

USE OF COLOR LIGHTS FOR THE DETECTION OF ANOMALIES IN QUALITY SYSTEMS

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RESUMEN: La importancia del cuidado visual es un tema de primer nivel en las empresas orientadas al ensamble o fabricación de diversos productos ya que requieren de atención directa de la salud general de los trabajadores y particularmente de la salud visual.

El sistema de iluminación, las características de las lámparas y las actividades a realizar son factores que inciden sobre el rendimiento visual del trabajador. Cada uno de estos factores, ya sea de manera individual o en conjunto, influyen sobre el rendimiento visual del trabajador y por tanto sobre su seguridad y eficacia.

La fatiga visual puede producirse por problemas de visión que pueda tener una persona, por el uso de gafas de corrección inadecuadas, diversas alteraciones del órgano de la visión, edad, por causas relacionadas en la estación de trabajo (deficiencias de alumbrado, contrastes inadecuado, etc.). Algunos de los síntomas que se presentan son: Problemas para fijar la vista, ojos rojos, lagrimeo, dolor de cabeza, visión borrosa, pesadez de los párpados y sequedad de ojos (Llaneza, 2006).

Esta investigación se realizó con 48 personas; de las cuales 27 pertenecen al género masculino y 21 al femenino, con edades entre los 17 y 58 años. Se utilizaron sistemas de iluminación basados en LEDs de color (blanco, azul, verde,

rojo y amarillo) ya que emiten luz monocromática, además de que son una excelente alternativa en el ahorro del consumo de energía eléctrica; para encontrar el color adecuado para la detección de anomalías en las piezas de metal al momento de la inspección visual, ya que el ser humano es el recurso más importante para cualquier organización y/o sociedad, y de ellos depende el éxito de la empresa.

Palabras claves: Fatiga visual, Detección de anomalías y Diodos Emisores de Luz (LEDs, por sus siglas en inglés).

ABSTRACT: The importance of the visual care in the industry is a first level topic, due to most of the assembly and manufacturing aimed companies of various products that require direct health care of their employees, specially eye care.

The lighting system, the lamp features and job tasks are factors that impact over the visual performance of the worker. Each of these factors, either by themselves or in conjunction, influence the visual performance of the employee, and therefore its safety and efficacy.

Visual fatigue can be caused by the vision problems that a person may have, for the use of inappropriate corrective glasses, various alterations of the organ of vision, age, workplace related causes (lighting deficiencies, inadequate contrast, etc.). Some of the reported symptoms are: problem of visual fixation, eye redness, tearing, headache, blurred vision, eyelids heaviness and dry eyes, (Llaneza, 2006).

The research was developed with 48 people, 27 male and 21 female, in the range of ages of 17 to 58 years old. In the experiment were used illumination system base on Diode Emitting lights (LED's) of five different colors (White, Blue, Green, Red and Yellow), the reason of use of LED's it is because are source of monochromatic light, also it is also saving power light and low heating dissipation. The LED's illumination system was used in this research to detect defects in metal

sheet pieces used in automotive body parts, simulating a work station related with inspection and quality department.

Keywords: Visual Fatigue, anomaly detection and Light Emitting Diodes (LEDs).

I. Introduction

The work environment is one of the key elements that really impact on the behavior, performance and motivation of the worker, impacting their health, performance and comfort (Ramírez Cavassa, 2006). A poor lighting can potentially increase the chance of mistakes while working and accidents, therefore can lead to visual fatigue, with all of the damages that this represent on people's health, for example, eye issues (dryness, itching), headache, fatigue, irritability, moodiness, etc.

Human beings possess an extraordinary ability to adapt to its ambiance. Of all the types of energy that humans can use, light is the most important. Light is an essential element of our capacity to see and its necessary to appreciate the shape, color and perspective of the objects that surround us in our daily living. Therefore the visual system is a major of the human being, due to most of the tasks are performed with the help of the eyes; it is also stated that 80% of the information we obtain through our senses we get it by the sight (Ramos Pérez & Hernandez Calleja, 1997).

