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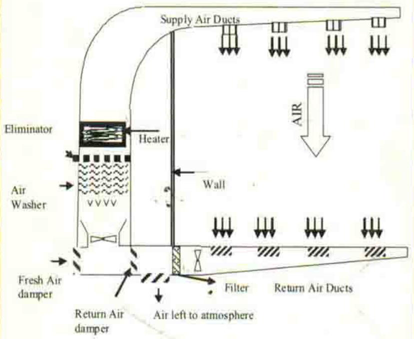

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Humidification and ventilation management in textile industry

About the Author

B. Purushothama completed his B.Sc (Textiles) in 1969 and then M.Sc (Textiles) in 1974 from Bangalore University. He is a postgraduate in Business Administration from St Joseph's College of Business Administration, Bangalore. He associated with The Textile Association (India) in 1973 and got Fellowship of The Textile Association (India) in 1985, and Fellowship of Institute of Engineers in 2009. He is a Lead Auditor in ISO 9000 since 1994 and a Certified Quality Analyst from Tata Quality Management Services. He took extensive training in Total Quality Management from M/s Win Research and Consultants, Mumbai. He got trained by Tata Quality Management Services for the JRD QV (The Quality System named after late JRD Tata and now called as TBEM, i.e. Tata Business Excellency Model) and Malcolm Baldrige National Quality Awards. He worked as an examiner for TBEM for 5 years and has trained thousands in Total Quality Management, Malcolm Baldrige Quality Awards and in various technical aspects of textiles.

B. Purushothama, in his service of 40 years in the textile and garment industry, has worked in various capacities in Spinning, Maintenance, Projects, Quality Assurance, and in Research. He has published over 50 papers in various technical and management areas, and has presented papers in various conferences and seminars. Some of his publications include Fundamentals of Textile Mill Management, Guidelines to Process management in Textiles, Quality management in Garment Industry, Winning Strategies, In the Wonderland of Problems, etc. He has guided hundreds of students from different universities and colleges in their project works.

He is an active member of The Textile Association (India) and has served as Joint Secretary, Secretary, Management Committee Member, and Chairman of Ichalkaranji Miraj Unit. He is also a member of Spinning Advisory sub-committee of BTRA (Bombay Textile Research Association, Mumbai). He was a member of TX-30 sub-committee of Bureau of Indian standards, dealing with Industrial textiles and Geo textiles. He has also served as a member of syllabus committee for Shivaji University for B.Text. He is a member of various associations like Quality Council of India, Gokak Management Association and Asian technology group, which work for the spread of knowledge.

He is also active in Kannada Literature and has written novels, poems, and devotional songs in Kannada, and several books on Management, Hilarious talks, etc. *Huchchuraamana Muktakagalu* and *Kareyutide Yasha Shikhara* are books on Management written in Kannada. *Huchchana vichaaradhaare*, a hilarious book of philosophy; *Tumula*, *Kaalada hakki*, *Ayyo Huchchumundede*, *Miss Maala* and *Jagadodharana* are social novels; *Gaardhabha Maartanda* and *Banni Makkale Kathe Heltini* are short stories for children; *Sumamaale*, light poems; and *Gana stuti* and *Devaranaamagalu* are devotional songs.

Preface

The importance of maintaining and managing humidity and temperature in a textile mill is not a new concept, but understanding the requirements, the equipment capabilities and utilizing them to get the best results is a challenge the technicians face all the time. Now the systems have changed from manually operated to fully automatic; however, unless one knows how to monitor, he shall still have the problem. Some guidelines are needed for the shop floor technicians relating to maintenance of humidity and monitoring the air.

The idea of writing a book on Managing of Humidity came from my friend Ananth Harnahalli. I hesitated first, as I was only a Textile Technologist and not a Humidification Engineer. Ananth reminded me that I had faced lot of problems due to improper maintenance of humidity while working on the shop floor and had struggled a lot to get required conditions. The problems faced were always unique as the systems were getting changed, materials were getting changed and also the working conditions. Ananth told that the purpose of this book should be to guide the shop floor technicians and engineers in maintaining required conditions and to act in advance. They need the basic concepts and the choice available in the market to update their humidification plants; hence this book.

