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Research Article

The of V-Belts which is Used for Drive of Casting Pulleys Experimental Investigation of Automatic Cooling

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Abstract

As it is known, V-belts, which are an important element of the automotive industry, are used as a insurance in the protection of the machine as well as in reducing the speed. It is not possible to provide this insurance situation with gear or (chain) gears, which are also used in reduction of speed. Therefore, it has an important place in the automotive industry. In this study, cast pulleys were designed and manufactured, 8-16-32 straight and curved vanes were attached to the pulleys, and the effect of V-belts and pulleys on cooling was investigated. It was investigated how these vane types and numbers will affect the temperature compared to the normal pulley when the determined total number of revolutions (4000-8000-16000-32000-64000 revolution) is reached. Belt and pulley temperatures were measured with an infrared laser thermometer. In the study, it was seen that the type and number of vanes that gave the best results compared to the normal pulley were 32 forward vane pulleys. It was analyzed using SPSS T-Test analysis program. Looking at the analysis results, it was seen that the standard deviation amounts were at an acceptable value. SPSS correlation coefficient test analysis showed that 32 forward vane pulleys decreased the temperature the most compared to the normal pulley. We think that the results obtained as a result of these studies will be an important contribution to the automotive industry and machines using V-belts.

Keywords: V-Belt pulley mechanism, automatic cooling of v-belts, straight vanes, forward vanes

Döküm Kasnakların Tahrikinde Kullanılan V-Kayışlarının Otomatik Soğutulmasının Deneysel Olarak Araştırılması

Öz

Bilindiği gibi otomotiv sanayisinin önemli bir elemanı olan V-kayışları, devir düşürmede kullanıldığı gibi, makinenin korunmasında da bir sigorta görevi görmektedir. Bu sigorta durumunun, yine devir düşürmede kullanılan dişli veya (zincir) dişliler ile sağlanması mümkün değildir. Bu yüzden otomotiv sanayisinde önemli bir yer tutmaktadır. Bu araştırma V-kayışların ömrünü etkileyen önemli faktörlerden biri olan sıcaklığı en aza indirmek için, kasnaklar üzerine 8-16-32 adetlerde düz ve eğik kanatlar yerleştirildi. Takılan bu kanat tiplerinin ve sayılarının, belirlenen toplam devir sayılarına (4000-8000-16000-32000-64000 devir) ulaşıldığında kanatsız kasnağa göre sıcaklığı nasıl etkileyeceği araştırıldı. Kayış ve kasnak sıcaklıkları infrared lazer termometre ile ölçüldü. Yapılan çalışmada kanatsız kasnağa göre en iyi sonuç veren kanat tipinin ve sayısının eğik 32 kanatlı kasnak olduğu görüldü. SPSS T-Test analiz programı kullanılarak incelendi. Analiz sonuçlarına bakıldığında standart sapma miktarlarının kabul edilebilir bir değerde oldukları görüldü. SPSS kolerasyon katsayı testi analizi 32 eğik kanatlı kasnağın sıcaklığı kanatsız kasnağa göre en fazla düşürdüğünü gösterdi. Bu çalışmaların sonucunda elde edilen sonuçların otomotiv sanayisi ve V-kayışların kullanıldığı makineler için önemli bir katkısı olacağını düşünmekteyiz.

Anahtar Kelimeler: V-Kayış kasnak mekanizması, v-kayışların otomatik soğutulması düz kanatlar, eğik kanatlar

1. Introduction

Belts are versatile and affordable machine elements that transmit power to the unit with multiple power requirements, but also act as shock absorbers, speed reducers and overload regulators. To keep the belt life high, it must be operated within certain stress limits and in environments and temperatures appropriate for the material life. There are different types of belts such as flat belts, V belts, round belts and gear V belts. V-belt mechanisms among themselves; classical V-belts, metric V-belts, narrow V-belts, fractional horsepower V-belts, joined V-belts. Factors affecting the efficiency of V-Belt pulley mechanisms are divided into two groups. The first group is the mechanical and constructional structure of the system, the second group is the effect of temperature, humidity and environmental conditions involving various particles. The V-belt is an important power train that transmits power through friction. During the working process, structure aging, surface hardening, brittle fracture, and other features occur on the V-belt and this significantly influences service life of the belt and stability of the entire machine because of increase in temperature. Hence, research in the temperature field of V-belt is of great importance to increase its service life Krawiec et al. (2020) and Wurm et al (2016). Firbank (1970) determined that tensile stresses in the belt are a powerful factor determining the behavior of the mechanism and in this event is in contrast to the traditional creep phenomenon based on belt elongation. Reynolds (1874) showed that torque transmissions between pulleys cause loss of speed due to elastic slippage of the belt. Gerbert (1975) stated in his studies that for a certain pre-stress in the slip curves corresponding to the power he obtained experimentally, the slip at low power values increased in direct proportion to the transmitted power. Oliver et al. (1976) worked on a new life expectancy for belt-pulley mechanisms in their study and developed a formula for the effect of belt tension scale on fatigue in V-belts. Dolan et al. (1985) achieved the highest tension ratio by increasing the angle between the rotating and rotated pulley in their work. In their studies, they explained that the mechanism should be at the proper tension in order to achieve the highest efficiency in the belt and pulley mechanisms. Peeken et al. (1989) conducted a study on the working conditions and power losses in statically loaded belt-pulley mechanisms in their work and examined the heat factor superficially in these studies. Cengiz and Uçar (2004) stated that temperature and humidity in V-Belt mechanisms have some disadvantages besides the great advantages of V-belt pulley mechanisms. The first is that the belt is exposed to slipping on the pulley. According to the research conducted by Maamuri (2003); Exposure of the belt to high temperatures and rays causes deformations in the belt structure, leading to early wear in the belt's service life.

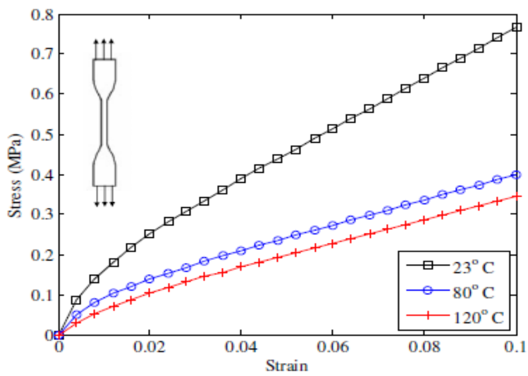
2. Material and Method

In order to test the cooling of cast pulleys and belts with straight and forward vanes, first the project was prepared and then the experiment environment was prepared for this project. The cast pulleys were produced on a lathe machine. The vanes were obtained from 0.5 mm galvanized sheet. The electric motor was choosed 220 volts. The electrical power of the motor is 0.25 kW, its power coefficient Cosφ is 0.72, it draws 1.73 torque and 0.81 amperes of current. The speed of the motor shaft is 1380 rpm. Here, a rotation measuring device, ENDA SİSEL A.Ş. ECH 4400 brand counter was placed and controlled at 15 Hz frequency with Siemens Sinamics V20 0.25 kw speed control device. 17x1400TS148 standard V-belt (continental) was used. A weight of 25 kg was applied for the strain strength. In addition, the duration of each experiment was followed. In the experiment set, cast pulleys with straight and forward vanes placed in their centers were prepared and the experiment was carried out. Experiment; It was made at 4000, 8000, 16000, 32000 and 64000 revolutions, with 8-16-32 straight and forward vanes and normal pulleys, the conditions in different parameters were measured. Since a fixed point on the upper surface of the v-belt and the inner surface of the v groove in the pulley will increase the margin of error, it was measured from several different regions giving the high temperature. Temperature measurements were obtained with an infrared laser thermometer. The experiments were repeated three times. Test average temperatures were taken. The experimental results were compared. It was analyzed in the SPSS program. The most efficient vane type and number were determined in the results.

