ENVIRONMENTAL IMPACT STUDIES OF CHROME ROLLERS USED BY COTTON ROLLER GINNING INDUSTRIES AND DESIGN AND DEVELOPMENT OF POLLUTION FREE CHROME LESS RCF ROLLERS

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Abstract

This paper realizes the hazards of chromium contamination and pollution caused by the use of Chrome Composite Leather-Clad (CCLC) rollers commonly used in cotton roller ginning industries and attempts to eliminate the chromium contamination and pollution during the complete process. The cotton roller ginning process is the mechanical separation of cotton fibres from their seeds by means of one or more rollers to which fibres adhere while the seeds are impeded and struck off or pulled loose. Most of the cotton ginning operations are done using roller gins. The roller coverings contain about 18000 to 30000 mg/kg (ppm) as total chromium of trivalent and hexavalent forms which are toxic on human health. When the seed-cotton is ginned, the ginned lint cotton adsorbs with it about 140 to 1990 mg/kg (ppm) as total chromium of trivalent and hexavalent forms. Cotton dust is a good adsorbant of Cr (III) and Cr (VI) from chrome Specific Dust (CSD) being powdered during ginning operation. Due to persistent rubbing of CCLC roller over the fixed knives, this carries with it 25 to 100 mg/kg (ppm) which according to eco-standards for yarn and fabric, should not be more than 0.1 mg/kg (ppm). The chromium contamination in cotton seeds and oil are 125 to 300 mg/kg (ppm) and corresponding eco-standard is 2 mg/kg. This causes chromium poisoning lead to skin disorders and liver damage on human and animal health. Subsequently the same or less amount is carried till textile of effluent which according to environmental standards should not be more than 2 mg/l. The traces found contain hexavalent chromium being adsorbed from chromium-contaminated lint, yarn, fabric, seeds and by products and textile effluent. The chromium concentration in suspended particulate matter (SPM) is 1994 mg/kg (ppm), which according to environmental standard should not be more than 2 ppm. The

chromium content in respirable suspended particulate matter (RSPM) is 150 ppm. Gin and mill workers are exposed to this chromium pollution, is susceptible to health hazards. Toxic effects are produced by prolonged contact with airborne or solid or liquid chromium compounds even in small quantities. The three pollutants, viz., cotton dust, chromium and leather powder and/or other foreign matter, under favourable conditions of sunlight (photo energy), humidity, temperature and air movement interact and produce chrome specific dust (CSD) which is a serious pollutant due to synergistic interacting function. A human health survey is made among the workers of the cotton ginning industry and the people exposed to the contamination and pollution such as the children with working mother in order to study the occupational health and safety of the industry. Chromium poisoning is observed in animal liver due to the consumption of contaminated cotton seeds. To offset this problems, pollution-free rubberized cotton fabric rollers or eco-friendly rollers for commercial studies have been designed, fabricated and experimented in rollers gins. This controls and nullifies chromium contamination and pollution during the complete process. Cotton technological parameters are well proved for commercial acceptance.

Introduction

The cotton roller ginning process may be briefly defined as the mechanical separation of cotton fibres from their seeds by means of one or more rollers to which fibres adhere while the seeds are impeded and struck off or pulled loose. The principle of this roller ginning process was invented by McCarthy. The method is holding the fibres by adherence over the surface of leather rollers and removing the seed-cotton. Figure-1; Configuration of Cotton Roller Ginning Process. Since the semi-finished chrome leather washers contains 3 to 4% as total chromium and are being used by roller ginning industries in India, Africa, Tanzania and Egypt attention has been drawn to view the contaminating and polluting aspects during the complete process. The chrome specific dust pollutes the gin-house air and the cotton processing workers suffer from chromium bound diseases and physiological disorders. The chromium adsorbed into lint causes allergic symptoms, cancer incidence, brain damage, chronic ulceration and perforation of nasal septums to cotton processing workers. Toxic effects are produced by prolonged contact with airborne or solid or liquid chromium contamination and pollution even in small quantities.

