©2022 Published in 10th International Symposium on Innovative Technologies in Engineering and Science 21-23 October 2022 (ISITES2022 Bursa - Turkey)
https://doi.org/10.33793/acperpro.05.03.4369

Experimental Study of 430SS Burner Plate Yellowness Measurement on Gas Hobs

[1]Berkent Parim, [1]Mehmet Kara, *[2]Ayberk Salim Mayıl, [2]Güven Eraktaş

[1]Haier Europe, Research and Development Center, Eskişehir, Türkiye, bparim@hoover.com.tr
0000-0001-8640-2219
[1]Haier Europe, Research and Development Center, Eskişehir, Türkiye, mkara@hoover.com.tr
0000-0002-7498-0596
*[2] Haier Europe, Research and Development Center, Eskişehir, Türkiye, amayil@hoover.com.tr
0000-0002-6916-3487
[2] Haier Europe, Research and Development Center, Eskişehir, Türkiye, geraktas@hoover.com.tr

Abstract

Color is one of the main esthetical basics of design in domestic appliances. For the household appliances which are used with high temperatures like oven, hobs etc. it has been observed yellowness on their metal sheets. For evaluating of the yellowness period, in this study 430 SS sheet is tested on 2 different hob models which 60cm gas hobs and 75cm gas hobs with a several samples as a total 12. During 360 cycles of hob working, 4 times yellowness is measured by using colorimeter method in Haier Europe internal Quality Reliability Laboratory. End of this study, all critical areas, which observation of yellowness ratios is high, are specified to improve the design.

Key words: Colorimetry, Gas Hob, Yellowness

1. Introduction

Accurate color selection is significant criteria for esthetic accomplishment. For household appliance sheet metals which they work under high temperature conditions, it has been observed yellowness problem. This is esthetical problem and creates quality issues in the market. There is no relevant color standard for the yellowness measurement. When the oxide film of stainless steel is thickened, several colors are composed due to interference. Oxidation can occur by thermal, chemical or electrolytic [1,2]. Oxidation could be observed to yellow color on metals when it occurs by thermal. To standardized yellowness in the metal sheet, it is needed color measurement method. Color measurement methods can be examined in 4 category which are colorimeter, spectroradiometer, spectroradiometer and digital cameras [3]. In this study Colorimeter method is chosen as a measurement method [4].

CIE L*a*b* pointed that four color are unique which are red, green, yellow and blue [5]. If

*Corresponding author: Address: Eskisehir 75. Yıl Organize Sanayi Bölgesi Candy-Hoover No:1, Eskisehir TURKEY. E-mail address: amayil@hoover.com.tr, Phone: +905376780352

white and black hues are count with other 4 color, six basic colors are obtained. With these 6 hues, three opponent pairs are acquired, and other hundreds of colors can be mentioned based on these basic six colors [6].

In this study, 6 samples from supplier A and 6 samples from supplier B of 430 SS sheet material is examined. 3 samples from supplier A and 3 samples from supplier B are used in 60cm gas hobs. 3 samples from supplier A and 3 samples from supplier B are used in 75cm gas hobs. With these samples, yellowing index are specified by using colorimeter method during 4 different cycles 0-120-240-360 in internal Haier Europe Quality Reliability Laboratory (QRL).

2. Materials and Method

In this study, two different hob models are used which they have different power and dimension properties as shown Figure 1 and Figure 2 below. One of these models is Haier Europe 60cm gas hob. Other model is Haier Europe 75cm gas gob.

As a total 12 hobs are tested which 6 samples from Supplier A and 6 samples from Supplier B. 3 samples of Supplier A are tested on 60cm hobs and other 3 samples are tested on 75cm hobs. 3 samples of Supplier B are tested on 60cm hobs and other 3 samples are tested on 75cm hobs as shown Table 1 below.

