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A Comparison of Infrared Radiation Welding and Adhesive Bonding Methods on Some Performance Properties of Fuel Filters

Yakıt Filtrelerinin Bazı Performans Özelliklerinde Kızılötesi Işınım Kaynağı ve Yapıştırıcı Yapıştırma Yöntemlerinin Karşılaştırılması

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YAKIT FİLTRELERİNİN BAZI PERFORMANS ÖZELLİKLERİNDE KIZILÖTESİ IŞINIM KAYNAĞI VE YAPIŞTIRICI YAPIŞTIRMA YÖNTEMLERİNİN KARŞILAŞTIRILMASI

ÖZ

Araçlarda kullanılan yağ-yakıt filtrelerinin birleştirilmesinde kullanılan en yaygın yöntem yapışkan yapıştırmadır. Bu filtre plastik merkezi boru, plastik kapak ve filtre kağıdının yapışkan yapıştırma ile birleştirilmesinden oluşur. Kızılötesi radyasyon (IR) kaynağı, sağlık ve çevresel kaygıları beraberinde getiren geleneksel yapışkan yapıştırmaya alternatif geliştirmek için yakıt filtresinin filtre kağıdı ve gövde kapağını birleştirme yaklaşımlarından birisidir. Bu çalışma, aynı filtre kağıdını içeren ancak farklı birleştirme yöntemleri ile birleştirilmiş filtre örneklerinin sızdırmazlık, gerilme-gerinim ve kabarcık performansını araştırmaktadır. Sonuçlar IR kaynaklı filtrelerin daha iyi performans gösterdiğini göstermektedir.

Anahtar Kelimeler: Kızılötesi Işınım (IR), Yapışkan Yapıştırma, Filtre Elamanları Yakıt Filtreleri, Otomotiv Filtresi.

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A COMPARISON OF INFRARED RADIATION WELDING AND ADHESIVE BONDING METHODS ON SOME PERFORMANCE PROPERTIES OF FUEL FILTERS

ABSTRACT

Adhesive bonding is the most common method used for combining oil-fuel filters used in vehicles. This filter consists of combining the plastic center tube, the plastic cover and the filter media with adhesive bonding. Infrared radiation (IR) welding is one of the approaches to join the housing cap and filter paper in the fuel filter to develop an alternative to traditional adhesive bonding which brings health and environmental concerns. This study investigates the sealing, stress-strain and bubble performance of filter samples including the same filter media but differing in joining methods. The results pointed to better performance for IR welded filters.

Keywords: İnfrared Radiation (IR), Adhesive Bonding, Fuel Filters.

Outlined: This study showed that IR welding of thermoplastic compounds and filter paper would be successfully applied in a fuel filter.

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1. INTRODUCTION

Fuel filters are the mechanical components that serve as safety belts for modern compression-ignited engines by preventing the wear in injection systems and engine cylinders, the loss in engine performance and power, and protecting fuel supply systems by removing dirty particles in the fuel tank and water in the fuels [1,2].

Different components like stainless steel filter elements, filter media (paper), sieve, etc., and different types of bonding adhesive materials such as acrylics, polyvinyl chloride, and epoxies, are used in the fabrication of fuel filters. To provide impermeability and good filtration performance filter components should be well combined. It is important to choose suitable adhesives but the bonding of these adhesives onto different filter materials and resistance to fuels is limited owing to their chemical nature. Adhesive bonding has various advantages including reduced vibration transmission [3], design flexibility, a good strength-to-weight ratio [4], and the elimination of unsightly fasteners [5]. On the other hand, the performance of the filters determine either in liquid or dry media when exposed to hot steam, air, and a humid environment; production time and cost conditions should be taken not consideration [6,7]. There are various efforts on the development of adhesives with the better corrosion resistance of filter components [8-11], also to design adhesive-free filter structures is also another interest. Those studies are driven by the health and environmental concerns in the usage of adhesive/solvent systems along with corrosion and surface deformation-related problems of the joint; the non-recyclable nature of adhesives is also another setback.

One of the approaches for joining the components in fuel filter manufacturing is using infrared radiation (IR). IR is defined as part of an electromagnetic spectrum whose wavelength ranges from 0.75 to 1000 μm. Infrared heating depends on the spectrum because the energy emitted from the emitter consists of different wavelengths and part of the radiation depends on the source temperature and the lamp emission. Today, IR is used in various applications like food heating, food, fruit and vegetable drying, free radical scavenging, enzyme inhibition, and deactivation of micro-organisms [12].

This paper investigates the applicability of fuel filter fabrication with infrared radiation (IR) welding to remove the need for adhesives by comparing some performance testing. The study covers the IR welding of not only the thermoplastic components but the filter media together. The findings revealed the clear advantage of IR welding of filter media.

