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Ageing Experiments of Mastics and Silicones Used in Bonding of Range Hood Glass

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ABSTRACT Silicon is a synthetic compound consisting of elements such as silicon (silicium), oxygen, carbon, and hydrogen. Silicones are frequently used in adhesive, sealing, and insulating products. It that can be found in different colors and characteristics and it is for various purposes. In terms of structure, it is usually liquid and flexible, and used as adhesive and sealing material in white goods sector. The adhesive in the mastic structure is mixed with the filling materials and the frequent use of this mastic material which is cheaper structure, causes various problems in the sector. In this study, ageing experiments for silicon and mastic materials were conducted and the results were compared.

Keywords: Silicon, Mastic, Life of mastic, Tensile test, Ageing, Silicon ageing experiments

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1. INTRODUCTION

As the world population and human needs increases continuously mass production activities are indispensable [1]. Mass production methods have been developed continuously for profit and productivity increase; in parallel with this, automation and production speed have gained importance [2]. Serious investments have been made to produce more in less time and cost-effectively. As a result of efforts made for the productivity increase and low-cost, the search for new materials for products is emerging. However, products are in variety characteristics in the market can lead to wrong choices even though it may offer some cost advantages. The fact that silicone and mastic products, which are often used in the bonding process in the white goods sector have different characteristics that leads to negative technical situations [3]. In this study, ageing experiments of silicone and mastic materials were performed and their adhesion and sticking characteristics over time were compared.

1.1. Building Blocks of Silicone

The silicone is both a natural element found quite a lot in nature and it is also the name given to the synthetic substance artificially produced from the silicon element. The silicon (silicium) element is the 14th element in the periodic table. It is a semi-metal element whose symbol is Si, atomic weight is 28.085, specific gravity is 2.42 g/cm^3, and the melting point is 1410 °C. It exhibits both metallic and nonmetallic properties. Silicon is the generic name of many different polymeric chains and systems structured based on Si-O-Si. According to the study by Jorgersen, active oxygen plays an important role in the formation of these silicon bonds [4].

1.2. Silicon and Mastic Materials

Silicon is a synthetic compound consisting of elements such as silicon, oxygen, carbon, and hydrogen. Silicones are frequently used as adhesive, sealing, and for insulation purposes. Silicon can be found in different colors and characteristics are used for various purposes. It is usually in a liquid and flexible form. It is mixed with adhesives and filling materials in mastic structure and they are frequently used as mastic material, which is a cheaper structure, and causes various problems in the sector. These polymers have already shown potential for applications such as ceramics, heat-resistant materials, and advanced composites in aerospace [5-7].

On the other hand, mastic is a single component and highly elastic substance that contains polyurethane. It is used to provide expansion and sealing. It loses its elasticity when it dries. A basic comparison of both materials is presented in Table 1.

Table 1. Comparison of silicone and mastic

Property	*Silicone*	*Mastic*
Purpose of use	Insulation and bonding purposes	Filling and bonding
Usage Area	In PVCs, aluminum-wood joints, bathtub, sink, toilet seat, tiles, ceramics, and sound, water, and dust insulation of vehicles	In PVCs, aluminum-wood joints, repair of joints and small cracks, and sound, water, and dust insulation of vehicles
Color	Transparent, white, black, grey, brown	White, black, grey, brown
Paint Adherence	Cannot be painted	Can be painted
Elasticity	When it dries, it does not lose its elasticity.	When it dries, it loses its elasticity.
Antibacterial	Antibacterial	Antibacterial
UV Resistance	UV resistant	UV resistant
Price	More expensive than mastic	Cheaper than Silicone

2. EXPERIMENTAL

2.1. Ageing Experiments of Silicone and Mastic Materials

The adhesives in silicone and mastic structure, which are often used in the white goods and furniture industry, have been tested using different test methods. Metals and glasses bonded with silicon show different reactions at different temperatures. Wallis and Pomerantz have stated that strong bonds can be formed in heating of metal and glass at temperatures much lower than those required for thermal bonding [8].

