ABSTRACT

Energy Efficiency and conservation in textile sector is becoming essential in view of the expected shortages in energy supply and textile sector being one of the growing sectors of the world economy. Textile wet processing consumes significant portion of the total energy in the textile sector and in the wet processing, dyeing process occupies a significant place for contributing towards both air and water pollution. The wastewater generated in the dyeing process is extremely high and Green House Gases emission from dyeing sector are also increasing day by day. Therefore, alternate dyeing technologies are to be considered for evaluation and analysis. Conventional technologies are energy inefficient, time consuming and not environmental friendly. The non-conventional technologies considered for evaluation are (i) ultrasound assisted dyeing (ii) microwave assisted dyeing (iii) infrared assisted dyeing (iv) magnetic stirred hot plate dyeing. It has been reported in several earlier studies that all of these technologies has led to an increase in dye uptake with reduced process time, energy and less effluent generation.

In this study, the experimental investigations are carried out using non-conventional technologies like ultrasound, microwave oven, infrared machine and magnetic stirrer for cotton, polyester and a blend of polyester and cotton. Temperature, time and concentration are the three parameters varied in the dyeing process. These parameters have major impact on energy consumption. Reactive dye is used for cotton while disperse dye is used for
polyester. Both reactive dye and disperse dye is used for blends. Carrier dyeing is adopted for polyester while blend is dyed in 2 bath dyeing. Temperature is varied from 40°C to 90°C and time is also varied from 60 minutes to 220 minutes. Concentrations are also varied from 1 to 7%.

From the experimental values of absorbance of initial dye solution and spent dye solution, dye uptake in each experiment is calculated and dye uptake is used as comparison factor. The energy efficiency for the non-conventional dyeing technologies is assessed on the basis of equal dye uptake in all materials. The energy consumption in these experiments is also measured using Watt hour meter and normalised specific energy consumption is estimated for each processes and each materials. The time, temperature and concentration are the process variables and energy efficiency is calculated for the same. The specific energy consumption is normalized with respect to dye uptake to make realistic comparison. This is compared for different materials in each technology. The energy efficiency is found to be better in the all cases of all non-conventional dyeing technologies than the one obtained in conventional dyeing technology. This is the case for all temperature levels, time and concentrations. This is true for all types of textile materials like cotton, polyester and blend.

In case of cotton, ultrasound assisted wet processing is more energy efficient compared to other non-conventional dyeing technologies. In case of polyester, microwave and infrared assisted dyeing technologies are more energy efficient compared to other non-conventional dyeing technologies. In case of cotton-polyester blend, ultrasonic assisted dyeing is more energy
efficient in relation to other technologies. This is due to the fact that blend contains more percentage of cotton (67%) than polyester (33%).

In order to assess the final quality, the dyed fabrics are tested for wash fastness, K/S (ratio of light absorption to scatter coefficient) values, and they are found to be either equal or higher in the case of non-conventional dyeing technologies. Energy Efficiency has been evaluated for different colours also.

The apparent diffusion coefficients in experiments are evaluated for each technologies and it is observed that apparent diffusion coefficients have increased due to the use of these new technologies. Thus, it is possible to reduce energy consumption and the GHG emission by a significant extent through the application of these technologies. The average energy saving works out to around 30%.

Based on the specific energy consumption values, empirical relations are developed relating the variables of time, temperature and concentration to the normalized specific energy consumption values in all materials. These relations are derived using regression analysis. From these relations, it is observed that normalised specific energy consumption in these new technologies are more influenced by temperature first, then by time and thirdly by concentration.

An attempt has been made to estimate the Green House Gases emission reduction potential achievable in Indian textile dyeing sector by possible implementation of these technologies during the next decade. A
reduction of 30% in emission is possible in a phased manner by application of these technologies.