An attempt is made to collect and provide information starting from the basic concepts, developments, varying needs of the industry, the problems associated with maintenance of plants to get the required conditions, designing of plant capacity, modification or designing of building to get the best results, various issues of health and hygiene, the pollution control issues, various models available in the market, etc. However, it should be noted that it is practically impossible to explain all the equipments and give details of all manufacturers. Hence, efforts are made to explain at least one unit in each type.

I am thankful for all the information providers, without which this book would not have come out. Also I am thankful to all my friends who

encouraged me to write this book, and the family members for their complete cooperation. My special thanks are to Ravindra Saxena and Sumit Aggarwal for the initiations taken to publish this book so that it could reach masses.

B. Purushothama

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1 Need for maintaining humidity

1.1 Introduction

Spinning of yarn from cotton and then weaving or knitting cloth from the yarn is known to mankind for millenniums. It is probably one of the first crafts developed as men's thought of civilisation. As this primitive craft flourished in tune with civilisation, the ancients learnt that if water is sprayed on the floor on the hot days or if wet cloth is kept over the warp, the working is easier because of less yarn breakage. This was the state of affairs till 200 years back, but as the industrial revolution took place and mass production was aimed, different methods were developed to provide moisture to the material in process. As more people were concentrated under one roof along with number. of machines working at a pace, the generation of temperature also added to the problem. Though frequent use of water cans for humidity, and wide windows for fresh air were provided, it did not help in improving the working conditions. The increase in speed of machinery also liberated fibrous dust.

Air is an important element for every human being. Man's capacity for work and his general health may seriously be impaired by defective ventilation. The purity of air, the temperature and the movement of air are few of the many factors to be considered. The comfort of an occupied space depends as much on its condition as on its freshness. Although humidity is invisible to our eyes, we can easily observe its effects. In human terms, we are more comfortable and more efficient with proper humidification. In business and industrial environments, the performance of equipment and materials is enhanced by effectively applying humidity control. Maintaining indoor air quality through humidity management can lower the energy costs, increase productivity, save labour and maintenance costs, and ensure product quality. Controlled humidification helps to protect humidity-sensitive materials, personnel, delicate machinery and equipment. Beyond the important issues of comfort and process control, humidity control can help safeguard against explosive atmospheres. In short, humidification can provide a better environment and improve the quality of life and work.

Air free from dirt, debris and fibres that is closely maintained within fixed limits of temperature and humidity is a vital necessity to the textile industry. It is not only because of the changes in dielectric properties and tensile properties of fibres due to varying humidity and temperature, but also for maintaining a clean working environment. The generation of static electricity while processing in spinning and weaving creates dust and fibre fly (fluff). Higher moisture content lowers the insulation resistance and helps to carry off the electrostatic charge. Hence, relative humidity needs to be maintained above the lower limit, specified for various textile processes so as to avoid the problems of yarn breakage in dry and brittle condition and also minimise the build up of static charge so as to reduce dust and fibre fly (fluff).

1.2 Relation of humidity to working in the textile mills

Correct ambient conditions are essential to prevent degradation of textile materials during a series of operations right from beating in blow room to weaving fabric at loom shed or knitting the fabric or producing non-woven sheets. Fibres should have requisite properties so that the final product retains its basic shape, size and strength. Above certain moisture limit, i.e. above the upper limit of relative humidity for the fibre and the process, fibres tend to stick and lead to formation of laps on the rolls which disrupt the production process. Removal of laps is not only a manual and time-consuming process, but results in the damage of machine parts, especially the rubber coatings. Fibres become brittle and store electric charges generated because of friction between the fibres during their individualisation process when atmospheric relative humidity is very low. In case of weaving, as the warp yarns are coated with size film, the environment should be suitable for the size film on the yarn. Too low humidity makes size film brittle resulting in cracking of the film, where as too high humidity makes the beam soft.

Modern spinning equipments are designed to operate at high spindle speed; however, the increase in ambient temper ature curtails the speed limits of operation. Moreover, the sophisticated electronic controls in modern textile machinery also require controlled temperature which should not exceed 33°C or so. It is also necessary to limit the range of temperature to which the textile machinery is exposed, since the steel and aluminium parts of machinery which expand at different rates with temperature rise (due to difference in co-efficient of thermal expansion) will be subjected to mechanical stress. Hence, along with the maintenance of stable relative humidity conditions, recommended for different textile processes, it is also desirable to maintain the temperature level within a range, without fluctuation.