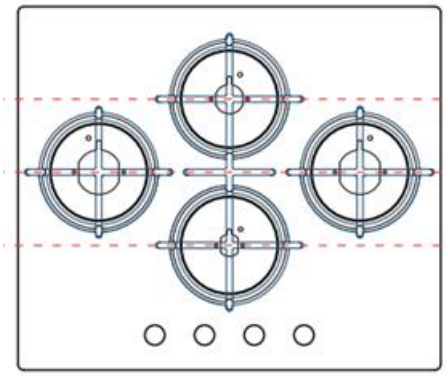

Figure 1. 60cm Gas Hob

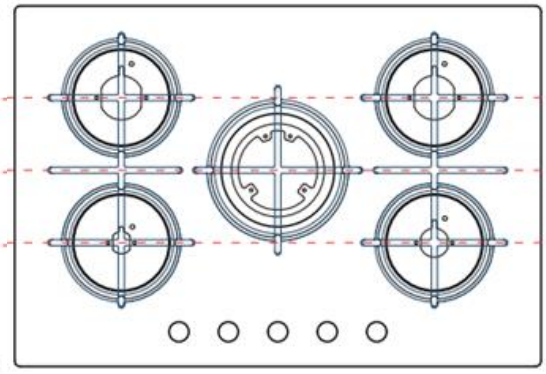

Figure 2. 75cm Gas Hob

Table 1. Test Classifications

HOB MODEL / SUPPLIER	SUPPLIER A	SUPPLIER B
60cm Gas Hob	3 Samples	3 Samples
75cm Gas Hob	3 Samples	3 Samples

For 60cm model 8, For 75cm models 10 critical areas are specified to measure as shown Figure 3 and Figure 4. For each of critical areas, 2 measurements are taken to validate the measurement

(M1, M2) for more accurate calculations.
Measurement is taken from end of 4 different cycle which are 0,120,240,360 respectively to observe the yellowness of hob metals because of high temperature. 1 cycle is mean, 20min max working, 40min minimum working and 30min cooling (hob is off) as shown Figure 5 below. By using this method, yellowing index are specified and compared between different hob models in beginning of the test, end of the 120. cycle, 240. cycle and 360. cycle.

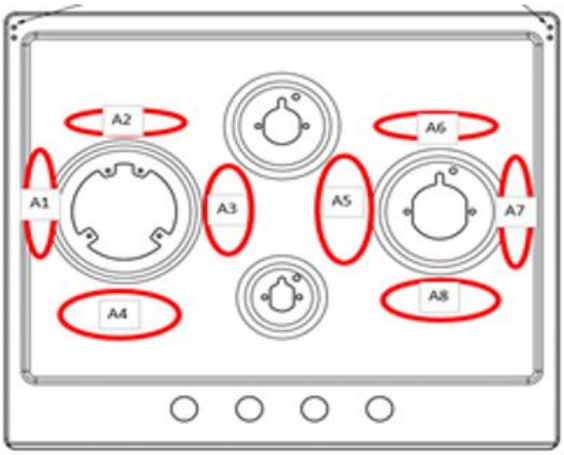

Figure 3. 60cm Hob Measurement Area

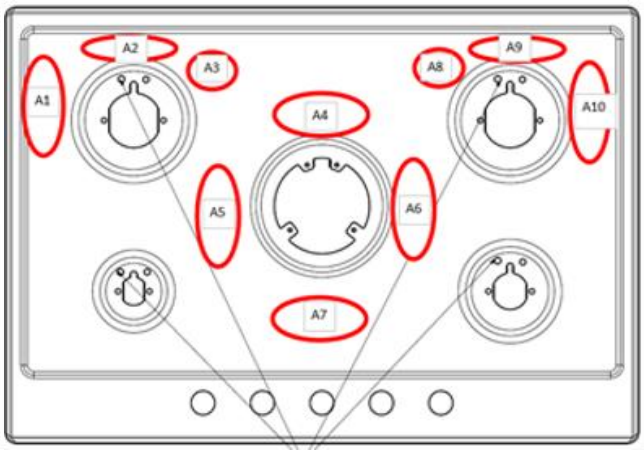

Figure 4. 75cm Hob Measurement Area

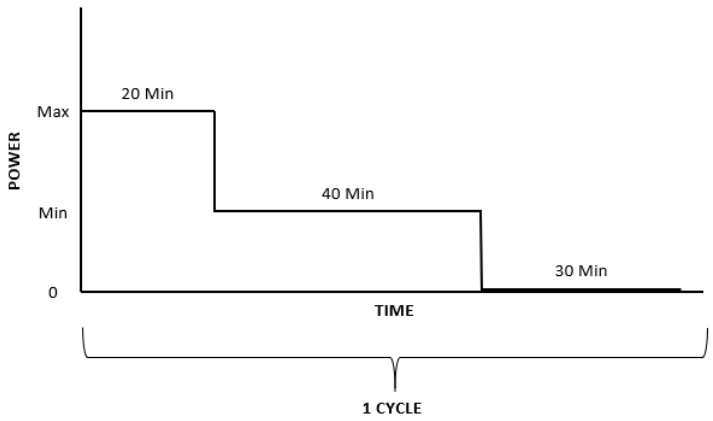

Figure 5. – Gas Hob 1 Working Cycle Diagram

2.1. Theory

Calorimetry measurement method is based on CIE L * a* b* color space as shown Figure 6 below. *L* represents lightness, *a* represents redness of color and *b* represents yellowness of color in positive side. In negative side a represents greenness and b represents blueness [6]. L*a*b values

are calculated from XYZ values by using Equation 1 as shown below.