In our study, the sheet material was bonded onto the glass drawing as shown in Figure 1. The sheet metal piece had approximately 100 cm^2 surface. In Figure 1, number 1 and 2 represent metal materials, number 3 represent glass surface. Metal materials are fixed to the glass surface by silicon or mastic adhesive.

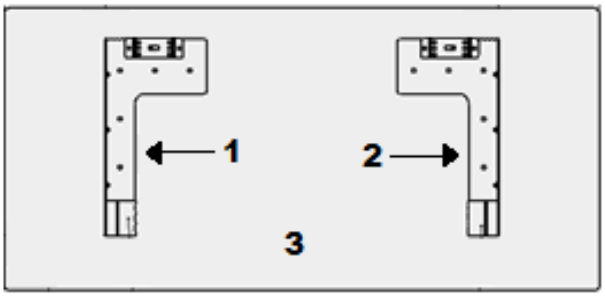

Fig. 1. View of the sheet material bonded onto the glass

Taking into account the fact that the paints of the glass differ in themselves, the experiments were enriched with different glass types and colors. First, metal parts were pasted onto glass with an automation in a way that all parameters (standard 400 N force, 5.45 mL adhesive, 22°C ambient temperature, and 50% ambient humidity) to be the same. Different waiting times were taken into account when performing aging experiments and tensile tests were repeated five times at the end of the first 24 hours, at the end of the 3rd day, and the end of each week for eight weeks. The tests were carried out at a 90° angle from the marked section of the sheet metal, as it can be seen in Figure 2.

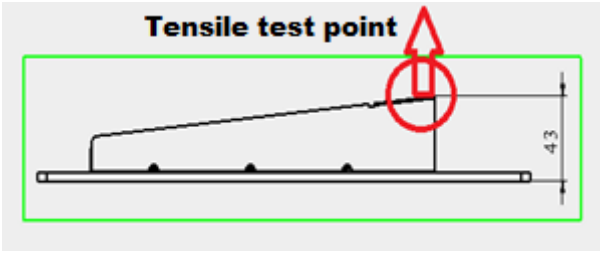

Fig. 2. Tensile test connection point to metal surface

In the tensile tests, the highest strength point was measured with the digital Lutron FG-5100 force gauge, newton meter, and these values were taken into consideration for experimental results [9-10]. In Figure 3, 50 x 100 mm dimension metal materials were bonded to the glass surface with silicone and mastic adhesive. Tensile test results were received from the FG-5100 device.

Fig. 3. Glass strength/tensile test mechanism

2.2. Ageing Experiments

When determining the experimental conditions, especially the conditions of use were taken into account and the experiment plan was prepared by a team of experts in a leading company in white good sector.

To simulate different climatic conditions and force applied to the material, an experiment plan was created as follows:

Cycle 1:
2 hours: T= 70℃, humidity=80%
6 hours: T= 25℃, humidity=40%
2 hours: T= 70℃, humidity=80%
2 hours: T= 10℃, humidity=30%

In a drying-oven, 70℃ and 80% relative humidity for 2 hours, 25°C and 40% relative humidity for 6 hours, 70℃ and 80% relative humidity for 2 hours and finally 10°C and 30% relative humidity for 2 hours were applied to the pieces respectively and tensile tests were carried out. The cycle one was repeated continuously until the tensile test was performed. Thus, a complete cycle lasting 12 hours was repeated 14 times by the end of one week. Tests lasted 8 weeks, yielding 112 cycles of tests, in total.

2.2.1. Results of the Standard Ageing Experiment

The data obtained at the end of the tensile tests were recorded and then analyzed with the statistics program. The results of “Brand A” silicone are shown in Table 2.