Mechanical properties of fibres and yarns also depend on the surrounding temperature conditions to which these are exposed during the textile process. Apart from the dust levels, the stickiness in some of the cottons also demands controlled weather. When cotton is sticky, higher humidity creates sticking of fibres to rollers and other parts of the machine. The general reasons for controlling temperature and humidity in a textile mill are as follows:

- Dry air causes lower regain and this contributes to poor quality and lower productivity.
- Yarns with low moisture content are weaker, thinner, more brittle and less elastic, create more friction and are more prone to static electrification.
- Materials at optimum regain are less prone to breakage, heating and friction effects; they handle better, have fewer imperfections, are more uniform and feel better.
- Higher humidity reduces static problems. Reduced static makes materials more manageable and increases machine speed.
- Textile weights are standardised at 60% RH and 20°C. Low humidity causes lower material weight and lowered profits.
- Low humidity causes fabric shrinkage. Maintained humidity permits greater reliability in cutting and fitting during garment creation and contributes to the maintenance of specification where dimensions are important, such as in the carpet industry.
- Humidification reduces fly and micro-dust, giving a healthier and more comfortable working environment.

Adequate yarn humidity (moisture in yarn) is needed to enhance the strength and the elasticity and to have smooth yarn surface. Both tensile strength and elasticity depend on fibre and spinning characteristics, on warp pre-treatment (slashing) and increase with moisture content of the yarn being fed into the weaving process. Hairiness depends on the spinning system, speed, humidity and the fibre quality. Higher spindle speed, lower humidity and abrasion while spinning are the major reasons for increased hairiness. It is reduced by slashing, as fibres protruding from the yarn are glued to it. Moisture content smoothens the hairs and lubricates the yarn surface. Abrasion between yarns, mainly in the shed area, removes short fibres (lint) and size dust from the warp yarn. Adequate yarn moisture reduces the fall out.

While weaving, the yarn adsorbs water from the air. Lint and dust falling out from the yarn are incorporated into the room air. Power consumed by the loom and other devices in the room is converted into heat and incorporated into the room air. This heat evaporates the moisture from yarn. Previous results show that yarns perform best in weaving machines when their moisture content is 7–9% (parts of water in 100 parts of dry yarn). Less moisture reduces strength, elasticity and smoothness. Higher moisture may make the size glue the warp yarns together. Therefore, there is a need to humidify the area with suitable controls.

Maintaining adequate high RH levels provides the most effective and economical means of preventing the build-up of static charges. With high RH, an invisible film of moisture forms on surfaces in the room. The presence of normal impurities makes this film a conductor that carries static electricity harmlessly to the ground before it can harm. A relative humidity of at least 45% is needed to reduce or prevent the accumulation of static charges, although some materials such as wool and certain synthetic fabrics may require higher RH levels. Similarly, heat-generating machines may require higher RH to provide sufficient moisture in proximity to the machine to dissipate static charges.

Due to high heat dissipation from spinning as well as weaving and knitting equipment, there is a significant increase in temperature conditions particularly in the vicinity of the machinery and their driving motors. The natural wax covering cotton fibres softens at these raised temperature conditions, thereby adversely affecting the lubricating property of wax for controlling static and dynamic friction.

Increase in temperature beyond the design limit also reduces the relative humidity condition near the processing elements of the machinery. Hence textile air-engineering design has to take care of controlled air flow within the textile machinery for dissipating heat generated at the source and it is customary to carry the waste heat along with the return air to the return air trench. The quantity of return air going to exhaust or re-circulation is regulated for controlling the inside design conditions.

The requirement of humidity is lower at blow room at around 45–50%, moderate at spinning processes from carding to ring spinning at around 55%, around 65% in winding and warping, where as weaving rooms need high relative humidity of 80–85% at the warp sheet level, i.e. at 'loom sphere', whereas it would suffice to maintain general humidity condition in the room at around 65% RH. Knitting operation also requires a stable relative humidity condition at 55±5% for precise control of yarn tension. Hence it is important to maintain stable relative humidity conditions within the prescribed tolerance limits at all steps of textile processing.