There are over 284 million people are visually impaired worldwide: 39 million are blind and 245 have low vision. Most of the vision impairment it is caused for refractive errors (myopia, hypermetrophy and astigmatism), it means that we are facing a major public health problem, according to the World Health Organization (WHO, 2011).

According to the National Institute of Statics Geography and Informatics (INEGI) visual problems is the second leading cause of disability in Mexico. Between 25 and 30% of the Mexican population has a refraction deficiency, which is manifested at different ages and can develop into a disabling factor according the Mexican Social Security Institute (IMSS, 2010).

2. OBJECTIVES

To determine the favorable visual environment for the appreciation of defects in metal parts by using lights of different colors. To find the right color of light to detect scratches, dings, chop and chip on metal pieces.

3. METHODOLOGY

The following describes the methodology used to conduct the research:

1. This research used LED lights color: white, green, blue, red and yellow.

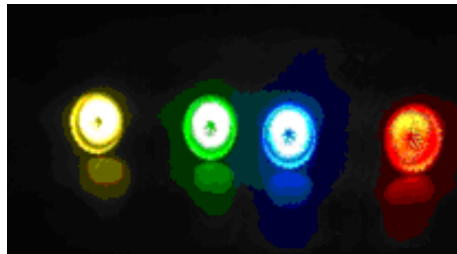


Figure 1. LED lamps

2. The use of black light, is known to be used in quality control for the detection of anomalies, being that by illuminating certain materials such anomalies highlight due to a phenomenon called fluorescence.



Figure 2. Black light

3. The type of material used in this research were samples of automotive body parts (18 pieces) which were provided by an automotive company for visual inspection with LED's light of different colors, therefore you must know the exact size, thickness, material type, shape, texture and color.



Figure 3. Metal sheets to inspect

4. The metal sheets will be listed from 1 to 18 (with a small number, that person cannot easily see), so this doesn't influence remembering the defect depending on the number of the metal sheet.

5. Some of the 18 metal sheets to be used will have some defects such as: scratches, dings, chop and chip, while others will be presented in perfect condition.

Table 1. Expected results in each metal sheet

Metal sheets	Expected results	Metal sheets	Expected results
1	Chop	10	Dings
2	Scratch, chop	11	Good
3	Dings, scratch	12	Dings, scratch
4	Good	13	Good
5	Dings	14	Dings, scratch
6	Scratch	15	Scratch
7	Dings, scratch	16	Dings
8	Good	17	Good
9	Scratch, chip	18	Dings

6. Arrangement for metal sheets and color lights in the experiment. It is a format with the experiment procedure to develop (See annex 1). The arrangement of the 18 metal sheets was performed randomly assigned to the 48 people included in this case of study.

7. It will be used the format shown in Annex 2 for recording results of each experiment is performed, this in order to capture the events objectively shed with every variation of light and metal sheet to use.

8. Laboratory tests (Experimental phase):

8.1 One of the cubicles of the Division of Graduate Studies and Research of the Technological Institute of Hermosillo will be used.

8.2 The cubicle's windows will be blinded so other cubicles' artificial and natural light does not affect.

8.3 The experiment will be performed with 48 samples (persons).

8.4 All unnecessary obstructions in the visual field will remove, since the person (inspector) must be in a position to detect anomalies at the time the metal sheets enter its visual field.

Steps for the experiment:

- a) Arrangement of metal pieces was made according experiment procedure (See annex 1).
- b) It was explained to the person the types of anomalies (Scratches, dings, chop, chip) that could be found or if the metal sheet is in perfect condition.
- c) The Inspection format is provided to each person.
- d) Will locate the LEDs lamp (white, blue, green, red or yellow) or black light depending on what arrangement procedure establish (See annex 1).
- e) Will turn off the cubicle's light so it does not affect LED lamp's light.
- f) The person inspects the metal sheet.