Cotton seeds get contaminated with chromium from the source. Present work is aimed to identify and study the environmental and health related problems faced with currently used Chrome Composite Leather-Cladding (CCLC) rollers. Some experimental results of chromium analysis and relevant eco-standards, quantity of respirable and suspended particulate matter samples, health survey observations and cotton technological reports of eco-friendly lint and chrome contaminated lint are presented for assessing the hazards of chromium contamination of lint, yarn and fabrics and air pollution problems due to chrome specific dust (CSD). After realizing the hazards of chromium contamination in lint, seed, yarn, fabric and textile effluent and air pollution problems due to chrome specific dust in ginning and textile environment, there is a need to eliminate contamination and pollution due to chromium at the source that is at cotton ginning process being done in these countries.

Description and Performance of CCLC Rollers in DR gins

The roller is the major component of DR gin. The gin roller length varies from 1025 to 1148 mm with a diameter varying from 178 to 180 mm suitable for operation. The roller consists of 78 to 80 numbers washer disks. Each washer disk is made of dimensions having the diameter 180 mm and thick 1 mm comprising of 18 numbers CCLC flaps stitched and bonded together. Basic Chromium Sulphate (BCS) $Cr(OH)SO_4 \cdot nH_2O$ and impure chromate having 45-50 % basicity are used during *chrome leather tanning process* for making such CCLC flaps. The various unit operations involved in making washers to final shape of the roller are (i) The washers are filled in a steel shaft having square cross section of 50 mm^2 or hexagonal section of 50 mm E/E to form a roller, (ii) The filled washers are compressed to a pressure of 14 kg/cm^2 by using a conventional pressing machine. The roller is to be pressed on both sides by adding required number of washers on each side, (iii) The pressed roller is turned and finished to diameter 180 mm in a center lathe, (iv) Spiral grooves are made on the surface of the finished rollers; The finished roller is ready for grooving operation by using band saw; initially by marking 'U'-shaped spiral grooves, fixing in the grooving machine and lastly spiral grooves are made on the roller surface by band saw or circular saw cutting machine.

The ginning efficiency primarily depends upon the surface speed of the roller and number of working strokes on the moving knife (Shete, D.G., *et.al.*, 1993). While operation of these rollers in the ginning machines, the rate of ginning goes on declining

when the roller diameter is reduced. At the end of cotton season having three months duration, that is after the diameter is reduced to 114 mm, the washers are removed from the shaft. Again the new washers are recovered and cladded in shaft. The worn out and consumed washer disks after considerable period of usage for about three months .

Environmental Impacts of CCLC Rollers

Environmental impacts of CCLC rollers are assessed from the pollutants *viz.*, *cotton dust* and *chrome specific dust* (CSD) in the mill atmosphere. Their sources and health effects are briefly described below.

The *cotton dust* released in the ginning process is a complex and variable mixture of cotton fibres, undeveloped ovules, cotton plant debris including twigs, bract and *pericarp* particles left after the ginning process together with soil particles, bacteria, fungi and residues from pesticides. The visible and invisible dust in the mill atmosphere is known as '*Fly*'. The ambient air particles of about 2.5 μm are classified as cotton dust in ginning environment. *Byssinosis* is a disease due to the inhalation of cotton dust over long period of time (Shirley Vol. II, 1982). It is a permanent disabling lung disease. The symptom is chronic cough ending in chronic bronchitis (respiratory disorder). India has a large number of ginning and textile mills employing 48% of all the factory workers (Rao, M.N., 1995). About 55% of mill workers suffer from *byssinosis* disease (Rao, C.S., 1995).

As per the rough estimate during field survey/discussions with ginning industry management, presently, there are about 2,13,000 CCLC rollers, which comprise of 1,70,40,000 CCLC washers are used for a cotton season of three months in our country. There are about 7,60,000 people working in roller ginning industries in India.

Due to the persistent rubbing action between CCLC rollers and stationary knives in ginning machines, they are wearing out constantly and exorbitantly contaminating the ginned lint cotton with chromium and gets permanently coated during the ginning process. CSD production during this process is the major environmental chromium contamination and pollution problem from roller ginning industries. It is mentioned that contamination of cotton by the foreign matter other than field originating trash is the serious problem. Lint cotton and cotton dust are the adsorbents of chromium from CSD emission. Thus, chromium is adsorbed in lint cotton, spun yarns, woven fabrics in macro level. During the wet textile processing stage, the concentration of chromium in the effluent is precipitated in micro amount.