$$F_x = \left(\frac{X}{X_0}\right)^{1/3} \quad [1]$$

Where X_0 is the X tristimulus value of a perfect white sample. F_Y and F_Z are calculated in a similar way **[6]**.

$$L^* = 116F_Y - 16 \quad [2]$$

$$a^* = 500(F_x - F_Y) \quad [3]$$

$$b^* = 200(F_y - F_Z) \quad [4]$$

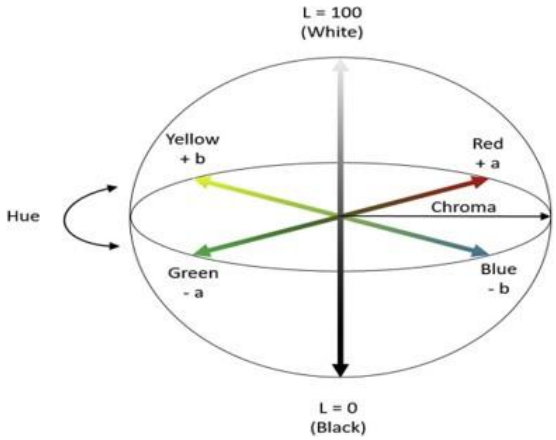

Figure 6. – CIE L * a * b Color Diagram

3. Results

In this study, 12 hobs are tested, and 8 area are measured two times each for the b* value to obtain yellowness values. This value is showed most critical area where it is affected from high temperature during working cycles. 3 60cm hob sample results from Supplier A are shown Table 2, Table 3, Table 4, 3 60cm hob sample results from Supplier B are shown Table 5, Table 6, and Table 7 below, 3 75cm hob sample results from Supplier A are shown Table 8, Table 9, and Table 10 and 3 75cm hob sample results from Supplier B are shown Table 11, Table 12, and Table 13

below.

Table 2. Supplier A 60cm Hob b* Values at 120. Cycle

CYCLE 120	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	1.51	1.96	2.42	1.96	2.49	2.31
A2	1.26	1.74	2.21	1.47	1.95	2.11
A3	2.65	3.14	3.43	3.6	4.09	4.25
A4	1.26	1.72	1.92	1.79	2.07	2.15
A5	1.95	2.34	2.29	2.52	2.13	2.15
A6	1.56	1.64	1.39	1.82	1.7	1.61
A7	1.74	1.93	1.93	1.69	1.86	1.75
A8	1.52	1.45	1.42	1.79	1.87	1.67

Table 3. Supplier A 60cm Hob b* Values at 240. Cycle

CYCLE 240	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	4.62	4.01	8.13	5.59	5.52	5.29
A2	2.44	2.48	3.46	6.17	3.12	3.75
A3	5.02	4.61	7.79	10.07	5.76	5.95
A4	1.43	1.43	2.74	4.28	2.21	1.88
A5	8.5	5.75	10.2	10.47	5.51	4.81
A6	3.33	2.78	10.12	4.48	1.58	1.19
A7	1.77	1.46	1.91	1.32	1.67	1.59
A8	0.86	0.95	1.36	5.6	0.89	1.13

Table 4. Supplier A 60cm Hob b* Values at 360. Cycle

CYCLE 360	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	3.05	3.75	2.03	5.89	4.31	4.65
A2	3.18	4.04	6.66	8.75	3.77	4.8
A3	5.82	4.88	10.62	11.34	6.54	6.5
A4	1.95	2.36	5.92	2.40	3.93	3.14
A5	3.87	8.15	9.81	10.05	6.23	4.61
A6	4.21	1.88	10.70	3.81	1.9	1.72
A7	1.52	0.77	2.21	1.22	1.94	1.32
A8	1.17	1.35	1.48	7.93	1.13	1.38