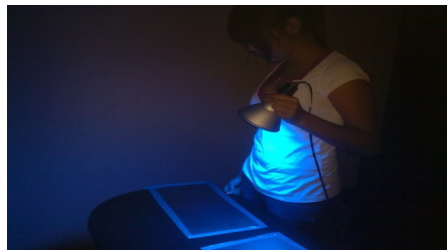


Figure 4. Visual inspection

- g) Cross with an "X" the inspection format (See annex 2), depending on what is detected in the metal sheet.
- h) The average inspection time is approximately 30 seconds per metal sheet.
- i) The step f) and g) will take place 18 times, since it is the total of metal sheets.
- j) Once the inspection of the 18 metal sheets is finished, will be given 1 minute for the accommodation of the eye, as well as for the preparation and arrangement of the metal sheets.
- k) Carry out the above steps d), e), f), g), h), i), j), each time you change the colors of light.
- l) After completing these steps with the 6 lights will end the experiment for each person.
 - The total time the experiment will take each person will be approximately 1 hour.

9. Capture the results of experiment in spreadsheets.

4. RESULTS

Information was analyzed by asking each person ¿what is the best color to find anomalies in metal sheets?, the results are: 35% of people said that the best is green light, followed by blue light with 21% and finally the red light with 10%, because they have difficult to inspect de metal sheets and the defects didn't appreciate by the red light. These results can be seen in figure 5.

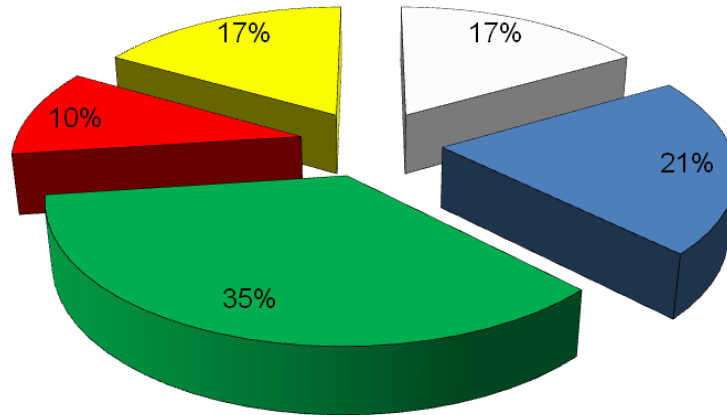


Figure 5. Results of appreciation using different colors of light

67.6% of the scratches are more easily identified with the green light, 69.7% of the dings with the blue light, the 94.9% of the chop with blue light and 98.6% of the chip with green light in the metal sheets, see Table 2. In annex 3 we see the data obtained of how to inspect scratches in metal sheets.

Table 2. Experiment results

	WHITE LIGHT	BLUE LIGHT	GREEN LIGHT	RED LIGHT	YELLOW LIGHT
SCRATCH	0.640046	0.66088	0.675926	0.633102	0.6412037
DINGS	0.668981	0.696759	0.663194	0.668981	0.6736111
CHOP	0.946759	0.949074	0.946759	0.943287	0.9444444
CHIP	0.980324	0.982639	0.986111	0.978009	0.9826389

5. CONCLUSIONS

Based on the data collected and the analysis of data, considering the conditions under which the work was done, we conclude that it is much easier to illuminate the object from side to highlight your relevant details and that 73% of people who made the experiment said they are thus more easily appreciate defects (Scratches, dings, chipping and chopped) that if you put the light directly on the object to be inspected because it is more difficult, which can cause glare on the person.

It was determined that the LED lamps (Light Emitting Diode) green and blue are the best in the detection of scratches, bumps, bites and chipping for visual inspection of automotive body parts and that better results were obtained in the analysis data.

