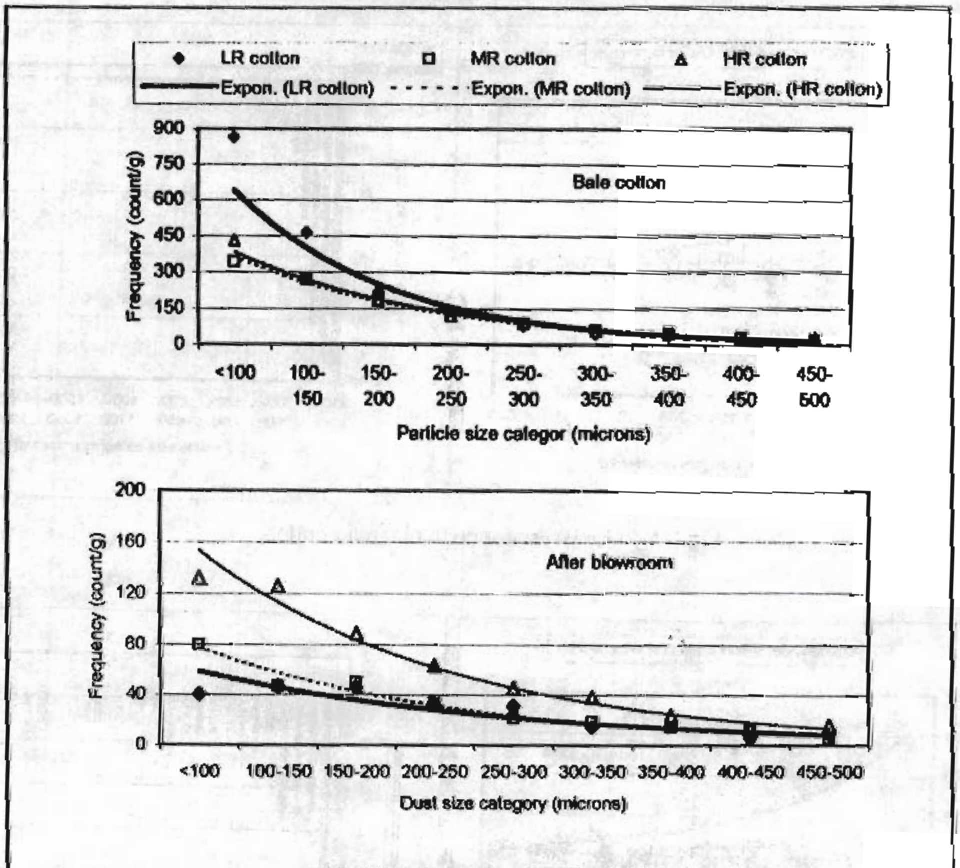
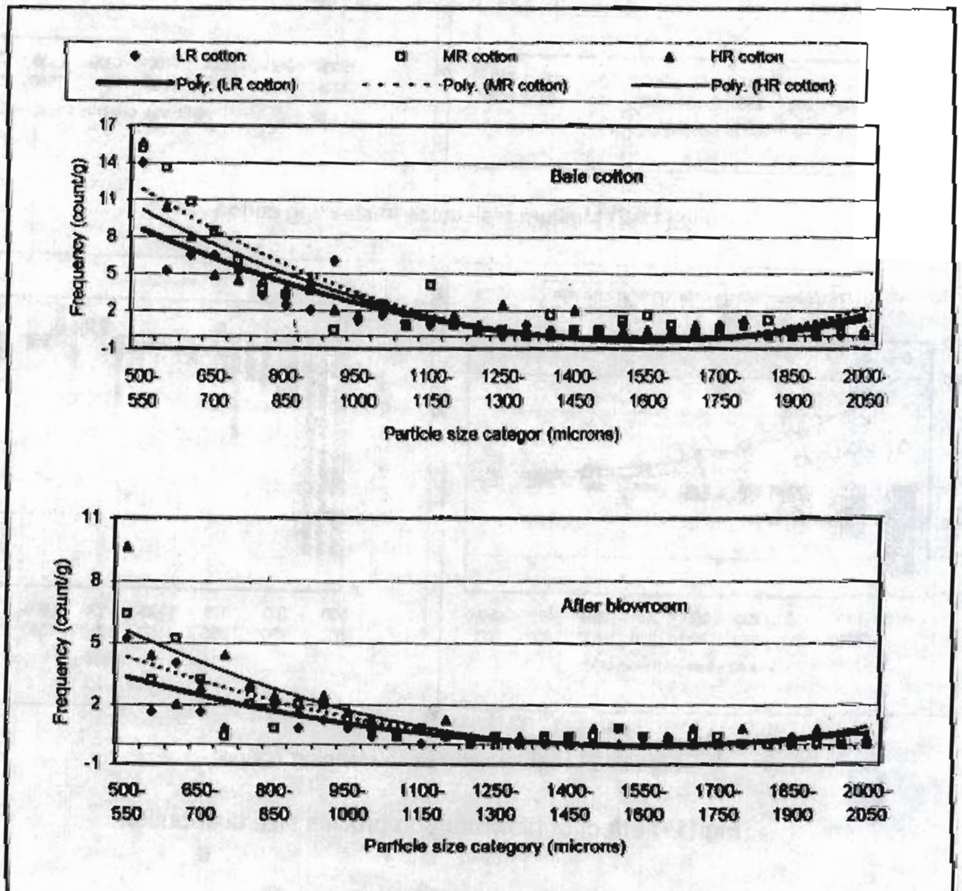