Table 2. The tensile test results for "Brand A" silicone (Unit Newton)

Time	*Mean*	*Minimum*	*Maximum*
After 24 h	267.2	257	274
After 3rd Day	535	530	540
After Week 1	614	605	622
After Week 2	592.8	567	639
After Week 3	620.4	600	646
After Week 4	627.6	606	657
After Week 5	606.2	588	620
After Week 6	638.4	586	675
After Week 7	661.8	588	698
After Week 8	624.4	603	661

Analysis results of the "Brand B" material used as mastic adhesive are presented in Table 3.

Table 3. The tensile test results for ''Brand B'' mastic adhesive (Unit Newton)

Time	*Mean*	*Minimum*	*Maximum*
After 24 h	525.8	418	564
After 3rd Day	455	450	460
After Week 1	612	545	652
After Week 2	567	527	595
After Week 3	565.8	539	578
After Week 4	621	581	654
After Week 5	592.6	560	634
After Week 6	559.6	554	567
After Week 7	475.8	362	542
After Week 8	434.4	390	464

The range values of both materials by time obtained as a result of the analysis are shown in Figure 4.

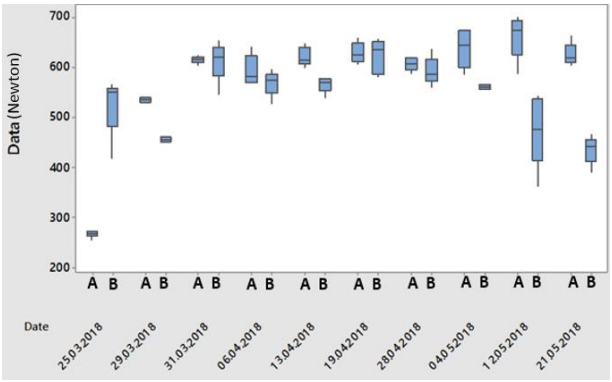

Fig. 4. The ultimate tensile force variation as a function of time belonging to A brand silicone and B brand mastic adhesive

The results of the tensile strength by time, which is one of the most important factors in ageing experiments, are as follows for both types of glass and adhesive.

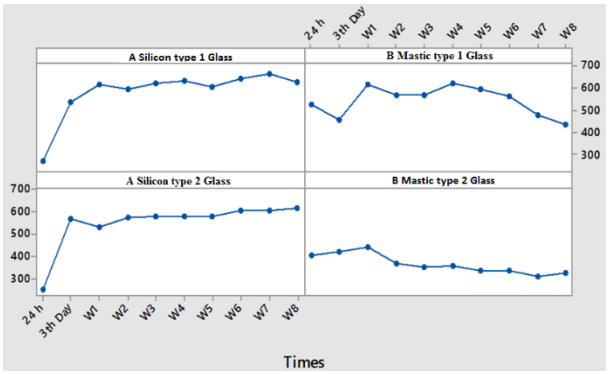

Fig. 5. The ultimate force - time graph of A brand silicone and B brand mastic adhesive

2.3. Ageing Experiments for Relevant Using Conditions

In these experiments, sheet metal material was pasted onto the glass. Taking into account the fact that the paints of the glass differ in themselves, the experiments were enriched with different glass types and colors.

Ambient conditions have been aggravated to simulate the use in a kitchen. In these tests, a special oil mixture was also applied to the surface of the sheet metal and glass to ensure the kitchen conditions. Before the tensile tests, surfaces of the sheet metal and the glass were cleaned with detergent.

Cycle 1:
2 hours: T= 70℃, humidity =80%
6 hours: T= 25℃, humidity =40%
2 hours: T= 70℃, humidity =80%
2 hours: T= 10℃, humidity =30%

In the drying-oven, 70℃ and 80% relative humidity for 2 hours, 25°C and 40% relative humidity for 6 hours, 70℃ and 80% relative humidity for 2 hours and finally 10°C and 30% relative humidity for 2 hours were applied to the pieces respectively and tensile tests were carried out.