Workers are a part of manufacturing process. Therefore, the conditions maintained in the shed should not only be comfortable for the process and the product but they should also be comfortable to the people. Following table gives generally recommended humidity levels in a textile mill:

Table 1.1 General recommendations of RH% in a textile mill

Department	Cotton (%)	Man-made fibres (%)	Department	Wool (%)
Opening and picking	45–60	50–55	Raw wool storage	50–55
Carding	50–55	50–60	Mixing and blending	65–70
Silver lapping	55–60	55–65	Carding – worsted	60–70
Ribbon lapping	55–60	55–65	Carding – woolen	60–75
Combing	55–65	55–65	Combing – worsted	65–75
Drawing	50–60	50–60	Drawing – worsted	–
Roving	50–60	50–60	Bradford system	50–60
Spinning	45–60	50–65	French system	65–70
Winding and spooling	60–65	60–65	Spinning – Bradford Worsted	50–55
Twisting	60–65	50–65	French (mule)	75–85
Warping	55–70	50–65	Woolen (mule)	65–75
Knitting	60–65	50–60	Winding and spooling	55–60
Weaving	70–85	60–70	Warping – worsted	50–55

Similar to the requirement of humidity, the temperature also plays a very important role in the textile processes. Following are the normal temperature levels followed in textile mills.

Table 1.2 Normal temperature levels followed in textile mills

Department	Minimum temperature		Maximum temperature	
	°C	°F	°C	°F
Cotton mixing	27	80	33	92
Blow room	27	80	35	95
Cards and draw frames	27	80	35	95
Comber	27	80	33	92
Ring frame	30	85	35	95
Winding	27	80	33	92
Warping	27	80	33	92
Weaving	21	70	31	88

1.3 Dust control

Normally, the term 'textile mill' reminds of cotton dust laden environment. Major problem of cotton dust exists in the blow room and carding section of spinning mill, whereas exposure level in other areas is comparatively not much. In spinning mill, the extent of cotton dust contamination varies from section to section; it is worst in the blow room and minimum at the cone winding section.

Cotton dust is defined as dust present in the air during the handling or processing of cotton, which may contain a mixture of many substances including ground up plant matter, fibre, bacteria, fungi, soil, pesticides, non-cotton plant matter and other contaminants which may have accumulated with the cotton during the growing, harvesting and subsequent processing or storage periods. Any dust present during the handling and processing of cotton through the weaving or knitting of fabrics, and dust present in other operations or manufacturing processes using raw or waste cotton fibres and cotton fibre by-products from textile mills are considered cotton dust within this definition. The workers are exposed to such working environment and inhale fibrous particles and dust whole day. Generally air suction system exists in all departments to maintain certain humidity and to remove air contaminants; however, at some places it works effectively, but at certain areas improper air exchange results into suffocation and inconvenience for the workers. In a weaving mill, fibrous particles in small quantity are present in the working environment, which are inhaled by most of the workers. These small fibrous particles are generated during weaving activities and disperse in occupational air. It is therefore essential to have sufficient circulation of filtered air. Air washers and ventilation systems are very essential for this.

All textile manufacturing processes, except garment making, generate environmental pollution. During cotton spinning and weaving, dust and fly are released into the air streams of the production departments. Most of the modern textile mills are equipped with automatic waste removal, dust filtration and humidification plants. The dust and fly released by the machines are sucked away by suction nozzles and ducts. The dust laden air is filtered, humidified and re-circulated. The number of air changes per hour is optimised in each department to keep the air streams clean and hygienic to prevent any risk to the health of the workers. The normal air changes are as follows:

Table 1.3 Normal air changes per hour

Department	Number of air changes per hour
Blow room, drawing, combing and roving	15
Carding	20
Spinning	45
Winding	30
Twisting, warping, sizing and weaving	20

To minimize risk of industrial diseases such as byssinosis (lung disease) among the workers, the US Occupational Safety and Health Authority (OSHA) has specified concentration limits of dust in the air streams of production rooms for compliance by the concerned industries as follows: