Çelik Tellerle Takviye Edilmiş Termoplastik Disklerin Elastik Gerilmelerinin İncelenmesi

Investigation of Elastic Tensile Behavior of Thermoplastic Discs Reinforced With Steel Wires

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Özetçe— Yapılan bu çalışmada termoplastik kompozit diskte oluşan gerilmeler nümerik analiz ile incelenmiştir. Elastisite modülünün sıcaklıkla değişmediği varsayılarak çalışmada 20 ° C, 40 ° C, 60 ° C, 80 ° C, 100 ° C sıcaklık dağılımları referans alınmıştır. Kompozit malzemeler, iki veya daha fazla malzemenin en iyi özelliklerini bir araya getirerek veya yeni bir özellik oluşturarak meydana gelirler. Termoplastik kompozitler ise bükülebilir ve sünektirler. Teknolojinin birçok yerinde tercih edilen bu malzemelerin ısıl davranışlarını bilmek hayati önem taşımaktadır. Yapılan sayısal analiz sonunda, yüksek sıcaklıklarda hesaplanan radyal ve teğetsel gerilme değerlerinin; düşük sıcaklıklarda hesaplanan radyal ve teğetsel gerilmelere göre daha büyük olduğu görülmüştür. Teğetsel gerilmelerin radyal gerilmelerden daha büyük olduğu görülmüştür. Termoplastik disk üzerinde etkiyen sıcaklığın değerindeki artışın, termal gerilme dağılımını ve değerlerini doğrudan etkilediği sonucuna varılmıştır.

Anahtar Kelimeler— kompozitler, termoplastik kompozit disk, termal stres, parabolik sıcaklık dağılımı

Abstract— In this study, the stresses occurring in the thermoplastic composite disc were investigated by numerical analysis. Assuming that the modulus of elasticity does not change with temperature, temperature distributions of 20 ° C, 40 ° C, 60 ° C, 80 ° C, 100 ° C were taken as reference in the study. Composite materials are created by combining the best properties of two or more materials or by creating a new property. Thermoplastic composites, on the other hand, are bendable and ductile. It is vital to know the thermal behavior of these materials, which are preferred in many areas of technology. At the end of the numerical analysis, the radial and tangential stress values calculated at high temperatures; It has been observed that it is greater than the radial and tangential stresses calculated at low temperatures. It has been observed that the tangential stresses are greater than the radial stresses. It was concluded that the increase in the value of the temperature acting on the thermoplastic disc directly affects the thermal stress distribution and values.

Keywords— composites, thermoplastic composite disc, thermal stress, parabolic temperature distribution

I. INTRODUCTION

Discs are indispensable for machines. Discs are preferred from vehicle brake systems to aircraft wings. In general, metal discs were used as machine equipment parts before, but today composite and thermoplastic discs are used. Temperature is indispensable for mechanics and engineers. The term warmth is almost like the name of a living being. The temperature behavior of the materials should be known and analyzed well. In the literature search, it was seen that thermal stress analyzes related to the discs were made, but it is thought that these studies should be reproduced.

They investigated thermoelastic stress analysis in FGM discs by using finite element method [1]. Kayiran and Öndürücü investigated the stresses occurring in the disc exposed to a certain temperature distribution [2]. He shared his findings with the literature in the form of graphs and tables by calculating the thermal stress analysis on the bi-material disc [3]. in a different study, investigated the thermal stresses in different temperature-influenced Aluminum Boron Carbide, Aluminum-Zirconium, Aluminum-Cast Iron, Aluminum-Titanium Bimaterial discs [4]. He investigated the stresses occurring in discs of different diameters consisting of (Al2024-T3) - Boron Carbide (B4C) in a different study [5]. He investigated the thermal stresses occurring in the boron carbide (B4C) disc in a different study [6]. They investigated the dynamic behavior of gradual discs [7]. They analyzed the variation of nonlinear and rotating discs in radial direction, parabolic, analytically [8].

II. MATERİALS AND METHODS

In this numerical study, the stress conditions at 30 ° C, 60 ° C, 90 ° C, 120 ° C were determined (Fig.1).Disc thickness is assumed as a unit and taken as σ_Z = 0 for plane stress [9].

$$\frac{r(d\sigma_r)_i}{dr} + (\sigma_r)_i - (\sigma_\theta)_i = 0 \qquad (i = 1) \qquad (1)$$

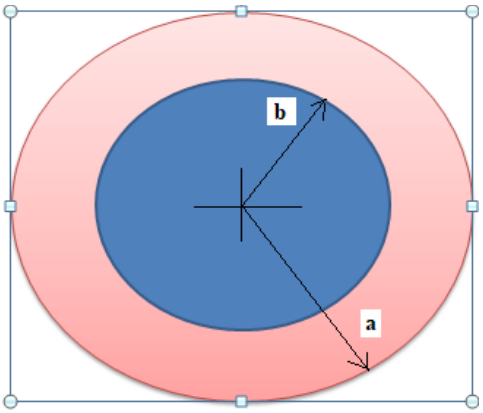

Figure 1- Thermoplastic composite disc

In equation (1), r is the radius of the disc at any point, σr is the radial stress, and σθ is the tangential stress.

$$\varepsilon_r = \frac{du}{dr} = a_{rr}\sigma_r + a_{r\theta}\sigma_\theta \quad (2)$$

$$\varepsilon_{\theta i} = \frac{u}{r} = a_{r\theta}\sigma_r + a_{\theta\theta}\sigma_\theta \quad (3)$$

ε_r, stands for radial strain, ε_θ stands for tangential strain. Strain-stress relationship (Timoshenko and Goodier, 1970); The general equation is obtained by using the equilibrium equation where the stress function can be defined as F and the equations between.

$$a_{\theta\theta}r^2\frac{d^2F}{dr^2} + a_{\theta\theta}r\frac{dF}{dr} - a_{rr}F = -\alpha_\theta r^2\frac{dT}{dr} + \alpha_r Tr - \alpha_\theta Tr \quad (4)$$

T_0 indicates the first temperature value, Tr 'indicates the temperature value of any point in the radial direction. The following equation can be used for the parabolic increasing temperature distribution;

$$T = \frac{T_0}{a^2 - b^2}(a^2 - r^2) \quad (5)$$

The function f from the solution of equations

$$\sigma_r = \frac{F}{r} = C_1 r^{k-1} + C_2 r^{-k-1} + Ar^2 + C \quad (6)$$

$$\sigma_{\theta i} = \frac{dF}{dr} = kC_1 r^{k-1} + kC_2 r^{-k-1} + 3Ar^2 + C \quad (7)$$

The calculations of A and C "λ" and k coefficients are as follows constants can be obtained.

$$A = -\lambda\frac{3(\alpha_\theta - \alpha_r)}{a_{\theta\theta}(9 - k^2)} \quad (8)$$

$$C = \lambda\frac{(\alpha_r - \alpha_\theta)b^2}{a_{\theta\theta}(1 - k^2)} \quad (9)$$

$$\lambda = \frac{T_0}{(b^2 - a^{2)}} \quad (10)$$

$$k^2 = \frac{a_{rr}}{a_{\theta\theta}} \quad (11)$$

$$C_1 = \frac{Aa^{k+3} + Ca^{k+1} - Ab^{k+3} - Cb^{k+1}}{(b^{2k} - a^{2k)}} \quad (12)$$

$$C_2 = -C_1 a^{2k} - Aa^{k+3} - Ca^{k+1} \quad (13)$$

III. THERMAL STRESSES ANALYSİS

In this study; Thermal stresses under parabolic decreasing distributions for two different discs with composite thermoplastic material were investigated. The disk is fixed and its dimensions are taken as a = 15 mm, c = 30 mm (Figure 1). Solutions were obtained by using temperature values of 20 ° C, 40 ° C, 60 ° C-80 ° C-100 ° C. The stress values obtained assuming that the modulus of elasticity remains constant with temperature are presented in graphics and tables. The properties of thermoplastic composite materials are given in Table 1.

Mechanical properties of Thermoplastic Disc						
Disc	**E_θ**	**E_r**	**k**	**α_r**	**α_θ**	**$\upsilon_{\theta r}$**
	6400	190	6.59	$140x10^{-6}$	$9.08x10^{-6}$	0,40

Table.1- Mechanical properties of thermoplastic disc [10]

As can be seen from Table 2, elastic tangential stresses for Discs made of Thermoplastic composite materials occurred as compression stress in the inner parts of the disc and tensile stress in the outer regions. Tangential and radial elastic stresses occurring in the disc are given in Table 2.

Tangential and radial elastic stresses in disc			
Temperature ΔT (°C)	**Surface**	**Thermoplastic Composite Disc**	
		σt (MPa)	**σr (MPa)**
20	(r=15)	-4,623	0
	(r=30)	2,199	0
40	(r=15)	-9,246	0
	(r=30)	4,398	0
60	(r=15)	-13,87	0
	(r=30)	6,597	0
80	(r=15)	-18,493	0
	(r=30)	8,796	0
100	(r=15)	-23,116	0
	(r=30)	10,995	0

Table 2. Tangential and radial elastic stresses in discs

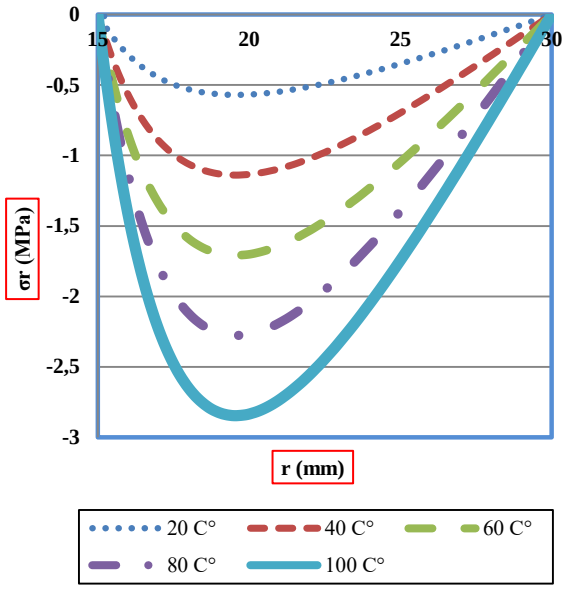

Figure 2. Radial elastic stress occurring in the thermoplastic composite disc

In Figure 3, tangential stresses occurring in the thermoplastic composite disc are graphically given.

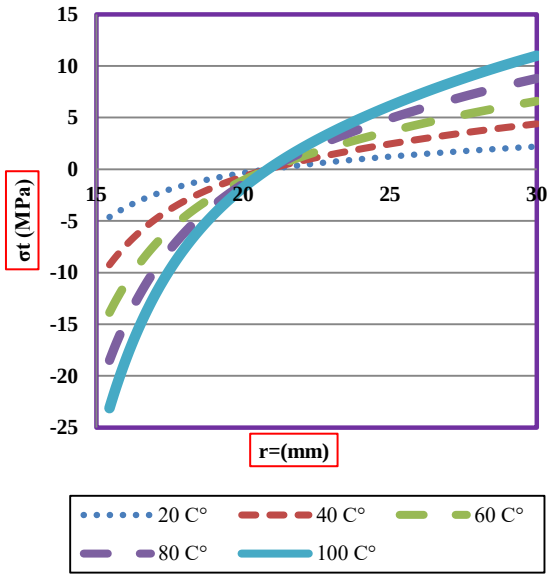

Figure 3. Tangential elastic stress occurring in the thermoplastic composite disc.

Radial stresses are zero on the innermost and outermost surfaces.Figure 2 shows the radial elastic stress occurring in the thermoplastic composite disc. As can be seen from Figure 3, tangential stresses were obtained as compression stress in the inner parts of the disc and tensile stress in the outer regions. The tangential stresses occurring on the inner surface of the disk are higher than the tangential stresses on the outer surface of the disk. It is seen that the tangential stress values increase as the temperature increases. It was observed that the tangential stress value was -4.623MPa on the inner surface for a temperature of 20 ° C, while it was 2.199 on the outer surface, -23.116MPa on the inner surface and 10.995MPa on the outer surface for a temperature of 100 ° C.

IV. RESULTS AND DİSCUSSİON

In this study, elastic stress analysis of a thermoplastic disc at different temperatures is made. It is assumed that the temperature changes as parabolic decreases. It is thought that the temperature does not change with the modulus of elasticity. Analytical method was solved with the help of a computer program. Radial and tangential stress components from the inner surface to the outer surface of the disc were calculated for 20 ° C-40 ° C-60 ° C-80 ° C-100 ° C values.

Radial stress components in the disc are always zero at the innermost and outermost surfaces of the disc. Radial stress is tensile stress in the entire region of the disc. It has been observed that the stress values increase with the increase in temperature. There is tangential stress tensile stress on the inside of the disc and compression stress on the outside. It has been concluded that the results obtained at the end of this study are compatible with the stress analysis performed for thermoplastic composite materials in the literature.

AUTHOR CONTRIBUTIONS

Hüseyin Fırat KAYIRAN is the responsible author of the study and has conducted literature research and other research. The aim of this study about discs is to present the basic information and formulation in a sufficient and summary form, and it is thought that this subject can be integrated with artificial intelligence in the future.

THANK

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