The chromium concentration is reduced in micro amount during beating operations, blow room mechanical cleaning and carding process. It is permanently coated with spun yarns and woven fabrics in considerable amount against the safe limits of 0.1 ppm prescribed by eco-standards. Cotton seeds are an important source of edible oil. The ginned cotton seeds are also contaminated with chromium in huge concentration, thus polluting edible oil. Chromium contaminated cotton seeds cause chromium poisoning lead to skin disorders, liver damage on human and animal liver. Oil cakes consumed by animals were found with chromium poisoning diseases.

Chromium in CSD and contaminated cotton products acts on human in three ways, viz., (1) local action as dermatitis or absorption through skin, (2) direct inhalation and (3) ingestion or absorption into stomach (Morton Lippman, 1991). Toxic effects are produced by prolonged contact with airborne, solid or liquid chromium compounds even in small quantities because of their properties viz., carcinogenicity, mutagenicity and corrosiveness (Sujana, M.G., *et.al.*, 1997). Complications do arise due to the reducing nature of these chromium traces that affect organic tissues of body.

The air pollution due to CSD and cotton dust, which is responsible for synergistic (augmentative) health complications of chromium based diseases and byssinosis diseases on ginning industry workers. Almost most of the mills in India *are not provided* with dust control systems. Nor they provide personal protection devices to the workers. It is mentioned that the ginning industries are located in and around cotton growing areas and employ women in the age group of 21 to 40 years for *menial jobs* and male workers in the age group of 18 to 50 years. The women often come along with their *children* for performing their jobs, like (i) feeding seed-cotton (or *kapas*), (ii) collecting the lint cotton, seed and floor sweeping, (iii) cleaning and grading the seed-cotton and (iv) light activities. The children are exposed directly to CSD. The health effects and reports of the workers has not come out into public, because (i) almost all the workers are not in regular employment, (ii) the cotton ginning industry functions seasonally for 6-8 months in semi-arid zones and 8-10 months in rain fed areas in an year, (iii) the workers are reluctant to go for their medical checkup because of their negligence and fear and (iv) they are economically not sound enough to go for their medical treatments.

Based on the environmental impacts of CCLC rollers in roller ginning industries, the first part of the present study pertains to assess environmental chromium pollution during the cotton ginning process.

Basis of Design and Development of Eco-friendly Chrome Less Roller for Cotton Roller Gins

In conventional ginning process, CCLC rollers emits tremendous chromium in ginning environment due to constant dust-producing, grinding action which contaminates the cotton and its products. This also causes air pollution in the mill environment. An exhaustive study is needed for the development of eco-friendly chrome less roller, which can be an alternative to the existing CCLC rollers.

An exhaustive material studies are done for the suitable material's selection of the gin rollers which are made of Walrus animal skin, Spider tuck packing, coir-board, rubber packing, metal cylinder, rubber roll, fabric and rubber packing, leather, cotton, rubber and cork, plastics and fluorinated ethylene propylene. The peculiar gripping action or adherence of the cotton fibres to the roller surface is considered while designing the rollers. The leather surfaces possess *interfibrillary* action, which enables to adhere the fibre on the surface. This particular property is studied extensively for the different materials and combination of different materials so as to design and fabricate laboratory gin chrome less rollers for gin roller experimentation device (GRED) and prototype eco-friendly chrome less rollers for existing DR gins. One of the associated objectives of laboratory studies are to define the physical properties of a roller covering material which contributes to its energy consumption, ginning rate potential, eco-friendly parameters, cotton technological parameters, mechanical engineering analysis, wear resistance properties, heat proof capacity and to search better roller covering materials.

Materials and Methods

For the present study, roller wearing and compaction rate study were conducted in Roller ginning industries at Belgaum, India for the cotton seasons 1996-1997 to 1998-2000 and 2001-2002. The roller gins are adjusted using spacers as per the standards. Grooving is done regularly at the start of each shift as per cotton varieties. To study the heavy metal as total chromium mg/Kg (ppm) in cotton lint samples, seed samples, seed-cotton samples, CCLC roller samples, CCLC roller samples collected during grooving operation, soil samples from the region of investigation is made, root

of the plant for bio-availability, fibre, yarn, fabric samples, textile effluent samples, the standard American Public Health Association (APHA) method is followed for chromium (as total and hexavalent) analysis using Atomic Spectrometer (AAS). Respirable and suspended particulate matter quantity in gin house air are monitored using High Volume Air Sampler (HVAS) with cascade impactor with appropriate glass fibre filters. The quantity of pollutants are collected in HVAS as 8 hours basis and analysed for chromium. The worker dose and exposure time are found using the personal sampler. Cotton technological parameters are tested in High Volume Instrument (HVI) and Scanning Electron Microscope (SEM) for chrome roller ginned lint and eco-friendly roller ginned lint and given in Table 2.