One of the reasons why you should pay attention to the type of lighting used in the workplace is because people who perform visual inspection are at risk of Asthenopy (Visual Fatigue), which is a latent uneasiness in most companies, If not treated, can lead to serious defects in vision, such as decreased visual acuity, defective color vision and accidents.

RECOMMENDATIONS

- Validate the results obtained in the industrial sector.
- Expanding the field of materials for inspection.
- Increase the training time.
- Increase the number of sample to achieve results more representative of the working population in the City of Hermosillo.

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ANNEX 1. Arrangement for metal sheets and color lights

Inspector	Color light	Metal sheets	Color light	Metal sheets	Color light	Metal sheets	Color light	Metal sheets	Color light	Metal sheets
1	Blue	6,3,8,4,1,9,2,5,7, 15,12,17,13,10, 18,11,14,7	White	9,6,8,4,3,1,2,5,7, 18,15,17,13,12, 10,11,14,16	Yellow	2,3,7,1,5,9,4,6,8, 11,12,17,10,14, 18,13,15,17	Red	2, 3,1,7,8,5,9,4,6, 11,12,10,16,17, 14,18,13,15	Green	3,7, 8,1,6,2,9,5,4, 12,16,17,10,15, 11,18,14,13
2	Yellow	7,4,3,5,6,8,9,2,1, 16,13,12,14,15, 17,18,11,10	Green	1,2,7,8,6,3,9,4,5, 10,11,16,17,15, 12,18,13,14	Blue	2,8,4,6,1,3,7,5,9, 11,17,13,15,10, 12,16,14,18	White	1,2,3,8,9,5,6,7,4, 10,11,12,17,18, 14,15,16,13	Red	2,3,4,9,7,6,5,1,8, 11,12,12,18,16, 15,14,10,17
3	Green	8,5,6,3,1,2,7,4,9, 17,14,15,12,10, 11,16,13,18	Red	3,2,5,4,8,9,6,7,1, 12,11,14,13,17, 18,15,16,10	White	5,6,8,7,4,9,2,1,3, 14,15,17,16,13, 18,11,10,12	Blue	6,4,9,5,3,7,2,1,8, 15,13,18,14,12, 16,11,10,17	Yellow	9,5,8,4,2,1,6,7,3, 18,14,17,13,11, 10,15,16,12
4	White	1,2,9,8,6,5,3,4,7, 10,11,18,17,16, 14,12,13,16	Yellow	1,7,4,2,3,6,9,5,8, 10,16,13,11,12, 15,18,14,17	Red	7,6,9,8,4,3,2,1,5, 16,15,18,17,13, 12,11,10,14	Green	8,5,2,4,7,9,1,3,6,6, 17,14,11,13,16, 18,10,12,15	Blue	5,3,6,4,1,8,2,9,7, 14,12,15,13,10, 17,11,18,16
5	Blue	7,8,5,3,2,6,4,9,1, 16,17,14,12,11, 15,13,18,10	Green	8,3,1,7,9,6,2,4,5, 17,12,10,16,18, 15,11,13,14	White	9,3,7,1,8,4,6,5,2, 18,12,16,10,17, 13,15,14,11	Red	9,2,3,8,5,4,6,7,1, 18,11,12,17,14, 13,15,16,10	Yellow	3,6,9,8,7,1,2,4,5, 12,15,18,17,16, 10,11,13,14
6	Red	2,9,7,1,5,6,4,8,3, 11,18,16,10,14, 15,13,17,12	Green	8,2,3,6,7,5,9,1,4, 17,11,12,15,16, 14,18,10,13	White	6,7,9,4,1,8,2,3,5, 15,16,18,13,10, 17,11,12,14	Yellow	6,3,4,1,5,8,7,9,2, 15,12,13,10,14, 17,16,18,11	Blue	1,8,5,3,4,7,6,2,9, 10,17,14,12,13, 16,15,11,18
7	White	4,7,8,9,2,5,1,3,6, 13,16,17,18,11, 14,10,12,15	Blue	9,2,1,6,3,5,8,7,4, 18,11,10,15,12, 14,17,16,13	Green	7,4,5,3,6,9,2,8,1, 16,13,14,12,15, 18,11,17,10	Yellow	9,1,7,4,8,5,2,6,3, 18,10,16,13,17, 14,11,15,12	Red	4,1,3,2,6,7,5,9,8, 13,10,12,11,15, 16,14,18,17
8	Yellow	8,6,1,7,9,2,3,4,5, 17,15,10,16,18, 11,12,13,14	Green	7,4,3,1,6,2,9,8,5, 16,13,12,10,15, 11,18,17,14	White	4,5,7,8,6,9,2,1,3, 13,14,16,17,15, 18,11,10,12	Blue	9,5,7,2,8,4,3,6,1, 18,14,16,11,17, 13,12,15,10	Red	3,1,6,5,7,8,4,2,9, 12,10,15,14,16, 17,13,11,18
48	Green	9,1,6,7,4,5,2,3,8, 18,10,15,16,13, 14,11,12,17	White	6,4,1,9,7,5,8,2,3, 15,13,10,18,16, 14,17,11,12	Blue	5,3,7,1,8,2,4,9,6, 14,12,16,10,17, 11,13,18,15	Yellow	1,9,3,8,6,7,2,4,5, 10,18,12,17,15, 16,11,13,14	Red	9,8,2,4,1,3,5,7,6, 18,17,11,13,10, 12,14,16,15