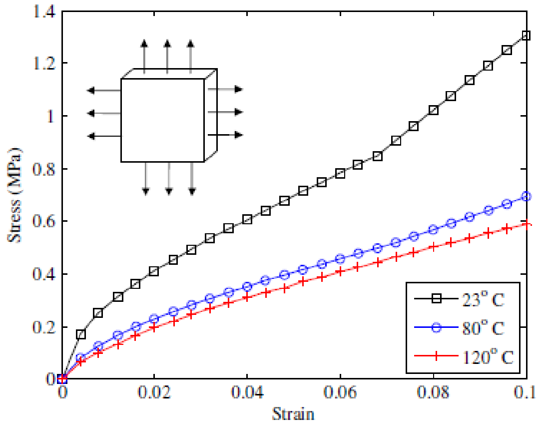
3. Results and Discussion

Song et al. (2005) performed the thermal–mechanical finite element analysis of a two pulley V ribbed belt drive system. The analysis took into account the thermal degradations and thermal expansions of belt rubber compounds. The temperature effects on stresses, strains, and belt-pulley contact slip rates were studied in detail. The temperature effects on stresses, strains, and belt-pulley contact slip rates were studied in detail. Legorju-jago and Bathias (2002) studied fatigue crack growth and damage mechanisms in natural and synthetic rubbers under varying thermal and environmental conditions.

Sundararaman et al. (2009) investigated the effect of temperature on fatigue life of V-ribbed serpentine belts. The fatigue life estimates obtained from the analysis show that the life of the belt is significantly affected while operating at elevated temperatures. Figure 1 shows the graphs of variation of stresses with respect to temperature.



Temperature dependent stress–strain data – uniaxial extension.



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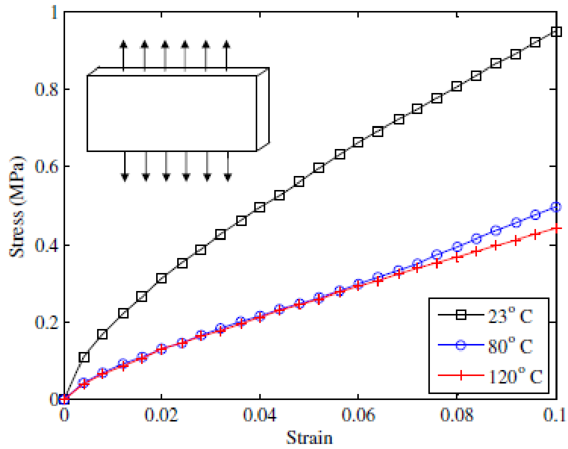
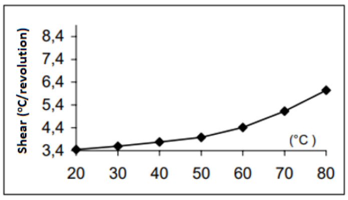


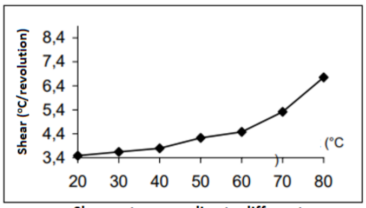
Temperature dependent stress–strain data – planar extension.

Figure 1. Effect of temperature on stress-strain (Sundararaman et al. 2009)

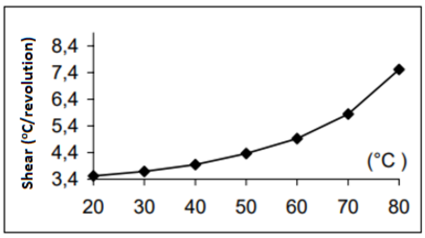
It has been shown by Uçar and Cengiz (2004) that temperature and relative humidity have an effect on slipping. However, it turned out that temperature is more effective than relative humidity. Uçar and Cengiz (2004) showed that shear stress increases with increasing temperature.



Shear rates according to different temperatures at 35% humidity



Shear rates according to different temperatures at 55% humidity



Shear rates according to different temperatures at 85% humidity

Figure 2. Effect of humidity and temperature parameters on shear (Uçar and Cengiz 2004)

As can be seen in Table 2, temperature and moisture have a greater effect on shear after 40 °C. Stress, on the other hand, is more effective up to 80 °C and less effective between 80 °C and 120 °C.

Cengiz and Uçar (2007) studied the effects of temperature and humidity parameters on the efficiency of V-belt pulley mechanisms. It was observed that the increase in temperature and humidity caused the friction coefficient to decrease and thus the slip to increase. The amount of slip increases considerably in high humidity conditions and environmental conditions between 60ºC and 80ºC.