A health study is conducted by the author at Guntur, Bailhongal, Sendwa, Surendranagar, India, Tanzania and other countries, where maximum number of ginning factories are situated to survey the health effects and occupational health hazards. In view of the environmental problems existing with the present CCLC rollers employed in ginning industries and subsequent to literature survey made, it was decided to develop environmentally free alternatives. The details are discussed henceforth.

The ginning investigations were carried out at Central Institute for Research on Cotton Technology (CIRCOT), Mumbai. The laboratory rollers for GRED were designed and fabricated at Calcutta at a local manufacturing firm. Experiments with the designed rollers were conducted at CIRCOT, Mumbai along with the cotton technological parameters. After the initial tests, pilot model rollers were designed and fabricated which were tested in ginning factories at Bailhongal and Sendhwa. Environmental analysis was done in Centre of Mining Environment, Indian School of Mines, Dhanbad, and Eco-Textile laboratory, Mumbai. Mechanical properties were analyzed in various mechanical engineering laboratories. Pilot model '*System after Modification*' was demonstrated in a ginning industry at Bailhongal.

Results and Discussions

An experiment is conducted to find out the wearing and compactness rate of CCLC rollers used by roller ginning industries for a season lasting three months. At the start of season the diameter of rollers are 180mm. At the end of season the roller dimensions are noted at left, middle and right positions for all the roller gins in the factory, that is 18 ginning machines. The results are presented (Table 2). Apart from the

wear and tear rate, the table expresses the quantity of pollutants generating during the operation, viz. chromium, leather powder, cotton dust and chrome specific dust. It is found that the wearing rate is 0.033mm / hour and the percentage material removed per roller 43.8%. The final diameter at the end of study is nearing 140mm. The compaction rate is 0.050 mm/hour. Figure-5 , Graph showing wearing rate of Dust-producing grinding of CCLC roller and RCF roller.

Chromium analysis report of cotton lint samples, seed and seed linter, seed-cotton samples, fibre, yarn and fabric samples are tabulated. The CCLC roller contains 18,077 mg/Kg (ppm) to 30,780 mg/Kg (ppm) as total chromium (3 to 4% as total chromium). This included trivalent and hexavalent chromium. During the ginning operation, lint adsorbs chromium particles which contains 143 mg/Kg (ppm) to 1994 mg/Kg (ppm). The CCLC roller is grooved at the start of each shift and filing or turning of the roller for leveling is done to get uniform diameter at start of each season. At that time, the wearing of roller is more and presence of chromium to the extent of 1994 mg/Kg (ppm) with lint. The total weight of chromium removed during a cotton season of 16 hours per day is 450 to 600 grams per gin roller gin. The chrome specific dust from one ginning machine enters in to environment and being adsorbed in lint stage having the level of 143 ppm. The environmental standards for chromium in spun yarn is 2 ppm and Cr (III) for baby clothing and fabric is 0.1 ppm and nil for Cr (VI). The traces found contain hexavalent chromium being adsorbed from contaminated lint, yarn to fabrics and subsequently cannot be removed in fabrics. There is evidence that the toxic effects on humans due to Cr (III) and Cr (VI) of its carcinogenicity and corrosiveness. The analysis show that traces of Cr (VI) are found in even analar grade trivalent chromium compounds and complications do arise due to the reducibility nature of these traces that affect the organic tissues of the body. This regenerating effects occur rapidly and dependent of the worker dose and exposure time.