The cycle was repeated continuously until the tensile test was performed. Thus, a cycle lasting 12 hours was repeated 14 times by the end of one week. Given that the tests took 8 weeks; it is understood that 112 cycles of the test were carried out on the pulled piece by the end of the final week. The analysis results of A brand silicone are shown in Table 4.

Table 4. The tensile test results for ''Brand A'' silicone (Unit Newton)

Time	*Mean*	*Minimum*	*Maximum*
After 48h	346.2	321	372
After Week 1	755.6	702	784
After Week 2	802.6	780	820
After Week 3	771	750	798
After Week 4	695.2	672	747
After Week 5	671.2	638	693
After Week 6	652	632	685
After Week 7	666.6	650	678
After Week 8	638.8	628	654

Analysis results of the ‘’Brand B’’ material used as mastic adhesive are presented in Table 5.

Table 5. The tensile test results for ‘’Brand B’’ mastic adhesive (Unit Newton)

Time	*Mean*	*Minimum*	*Maximum*
After 48 hour	542	525	568
After Week 1	583	563	603
After Week 2	582.6	555	650
After Week 3	534.2	521	547
After Week 4	494,6	472	560
After Week 5	431.6	420	440
After Week 6	411	400	427
After Week 7	422.4	415	430
After Week 8	411	404	418

In Figure 6, the values of both materials by time obtained as a result of the analysis are shown.

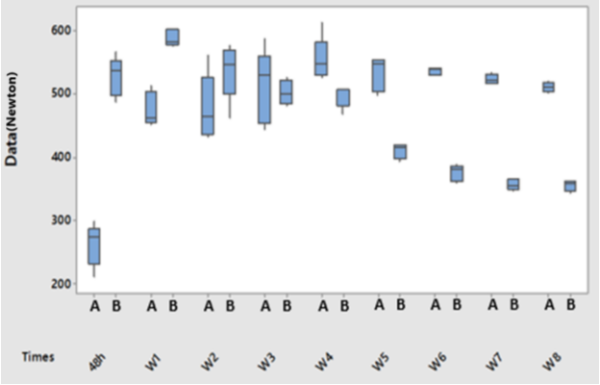

Fig. 6. The ultimate tensile force variation as a function of time for Brand A type silicone and Brand B type mastic adhesive

The results of the tensile strength for different variables by time, which is one of the most important factors in ageing experiments, are given in Figure 7 for both types of glass and adhesive in comparable form.

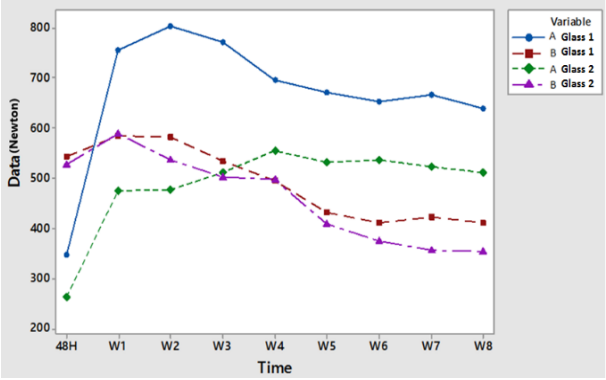

Fig. 7. The ultimate force - time graph of A brand silicone and B brand mastic adhesive

3. CONCLUSION

This study aimed to investigate the mechanical properties of silicon and mastic by means of tensile tests. It was shown that the adhesive property of the mastic material decreases, and it loses its flexibility structure as it hardens, and ultimately its tensile strength decreases. On the other hand, when the examined materials were bonded with silicone, it was observed that the adhesive property of the material increases over time, it does not lose its flexibility and as a result, the tensile strength increases. It was noted that, silicone adhesives can be preferred where load bearing is available while mastic can be preferred for sealing purposes. Material selection should be based on area of use, cost, and characteristic features.

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