Table 5. Supplier B 60cm Hob b* Values at 120. Cycle

CYCLE 120	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	1.80	1.08	1.47	0.62	0.74	0.73
A2	1.34	1.37	1.43	1.42	1.75	1.70
A3	1.22	1.78	1.05	1.58	1.29	1.49
A4	1.74	1.67	2.07	2.05	2.01	2.11
A5	2.67	2.10	2.78	3.18	2.83	3.32
A6	2.70	3.26	3.32	3.43	2.93	3.21
A7	2.01	1.54	2.58	2.70	3.16	3.08
A8	1.47	1.30	1.97	1.62	1.48	1.41

Table 6. Supplier B 60cm Hob b* Values at 240. Cycle

CYCLE 240	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	2.68	2.61	2.55	2.11	2.1	2.71
A2	1.65	1.64	2.1	1.78	1.78	1.73
A3	3.83	3.61	5.04	4.4	3.32	2.78
A4	1.35	1.27	1.44	1.46	1.02	1.13
A5	2.89	3.32	3.65	3.83	2.6	3.17
A6	1.22	1.11	1.37	1.05	1.49	1.57
A7	1.78	1.55	1.76	1.83	1.76	1.61
A8	1.01	1.21	1.01	1.25	0.84	0.78

Table 7. Supplier B 60cm Hob b* Values at 360. Cycle

CYCLE 360	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	1.93	1.83	2.49	2.18	1.86	2.9
A2	1.32	1.73	1.95	2.39	2.35	2.57
A3	3.04	3.53	5.5	4.68	3.51	2.84
A4	1.64	1.5	1.89	1.68	1.93	1.58
A5	3.6	2.91	4.33	4.42	3.32	1.99
A6	1.57	1.22	1.5	1.31	2.15	2.39
A7	1.59	1.46	1.92	1.41	2.16	1.49
A8	1.25	1.28	1.29	1.61	1.12	1.31

Table 8. Supplier A 75cm Hob b* Values at 120. Cycle

CYCLE 120	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	1.56	1.09	1.21	1.21	1.42	1.58
A2	1.78	1.94	2.08	2.32	1.30	1.83
A3	2.18	3.98	2.17	3.00	4.08	2.26
A4	3.19	2.95	3.21	2.92	3.31	2.75
A5	5.65	6.64	6.42	6.14	5.65	3.99
A6	7.71	8.92	6.48	5.85	6.62	6.62
A7	10.47	12.42	3.27	3.21	2.72	2.64
A8	2.85	3.30	1.90	2.46	2.51	4.24
A9	1.32	1.48	1.43	1.54	2.26	2.24
A10	1.53	1.41	3.76	1.71	0.92	1.24

Table 9. Supplier A 75cm Hob b* Values at 240. Cycle

CYCLE 240	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	1.48	1.44	1.28	1.32	1.25	1.47
A2	2.78	2.96	2.25	2.45	3.33	3.39
A3	2.42	3.36	3.19	2.95	2.82	4.03
A4	3.21	5.46	4.83	4.59	4.54	4.58
A5	7.08	7.73	6.1	6.69	7.59	6.11
A6	6.49	8.27	6.11	6.61	7.16	6.9
A7	12.76	11.5	3.52	3.12	4	3.32
A8	1.77	1.53	2.56	2.51	3.71	2.88
A9	1.89	1.85	2.97	2.8	2.66	1.63
A10	1.73	1.73	1.6	1.67	1.26	1.29

Table 10. Supplier A 75cm Hob b* Values at 360. Cycle

CYCLE 360	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	1.36	1.59	1.32	1.39	1.83	1.87
A2	2.28	2.44	1.81	2.26	2.05	2.88
A3	1.94	2.03	2.96	4.27	2.95	2.61
A4	2.92	3.06	3.56	3.67	2.5	3.04
A5	6.99	7.77	5.95	5.96	6.37	6.52
A6	6.89	7.86	6.83	6.57	7.78	7.35
A7	11.92	10.56	3.11	3.41	2.97	3.66
A8	1.55	1.61	2.83	2.19	2.58	2.31
A9	1.42	2.12	2.42	2.1	2.84	1.65
A10	1.71	2.37	1.84	2.05	1.38	1.58

Table 11. Supplier B 75cm Hob b* Values at 120. Cycle

CYCLE 120	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	0.24	0.24	0.41	0.27	0.82	0.50
A2	0.63	0.96	1.08	1.28	0.76	0.80
A3	1.13	2.34	1.36	3.07	1.02	2.20
A4	2.76	2.58	2.50	2.57	2.77	3.01
A5	4.78	7.09	3.54	4.63	4.68	5.98
A6	5.56	7.06	4.68	5.23	4.01	4.02
A7	8.16	6.31	5.67	5.40	4.28	4.89
A8	0.66	0.99	0.77	0.81	0.88	1.43
A9	0.49	0.91	0.37	0.72	1.02	1.34
A10	0.96	2.00	0.85	1.93	0.97	2.18