TABLE 1
RESULTS OF ROLLER WEAR OUT DATA

M/c No.	DIAMETER OF THE ROLLERS AFTER ONE SEASON IN mm					
	ROLLER SIDE 'A'			ROLLER SIDE 'B'		
	LEFT	MIDDLE	RIGHT	LEFT	MIDDLE	RIGHT
1	140	140	140	141	143	142
2	140	140	140	140	142	142
3	145	146	150	150	145	140

4	153	153	153	148	148	148
5	148	147	148	148	148	148
6	146	147	148	146	146	146
7	135	135	135	145	142	140
8	140	140	140	145	142	140
9	150	150	150	148	148	148
10	138	136	136	136	136	136
11	145	145	146	145	145	145
12	136	136	136	136	136	136
13	158	158	158	158	157	157
14	160	160	160	161	160	160
15	154	154	154	155	156	156
16	155	155	156	155	154	154
17	160	160	159	160	160	160
18	160	160	161	160	161	166

Initial diameter of the rollers = 180 mm . Chromium roller compactness rate is -0.010 to -0.050 mm, i.e. -10 to -50 μm per hour. Wearing rate is 0.033mm / hour and the percentage material removed per roller 43.8% .

Table-2
Chromium Contamination Levels in Cotton and Its Products

Source: Chrome composite leather-clad(CCLC) roller = 18,077 to 30,783 mg/kg			
· Bio-availability for chromium uptake on cotton = 3 ppm			
Sl.No.	Cotton and its Products	Total Chromium	Environmental Standards
			*MOEF Notification -157
1.	Lint cotton	143-1990 ppm	0.1 ppm
2.	Spun yarns	17- 250 ppm	0.1 ppm
3.	Woven fabrics	17-45 ppm	0.1 ppm

4.	Cotton seeds	0-312	ppm	-
5.	Edible oil	0-259	ppm	-
6.	Oil cake	0-190	ppm	-
7	Linters	0-159	ppm	-

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- * Ministry of Environment & Forests Notification No.157, Dated 1 st May 1996.
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Following are the significant findings of chromium in dust samples with relevant eco-standards:

TABLE-3

Chromium Level in Dust Samples

Sl.No.	Source of Dust	Total Cr	**Environmental Standards, LD ₅₀
1.	Ginning point	51-173 ppm	50 ppm
2.	CCLC grooving point	17-1994 ppm	50 ppm

**U.S. National Institute of Occupational and Safety Hazard Standards, 1992

The manufacturing technology, design engineering features and assembly drawings show that the conventional fabric and rubber roller gin covering material is selected with the following characteristics, namely,

Hardness of 90 (type DO durometer) ,

9 to 10 layers of fabrics 20 mm length,

Thickness of fabrics 1.2 mm,

The rubber compounding is resilient and

0.76 mm of fibre bristles protrude beyond the rubber surface is maintained in spite of wear.

On the basis of the design and development of various rollers with subsequent performance evaluation studies, chrome-free RCF roller has been demonstrated with

reference to techno-commercial and eco-friendliness in ginning industries. The newly developed RCF rollers are successful and effective in functioning and in ginning out the seed-cotton. Cost economics study reveals that eco-friendly RCF roller ginnery sounds better in all aspects with reference to environmental, cotton technological and techno-commercial aspects. Given below the table showing data of engineering analysis of eco-friendly cotton lint and chromium contaminated lint.

TABLE-5
DATA OF ENGINEERING ANALYSIS OF ECO-FRIENDLY COTTON
LINT AND CHROMIUM CONTAMINATED LINT

Sl. No.	PARTICULARS	ECO-FRIENDLY GIN ROLLER/GINNED LINT	CHROME GIN ROLLER / GINNED LINT
1.	Seed Index	7.07	7.34
2.	Knife blunting	Every four days	daily
3.	Grooving of gin roller frequency period	Every five days	daily
4.	Power at No load, 400 V	1.28 KW	1.6 KW
5.	Power at Full load, 400V	1.696 KW	1.92KW
6.	No load current	4A	5 A
7.	Full load current	5.3A	6 A
8.	Seed fuzz	6.2%	5.0%
9.	Diameter reduction per machine-hour	37.89 μm	64 μm
10.	Production per machine-hour	38.26 kg	36 kg
11.	Expected useful life of washer (wearing up to 30000 μm)	844 Machine-hour	437.5 Machine-hour
12.	Friction of roller to lint	0.768	0.123

