DEVELOPMENT OF SENSOR-BASED LIGHTING SYSTEM FOR SEWING MACHINE

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Abstract: It is the continuous effort of experts in this industry to help improve the productivity, increase the operator's efficiency and skill. While trying to achieve all these, we can't forget about the comfort of the operator. That's where ergonomics plays its role. It is important to ensure that proper working conditions are available to the operator. Amongst the working conditions, the less looked upon is the lighting of the production floor. It is crucial to help in the visual perception of the operator and to facilitate the sewing process. It has attracted the attention of ergonomists and garment technologists in the recent years, where they have derived the relationship between illuminance levels and productivity. It has also shown to have a direct impact on the operator's general well-being. To guarantee proper lighting conditions to the operator at the sewing machine, "Sensor Based Lighting System" has been developed. It takes into account the intensity and color of light, so that optimum quantity and quality of illuminance are provided. It has combined the principles of color psychology and physics along with ergonomics to come up with a solution that would provide maximum comfort and least amount of strain to the operator's eyes. The system has tested the use of colored light in industrial environment.

I. INTRODUCTION

Light plays a very important role in our everyday life. It enables us to see and perceive the world around us. Our eye works as a camera, which transmits the scenes around us and then the brain processes it. The rods and cones present in the eyes are responsible for detecting the intensity of light and the distinct colors respectively.

Sun is a natural source of light, and artificial sources simulate this light. To facilitate visibility there has to be some standard quantity and quality of light.

The Illuminating Engineering Society of North America (IESNA) defines light as "radiant energy that is capable of exciting the retina and producing a visual sensation." Light is a form of electromagnetic energy.Visible light lies in the range between 380-780 nanometers. The wavelength 400nm corresponds to violet color while 700nm corresponds to violet. Below 380 lies the ultraviolet radiation and above 780 lies the infrared radiation. White light when passed through a glass prism splits into the seven colors, namely, violet, indigo, blue, green, yellow, orange and red. Light has dual nature: it exhibits particle and wave properties.

II. LIGHTING CONDITION IN GARMENT INDUSTRY

Manufacturing industry has high dependency on artificial sources of light. Automated industries have lower dependency on humans than semi-automated industry. With tasks which are more human-dependent and visually demanding, the lighting conditions play an even major role.The more intricate the work, the more strain on the eyes, and thus, better should be the light available to the worker.

Taking examples from various researches involving color psychology and fatigue, the use of colored light could be revolutionary in terms of ergonomics. This could be used in making a device which emits lights of different colors to provide comfort to the operator who has long working hours and high visually demanding tasks.

III. OBJECTIVES

i. To develop a Sensor-Based Lighting System namely SBLS for the sewing machine to achieve the following:
   a. To create optimized lighting conditions during garment stitching
b. Reduce the eye strain of sewing operator
c. Improve the productivity and quality of garment manufacturing.

IV. LITERATURE REVIEW

Faber Birren (1969) found that with softer surroundings, cooler hues (blue, green, turquoise) and lower brightness, there is less distraction and a person is better able to concentrate on difficult visual and mental tasks. Good inward orientation is furthered. It is appropriate for sedentary occupations requiring severe use of the eyes or brain- offices, study rooms, fine assembly in industry.

Henri Juslen (2007) studied various researches contributed by various authors that have determined the relationship between illuminance levels and productivity. These researches tell us that increasing lighting levels increases productivity and hence profitability. A compiled graph has been included in this research, which is given below.

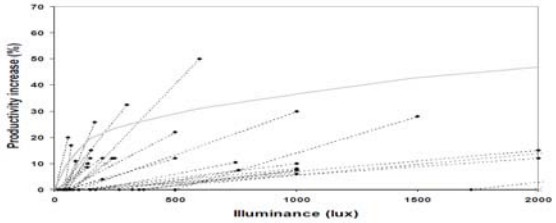


Figure 2.1: Relationship between lighting levels and productivity

The graph shows the relationship between illuminance level and productivity increase. These studies have been done in different industrial environments. The results all show an increase in productivity when illuminance was improved.

Hossain, Ahmed (2012), found that poorly designed and maintained lighting can result in glare and flicker that may cause vision problems. According to their study, across job categories, sewing operators, finishing helpers and quality controllers were found to suffer most from the eye troubles. About 21~37% (0.21~0.373 out of 1) of the illumination condition has the causal effect on effective production capacity of the worker. They have also suggested that illumination level at the work-plane of the workers should be within 600-800 lux (average 700lux) especially for Sewing Operators, Sewing Helper, Quality Controller and others.

V. EYE STRAIN TESTING

Eye strain or asthenopia is an ophthalmological condition which is determined by fatigue, pain in the eyes, blurred vision, headache and dizziness. (Liinamaa, Westmann, 2012)

Zeiss developed a software application for smart phones named “Eye Strain?” in the year 2014 to test digital strain. The amount of eye strain is determined using a near/far vision test that calculates how long your eyes need each time they have to focus on a distant object and then on a display again.

The app works on the principle of accommodation. It would tell how weakened the eye muscles are by evaluating the time it takes for the user to focus on the screen of mobile and the object kept at a distance of 6 meters. This tells about the condition of the ciliary muscles of the eyes, its functioning, and indirectly, the level of eyestrain.

VI. OPTIMIZED LIGHTING CONDITIONS

Faber Birren(1969) identified blue and green to be suitable for work requiring precision, with the special mention of fine assembly in industries

Ji-Hyun Lee, Jin Woo Moon and Sooyoung Kim (2014) identified light source of color temperature at 6500K with mediocre lux (500) to be suited best for long working hours to provide comfort and reduce fatigue. This corresponds to shorter wavelengths of blue and green.