2. MATERIALS AND METHODS

2.1 Materials

Table 1. Material

NO	Materials	Purchased Company	Alloy Ratio
1	1060 Aluminum	Metaltek	Al 99.21%, Fe 0.35%, Si 0.25%, Cu 0.05%, Zn 0.05%, Mg 0.03%, Mn 0.03%, Ti 0.03%
2	Polyamide 6.6	Tisan Mühendislik	PA6 GF30 - 30% of light fiberglass (1.13-1.15 g/cm^3)
3	Polyamide 6	Tisan Mühendislik	PA 6 – (1.12 - 1.14 g/cm^3)
4	Cellulose Filter Media	Chentai Filter Paper Co.	100% Cellulose - 190 g/m^2

2.2 Tests and Methods

The 1060 aluminum alloy and PA6-GF30 were cleaned with distilled water and ethanol for 10 min in the ultrasonic bath, respectively, to remove the pollutants attached to the surface. Then the cleaned materials were naturally in the air at room temperature for the process. The filter components were produced by injection molding according to the dimensions and technical drawings are given in Figure 1. The claw height was selected as 0.5. The fuel filter media were subjected to either adhesive hot-melt bonding by commercially available polyamide-based adhesive or IR welding. Before IR heating, dehumidification was applied for 4 h at a temperature range of around 80 – 100 °C. Then, IR welding was applied through 15 kw – 380 V IR lamps by a welding machine (Bedsam Makine, Türkiye). The samples produced are given in Figure 2.

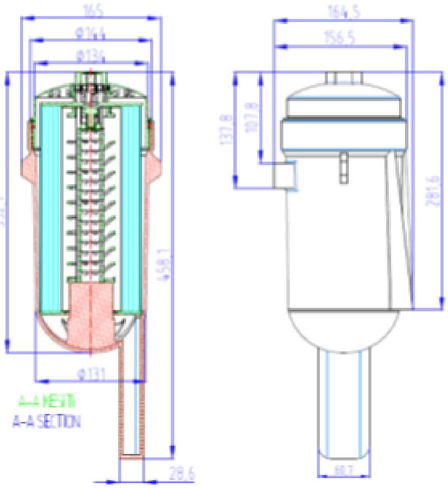


Figure 1. Technical drawing of the filter components

(a) (b)

Figure 2. Fuel filter where the filter paper was a) IR welded b) adhesively bonded

The seal performance of the filter samples was assessed by tensile and compression behavior by ASTM D638, pulse fatigue testing according to ISO 4548, and pore size according to bubble point testing to SAE ARP901 B. Tensile-compression testing was tested on a WANCE ETH 202A 200N capacity device. The test device complies with ISO 6892-1, ISO 6892-2, ASTME-8 and ISO 527-1 standards. The pulse fatigue testing was run at 6 bar pressure, 35 Hz impulse frequency, and the pulse cycle of deformation was determined; whereas the bubble tests were conducted at 18°C, 1 and 1,4 bar pressure with 200 mm dipping depth, separately. The bubble pressure and pore size were recorded by the testing device PLC. The joint area of the filters was also observed under an optical microscope at 50x magnification. China. The filter media was subjected to air permeability at a constant pressure drop of 200 Pa 20 cm^2 test area by ISO 9237 method and aperture measurement using ethanol as test reagent by EN 868-3 to determine the maximum pore size and evaluate the suitability. The measurements were repeated three times and the mean values were recorded.

3. RESULT AND DISCUSSION

The average value of air permeability and aperture tests of the filter paper shown in Table 2. The results have been confirmed the homogenous (due to very low CV% value) and applicable structure thanks to relatively low air permeability and maximum pore size values.

Table 2. The results of filter paper characterization

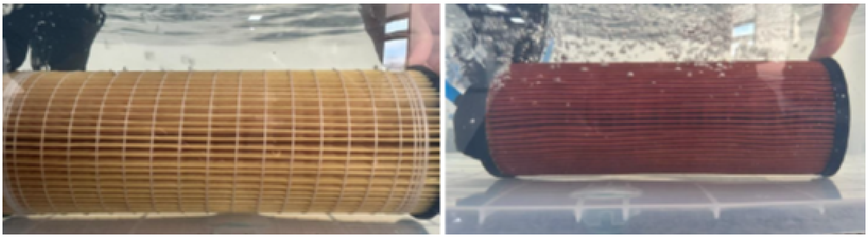
Tested parameter	Mean value	CV%
Air permeability (L/m^2/sec)	430.5	2.1
Maximum pore size (µm)	62.7	2.5

Table 3 gives the results of the performance tests. The IR welded filter sample gave better seal performance in terms of a longer deformation pulse cycle and higher bubble pressure (both at 1 and 1.4 bar measurement pressure). The adhesive bonded sample led to more dense bubbles through the bonding area where the IR welded caused well-distributed bubble formation (Figure 3).