Table 12. Supplier B 75cm Hob b* Values at 240. Cycle

CYCLE 240	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	0.45	0.16	0.73	0.76	0.9	0.82
A2	1.05	1.42	1.54	2.24	1.7	2.05
A3	1.15	1.73	1.49	1.7	1.37	1.93
A4	2.78	2.86	3.43	2.77	2.82	3.07
A5	4.33	5.93	6.91	4.89	4.12	4.01
A6	4.67	6.81	4.12	5.43	4.38	5.91
A7	7.57	6.97	6.37	5.87	3.82	4.84
A8	1.07	0.93	1.52	1.46	1.51	1.55
A9	1.12	1.11	1.61	0.96	2.01	1.55
A10	0.85	1.06	0.81	0.97	1.21	1.39

Table 13. Supplier B 75cm Hob b* Values at 360. Cycle

CYCLE 360	SAMPLE1		SAMPLE2		SAMPLE3	
AREA	M1	M2	M1	M2	M1	M2
A1	0.44	0.44	0.55	0.52	1.01	0.89
A2	0.72	1.56	1.16	1.68	1.08	1.92
A3	0.9	1.16	1.97	2.9	1.46	1.03
A4	2.46	2.42	4.9	5.43	2.36	2.8
A5	3.5	5.34	4.32	6.87	3.69	3.4
A6	5.14	7.12	4.88	5.37	4.51	6.16
A7	6.59	6.1	1.11	1.51	2.8	4.33
A8	0.91	1.08	1.11	1.02	0.96	1.11
A9	1.15	1.24	0.41	1.2	1.4	1.33
A10	0.93	1.02	1	1.02	1.95	3.72

Tables shown above, are results of experimental study of the 430SS sheet where on the gas hobs. In the Cycle 0, average b* value is 0.5. Measurement results show us yellowness are increasing with the cycle time because sheet is getting more reactive with the flame. In the Sample 1 measurement, variation is between 10% - 15%. For the Sample 2 and 3 measurements, variation is between 0.1% - %2 as an average.

4. Discussion

Yellowness is the parallel to the time the temperature is applied during hob working. For the yellowness value, it is measured b* value. But, if there is more interaction with the flame (if temperature is getting higher) a* values, which is redness, also could be increased. Increasing of the yellowness and redness on sheet metal creates esthetical problem which occur as a quality problem. Based on these results, instead of 430SS material as a burner plate on hob, more qualified stainless steel could be used to improve the esthetical and qualitative properties.

Conclusions

In this study, 12 hobs are tested to specify the yellowness value on burner plate which material is 430SS. Results shows, when the cycle time is increased, b* values is increased. With the b* values, a* (redness) value is also increasing by cycle time. There is no related standard for the yellowness value from esthetical perspective. Colorimeter method is the practical and systematically way to measure b*, so that if there is any request related esthetical and qualitative improving, based on these results, material of burner plate could be changed with the more qualified ones. But, apart from improving the materials, aim of this study is evaluating the current situation.

References

[1] [1] Wang, J. H., & Duh, J. G. (1995). Colour tone and chromaticity in a coloured film on stainless steel by alternating current electrolysis method. Surface and coatings technology, 73(1-2), 46-51.

[2] Naylor, C. E. (1950). Electrocoloring of stainless steels in aqueous solutions. Plates, 153, 154-159.

[3] Paravina, R. D., & Powers, J. M. (2004). Esthetic color training in dentistry (Vol. 1). Mosby.

[4] Müdüroğlu, R., KIVRAK, T. Ç., & NALÇACI, A. (2018). Renk Belirlenmesinde Kullanilan Yöntem ve Cihazlar. Cumhuriyet Dental Journal, 21(1), 61-69.

[5] CIE Publication 15.2 (1986) Colorimetry. Vienna: CIE

[6] Gilchrist, A., & Nobbs, J. (2017). Colorimetry, theory. Encyclopedia of spectroscopy and spectrometry, 328-333.

[7] Hirschler, R. O. B. E. R. T. (2012). Whiteness, yellowness, and browning in food colorimetry. Color in Food: Technological and Psychophysical Aspects. Editorial JL Caivano & Buera MP EE. UU, 93-104.