Fig (11-3) High resistance to cleaning cotton

Fig (11) effect of blowroom on prticles size distribution



(12-1) Particle size distribution



(12-2) SCI size dustribution

Fig (12) Particle size distribution before and after blowroom

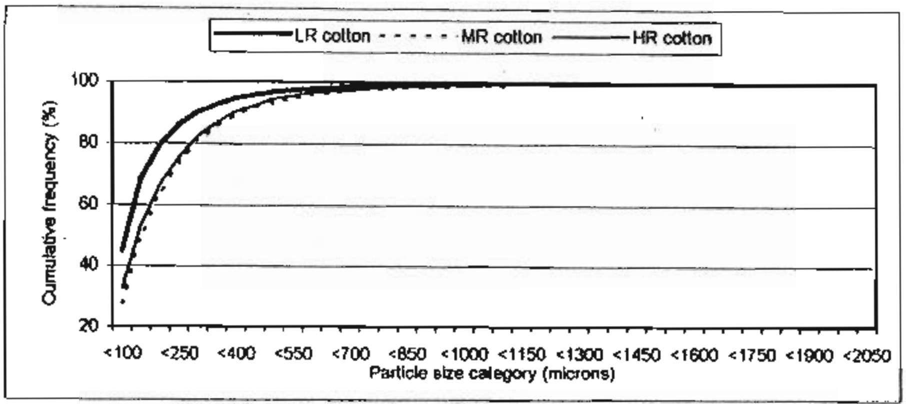


Fig.(13-1) Particle size distribution for bale cotton

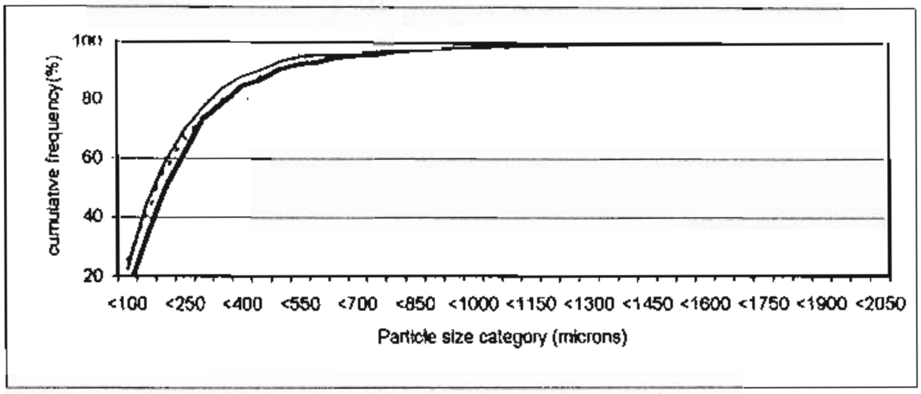


Fig.(13-1) Particle size distribution after blowroom

Fig (13) Particle size cumulative frequency distribution

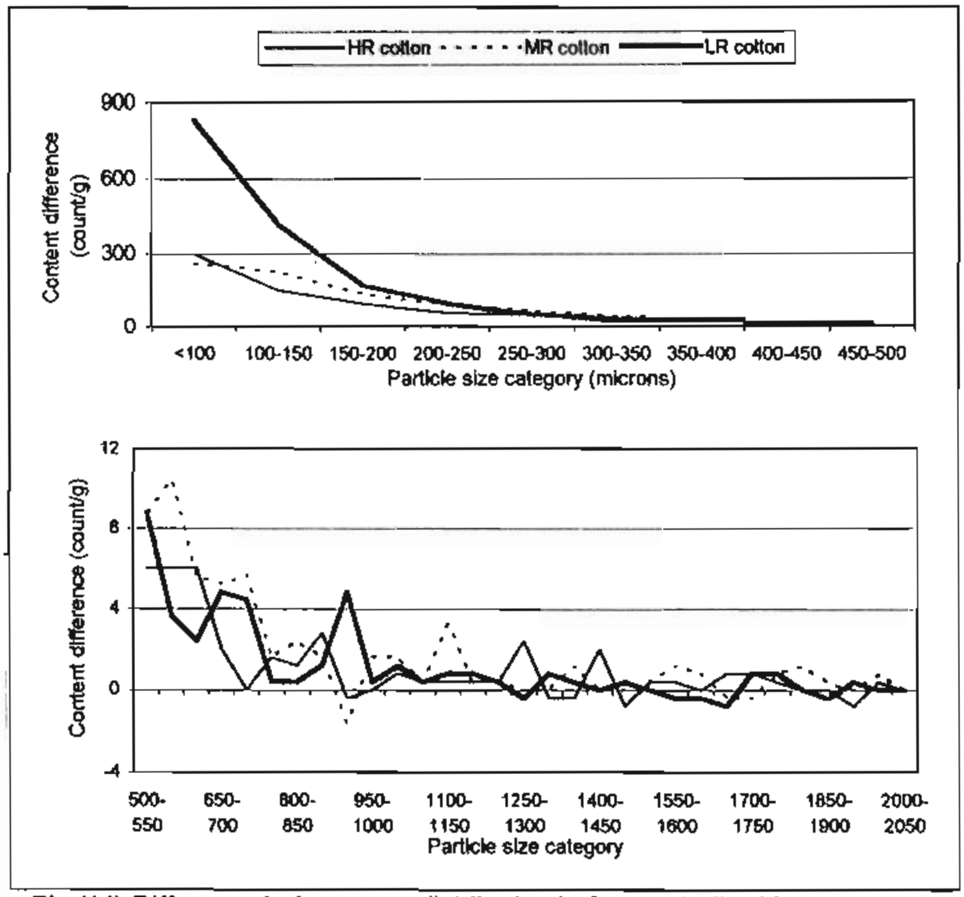


Fig (14) Difference in frequency distribution before and after blowroom