Table 3. The performance tests of the filter samples

Performance Parameter	Pulse Cycle at Deformation	Pressure (bar)	Pore Size (µm)	Temperature (°C)	Immersion Depth (mm)	Bubble Pressure (bar)
IR Welded	74000	1	59	18	200	0.7
		1.4	60	18		0.6
Adhesive Bonded	53000	1	62	18	200	0.5
		1.4	64	18		0.4

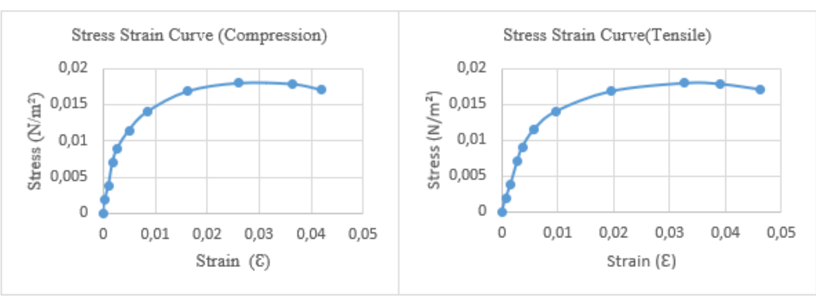
The upper values were obtained at 1 bar where the latter at 1.4 bar measurement pressure



(a) (b)

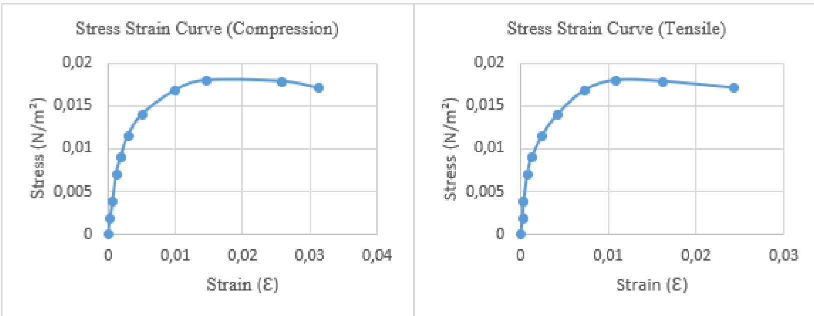
Figure 3. Fuel filter a) IR welded) b) adhesively bonded at bubble test

The stress and strain diagrams of the samples are shown in Figures 4 and 5, respectively. A comparison of Figure a and figure b shows demonstrated mechanical performance. IR welded unit's comparison test is stronger than adhesively bonded. The demonstrated point determines the fracture point in figure a and b. The value of the fracture point is 0,01706 N/m2 for compression test by giving IR welded in figure 4. The test result of the fracture point is 0,01701 N/m2 for the tensile test of IR welding in figure 4. The value of the fracture point is 0,01706 N/m2 for the compression test by giving an adhesively bonded in figure 5. The test result of the fracture point is 0,01701 N/m2 for the tensile test of adhesively bonded in figure 5. Tensile test of IR welded is stronger according to adhesively bonded. The curves demonstrated better mechanical performance of IR welded filter giving higher strain than that of adhesive bonding. The optical microscope evaluation showed (Figure 6) better joint of the paper and the filter components at the intersection, which was also an explanation for the higher strain at break. Also, Figure 6 shows adhesively bonded and IR welded respectively. Figure b shows that Filter media and components are welded perfectly according to adhesively bonded (figure a).



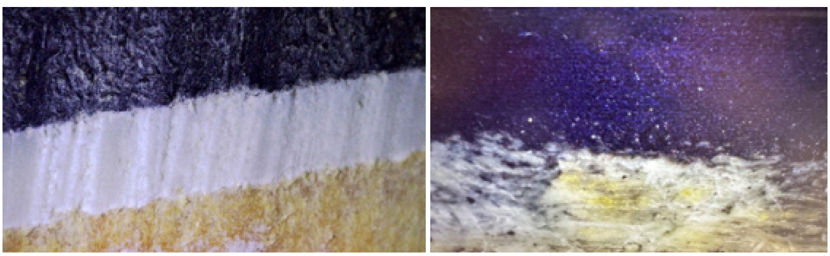
(a) (b)

Figure 4. Stress / Strain curves of a) compression b) tensile of IR welded fuel filter



(a) (b)

Figure 5. Stress / Strain curves of a) compression b) tensile of adhesively bonded fuel filter



(a) (b)

Figure 6. The optical microscope images of a) adhesively bonded b) IR welded sample

4. CONCLUSION

This paper compares the basic performance properties of IR welded and adhesion-bonded typical fuel filters. The cellulose filter media was characterized through air permeability and aperture tests for quality control and the filter samples were tested by seal performance, tensile / compression behavior, bubble test, and optical microscope images. The results showed that IR welding has been successfully applied and better performance would be achieved.

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Data Analysis: BGD (%25), MKE (%50), FK(%25)

Writing Up: BGD (%60), MKE (%40)

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