TABLE 6
HIGH VOLUME TESTS USING VOLUME INSTRUMENT FOR PHYSICAL PROPERTIES

Sl. No.	PARTICULARS	ECO-FRIENDLY GIN ROLLER/GINNED LINT	CHROME GIN ROLLER / GINNED LINT
13.	2.5% Span length	27.7	28.6
14.	Tenacity, g/tex	21.3 g/tex	22.2 g/tex
15.	Uniformity Ratio, UR%	46	45
16.	Short Fibres,%	3.5%	4.0%
17.	Color/grade/appearances	Yellowish and Very good	White shining, poor

SCANNING ELECTRON MICROSCOPE TEST

18.	Wax content proportion	0.3% and better dye Catching properties	Nil Poor dye Catch properties
19.	Dye up-take	Very good	Poor
20.	Scanning physical and chemical properties	Very good	Poor
21.	2.5% span length, mm	35.6	35.4
22.	Uniformity, %	46.0	44.0
23.	Baer sorter, Mean length,mm	32.3	32.8
24.	Elongation	40.0	42.0
25.	Short fibre, %	14.6	16.4
26.	Tenacity, g/tex	28.6	27.8
27.	Micronnaire	3.0	2.8
28.	2.5% Span length,mm	28.5	28.2
29.	Uniformity Ratio, %	47.0	47.2

TABLE -7

Sl. No.	PARTICULARS	ECO-FRIENDLY GIN ROLLER/GINNED LINT	CHROME GIN ROLLER / GINNED LINT
30.	Short fibre, %	6.2	5.2
31.	Tenacity, g/tex (1/8 "stello gauge)	21.8	21.4
32.	Elongation	6.0	5.7
33.	Micronnaire	3.4	3.3
34.	Leaf	3.0	4.0
35.	Area ,%	0.60	0.7
36.	Trash Count	28	28
37.	Rd	67.7	67.8
38.	+b	14.5	14.5
39.	Colour Grade	24.4	24.4
40	SCI	128.0	129.0

Conclusions and Suggestions

The CCLC rollers used in ginning industries get powdered during ginning operation and enter the environment as Chrome Specific Dust. It was observed that the chrome specific dust contaminates cotton and its products. The chromium contamination levels for cotton and its products were abnormal for all the samples except that the cotton samples obtained from RCF roller gin rollers *i.e.*, eco-friendly ginning industries. As per the environmental standards (MOEF Notification No.157, 1996), chromium content in cotton and its products not to be more than 0.1 ppm. The samples, namely, lint cotton, yarn, fabrics, seed, linter, edible oil and oil cake were found contaminated and their levels were in the range of 110 to 1990 ppm obtained from the source of dust-producing grinding CCLC rollers sample which contained

18,077 to 30,783 ppm. The ginned lint cotton gets contaminated to an extent of 143 to 1990 mg/kg (ppm) of chromium and the woven fabrics to the tune of 17 to 45 ppm of chromium against the safe limit of 0.1 ppm. The variations in concentration levels were because of the coating of chromium with fine dust particle and adsorption properties on to the cotton and its products. The chromium was not detected from RCF ginned lint cotton as there is no chromium in the source, which confines the eco-standards.

On the basis of the design and development of various rollers with subsequent performance evaluation studies, chrome-free RCF roller has been demonstrated with reference to techno-commercial and eco-friendliness in ginning industries. The newly developed RCF rollers are successful and effective in functioning and in ginning out the seed-cotton. Cost economics study reveals that eco-friendly RCF roller ginnery sounds better in all aspects with reference to environmental, cotton technological and techno-commercial aspects. This improved technology is amenable for commercialization to the industries.

Though the initial cost of the RCF roller is 11 times more than the life of CCLC roller, the high price is compensated, as it is durable upto an estimated life of seven years than more of a few months of CCLC rollers. Besides, it ensures the following advantages.