ANNEX 2. Inspection format

WHITE LIGHT						BLUE LIGHT						GREEN LIGHT					
	Scratch	Dings	Chop	Good	Chip		Scratch	Dings	Chop	Good	Chip		Scratch	Dings	Chop	Good	Chip
1						1						2					
10						10						11					
9						5						7					
18						14						16					
2						7						3					
11						16						12					
6						2						5					
15						11						14					
3						8						9					
12						17						18					
7						4						6					
15						13						15					
4						3						1					
13						12						10					
5						9						8					
14						18						17					
8						6						4					
17						15						13					

RED LIGHT						YELLOW LIGHT						BLACK LIGHT					
	Scratch	Dings	Chop	Good	Chip		Scratch	Dings	Chop	Good	Chip		Scratch	Dings	Chop	Good	Chip
3						6						18					
12						15						1					
5						8						15					
14						17						9					
4						5						17					
13						14						2					
7						9						13					
16						18						10					
2						1						3					
11						10						4					
6						2						16					
15						11						7					
9						7						5					
18						16						11					
1						4						14					
10						13						8					
8						3						6					
17						12						12					

ANNEX 3. Example of data analysis for the detection of scratches in the metal sheets

Metal sheet #	Expected results	Inspector # 1	
1	PASS	PASS	OK
2	FAIL	FAIL	OK
3	FAIL	PASS	NO
4	PASS	FAIL	NO
5	PASS	PASS	OK
6	FAIL	PASS	NO
7	FAIL	FAIL	OK
8	PASS	PASS	OK
9	FAIL	FAIL	OK
10	PASS	PASS	OK
11	PASS	PASS	OK
12	FAIL	PASS	NO
13	PASS	PASS	OK
14	FAIL	FAIL	OK
15	FAIL	FAIL	OK
16	PASS	FAIL	NO
17	PASS	PASS	OK
18	PASS	PASS	OK

Metal sheet

1 Chop
 2 **Scratch**, chop
 3 Dings, **scratch**
 4 Good
 5 Dings
 6 **Scratch**
 7 Dings, **scratch**
 8 Good
 9 **Scratch**, chip
 10 Dings
 11 Good
 12 Dings, **scratch**
 13 Good
 14 Dings, **scratch**
 15 **Scratch**
 16 Dings
 17 Good
 18 Dings

Total OK

% OK

13

0.7222

Total of times the person agrees with the expected results of the inspection.

Total of OK qualified by the person divided by the 18 metal sheet pieces.