The use of colored task lighting is justified by the following objectives:

1. To reduce the strain on the eyes at the point of stitching.
2. To leave the surroundings unaltered.

The other parameters identified are:

i. Productivity measurement.
ii. No of errors in the output- quality.
iii. Subjective assessment of fatigue and discomfort.

VII. PROBLEM FORMULATION

The reviewed literature reveals the need of developing a system which can dynamically respond to the change in lighting conditions during garment manufacturing. The following problems has been identified to the development of system

1) Adherence to intensity
2) Adherence to color of light
3) Adherence to fabric color
4) Dynamically optimised conditions

The importance of lighting has been derived from the literature review. The minimum lux required is 700 lx, to ensure proper sewing and comfort to the eyes. The lights used are white lights. Still the workers complain about eye strain and fatigue and related symptoms like dizziness and headaches after long working hours. Green color is the most soothing to the human eye, but no experimentation has been done which involves the use of colored lights. Also, there is no sensor-based ‘smart’ lighting device which would consider and process the fabric’s color and then give out a complimentary colored light.

VIII. METHODOLOGY

Study of the literature review to identify the existing work done and identifying the parameters.Understanding the basics of electronics for the experimental setup on live environment.Then, testing the system in the factory choosing the right components for the experiment.Proceeded with results and discussion.

IX. PROPOSED SYSTEM FOR AUTOMATIC LIGHTING

Proposed system namely **SBLS** (**S**ensor **B**ased **L**ighting **S**ystem) is developed to achieve the real time adherence to change in intensity, color of light, fabric color and maintain optimized lighting condition at stitching machine during garment manufacturing.

The following components are needed to make the required system:

I. Battery
II. Color Sensor
III. Voltage Regulator
IV. Capacitor
V. LEDs (Light emitting diode)
VI. Resistor
VII. Wires
VIII. Perfboard
IX. Microcontroller (Programmable)

A working prototype of SBLS has been made which delivers the output as proposed. SBLS has the following characteristics:

i. It has the ability to detect up to 7 colors
ii. It involves high degree of reducing the eye fatigue of sewing operators

iii. It increases the productivity of operators
iv. It works on a 7 volt battery
v. The setup is portable and can be carried easily
vi. The cost of the system encourages the garment industry to implement it

The given characteristics of eye fatigue reduction and productivity increase has been proved in the next chapter where we have tested this system in a live environment of garment factory.

X. TESTING

The operators are selected on the basis of their gender, age and vision. The general lighting is kept constant for all the days. The operators are asked to sew the same components under a particular light on each day of testing. The operators' eye strain is tested thrice every day to understand and study the effect of the system on their visual comfort.

Women suffer from dryness of eyes more than men, because of hormonal differences. (Bhowmik et al., 2010)

The efficiency of operators selected for testing lies in the range of 60 to 70%. Efficiency is calculated by the following formula: (Minutes produced/Minutes attended)*100. This has been calculated by the factory.

The average general lighting conditions are 270 lux.

Tests Conducted with the Use of Different Colors and Lights

LIGHT/FABRIC->	WHITE	YELLOW	BLUE
White	✓	✓	✓
Green	✓	✓	✓
Yellow	✓	✓	✓
Blue	✓	✓	✓

The following components were stitched:

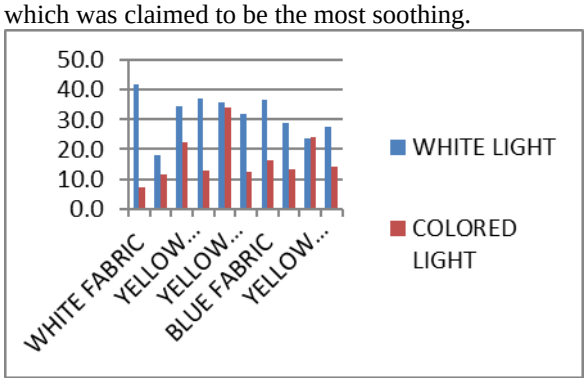
i. Pockets
ii. Collar
iii. Sleeve Placket

The eye strain app used helped to determine the strain levels of the operators. The testing was done three times in a day- morning, evening and afternoon.

The increase percentage of eye strain is calculated, for each operator, from morning to evening, for each set (e.g. white fabric and white light). The average increase of eye strain of all the operators is derived and documented.

RESULTS AND DISCUSSIONS

According to the results, white light showed an increase in eye strain more than colored lights. The minimum percentage increase was with green light, which was claimed to be the most soothing.



Percent increase in the productivity when colored light is used, against white light. According to the results, there is an increase in productivity from 0.2 to 4.1 percent when colored lights are used instead of white light. The highest increase is observed with the use of yellow light on blue fabric and green light on white fabric in comparison to white light.

CONCLUSION

The use of colored light at the sewing workstation has proved to reduce the eye strain of the operators and also increased their productivity.

A reduction in eye strain by 14.6% is observed when colored light instead of white light is used at sewing workstation.

Overall increase of productivity is 2.2% by using the system.

A fully automated system can help improve productivity and reduce eye strain, enabling the well-being of the operator and providing ergonomic comfort. This would also enable improvement of the quality of work being done, and thus reduce costs the organization has to incur on rework or quality related problem.

SCOPE OF FUTURE WORK

The accessible technology was limited due to economic constraints. The time boundation of three months was also a constraint. The testing has been restricted to solid colors, with the complimentary colors' combination restricted till the primary colors. Checks and stripes have not been tested, and this remains to be a subject of further research. The system can be made more compact and easy to attach to the sewing machine.

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