- (1) There is negligible wear and tear and also zero maintenance,
- (2) High ginning efficiency and output of about 1.25 times more than the CCLC rollers because the developed roller made up of rubberized cotton fabrics has a surface finish conducive to high ginning efficiency,
- (3) 50% reduction in the weight of the rollers consume 25% less in energy consumption that is power saving of three times less compared to CCLC roller ginneries.
- (4) It is observed that the noise level in eco-friendly ginneries is reduced to a range of 4 to 7 dB (A) due to inherent properties and cushioning effects,
- (5) Eco-friendly cotton and its products can be obtained.
- (6) Labour output / hr is 2.4 standard performance rating, that is twice than CCLC ginneries because of cleaner environment.
- (7) Medical charges for treating the affected workers decrease manifold.

The newly designed and developed eco-friendly ginneries eliminate chromium contamination and pollution from cotton ginning industries. These give rise to control at-source pollution control, such that the industries meet the requirement of environmental standards being enforced by many countries and high quality yarns and fabrics meeting international standards be produced. The industries will be free from chrome-related contamination and pollution problems, occupational and non-occupational health hazards. The ginneries have been tested commercially and found better in all aspects with reference to cotton technological parameters, dye-catching properties, physical and chemical properties. It could be successfully used commercially as an improved alternative in cotton ginning industries for the cleaner environment with benefits to society, industry owners, traders, workers, employees and the Government.

Recommendations

1. Most of the cotton ginning operations are done by using DR gins in India, Africa, Tanzania and Egypt. The lint cotton and cotton seeds processed through these chrome roller ginneries are contaminated. It is imperative that a policy decision can be taken to do away these rollers and get replaced with eco-friendly rollers, and
2. Industry, Government and Regulator should come forward to subsidize this venture in view of its demonstrated and proven techno-commercial feasibility in connection with eco-friendliness.
3. Most of the cotton ginning operations are done using roller gins in India, Africa, Tanzania and Egypt. Out of the lint obtained from these CCLC roller ginneries in this countries, it is quite important to appreciate the fact that the lint so produces is contaminated with chromium powder produces deleterious effect on the people working in the vicinity. Yarn and seed obtained is also contaminated with chromium. Toxic effects are produced by prolonged contact with airborne or solid or liquid chromium contamination and pollution even in small quantities. Hence, it is imperative that a policy decision be taken to replace the presently used CCLC rollers with eco-friendly rollers or vegetable tanned leather rollers.

Acknowledgements

The authors are thankful to Director, Indian School of Mines, (Deemed University), Branch I.I.T., Dhanbad – 826 004, India for giving permission to publish this research paper. The Authors are also thankful to Mr. Shrish R. Shah, Member, Indian Cotton Development Council, (ICDC), Ministry of Agriculture(Govt. of India) who have sponsored this research project.

The author of this research paper is thankful to FACULTY DEVELOPMENT BUREAU OF ALL INDIA TECHNICAL EDUCATION , New Delhi for awarding the prestigious faculty-specific AICTE EMERITUS FELLOWSHIP DURING 2005-2008. **The first author is also thankful to World Scientific and Engineering Academic and Society (WSEAS) , Athens, Greece for the award of Post Doctoral Research Fellowship during the year 2006.**

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**PLATE-1; COTTON ROLLER GINNING MACHINE;
Front- Single Roller (SR) Gin ;**

Rear - Double Roller (DR) Gin.

**PLATE-2 ; CHROME COMPOSITE LEATHER-CLAD
WASHERS USED FOR MAKING CCLC
ROLLER GIN ROLLERS**

**PLATE-3 : FILLED AND PRESSED CCLC WASHERS
ASSEMBLED IN THE FORM OF A ROLLER
OF DR GIN**

**PLATE-4; OPERATION OF GIN ROLLER
EXPERIMENTATION DEVICE (GRED)
ASSEMBLED WITH RUBBERIZED
COTTON FABRIC ROLLER**

**PLATE-5; POLLUTION-FREE RUBERIZED COTTON FABRIC
(RCF) CHROME LESS WASHERS FOR MAKING RCF
ROLLERS OF ROLLER GINS**

**PLATE-6; PILOT MODEL ROLLER GIN ASSEMBLED WITH
POLLUTION-FREE RUBBERIZED COTTON
FABRIC (RCF) CHROMELESS ROLLERS WHILE
IN OPERATION**

**PLATE-7; ECO-FRIENDLY GINNED LINT COTTON FROM RCF
ROLLER GINNERIES**

**PLATE-8; TRIAL COMMERCIAL PRODUCTION FOR
COMMERCIALIZATION**