Results of experiments;

Looking at the test results (Figure 8), the temperature difference of 32 straight vane pulleys at the end of 4000 revolutions is 0.86 ºC, after 8000 revolutions 1.44 ºC, after 16000 revolutions 2.23ºC and after 32000 revolutions 2.5 ºC, after 64000 revolutions a decrease of 2.97 ºC was obtained. According to these results, it was seen that the V-belt decreased the temperature by 10.39% in 32 straight vane pulleys.

Looking at the test results (Figure 9), the temperature difference of 32 forward vane pulleys at the end of 4000 revolutions is 0.96 ºC, after 8000 revolutions 1.54 ºC, after 16000 revolutions 2 ºC and after 32000 revolutions 2.8 ºC, after 64000 revolutions a decrease of 3.34 ºC was obtained. According to these results, it was seen that the V-belt temperature was reduced by 11.67% in 32 forward vane pulleys. It has been observed that V-belt temperature gives 1.28% better result than straight vane pulley.

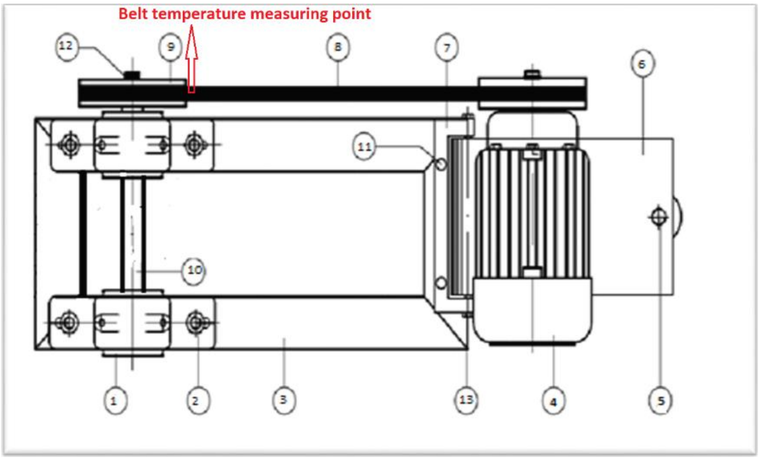
When the test results are examined (Figure 8), in straight vanes type pulley temperatures, at the end of 4000 revolutions is 0.84 ºC, after 8000 revolutions 1.17 ºC, after 16000 revolutions 2.24 ºC and after 32000 revolutions 3.27 ºC, after 64000 revolutions a decrease of 2.93 ºC was obtained. According to these results, it was seen that after 64000 revolutions, it reduced the temperature by 10.93% in 32 straight vane pulley.

When the test results are examined (Figure 9.), in forward vanes type pulley temperatures, at the end of 4000 revolutions is 0.77 ºC, after 8000 revolutions 1.47 ºC, after 16000 revolutions 2.87 ºC and after 32000 revolutions 3.6 oC, after 64000 revolutions a decrease of 4.43 oC was obtained. According to these results, it was seen that after 64000 revolutions, it reduced the temperature by 16.52 % in 32 forward vane pulley.

When the results of the experiments were examined (Table 1), it was seen that straight vane (32 vane pulley) pulleys cooled the V-belts 10.39% better than the normal pulley, and the forward vane (32 vane) pulleys cooled the V-belts 11.67% better than the normal pulley. Considering the measured pulley temperatures, it was seen that straight vane (32 vanes) pulleys cooled the pulley 10.93% better than the normal pulley, forward vane (32 vanes) pulley cooled the pulley 16.52% better than the normal pulley.

SPSS Analysis of correlation coefficient;

The temperature changes in the belt according to the number of revolutions in the SPSS program are shown in the Table 2 with the correlation coefficient analysis. Looking at the result table, it is seen that there are 32 bent-winged pulleys with the least associated pulley type with the bladeless pulley. With a correlation coefficient of 0.801, it was determined that the wing type that reduced the temperature the most was 32 curved wing pulleys. 32 flat bladed pulleys followed with 0.853. It is seen that the wing type that is the most related, that is, there is not much difference between their temperatures and reduces the temperature the least, is 8 straight and curved winged pulleys with a correlation coefficient of 0.942.



1) Ball bearing	5) Weight kit	9) V-Pulley
2) Bolt and nut	6) Motor pad	10) Shaft
3) Pad	7) Bearing	11) Bolt M8x 1,25
4) Elektric motor	8) V-Belt	12) Piston ring

Figure 3. Experiment setup

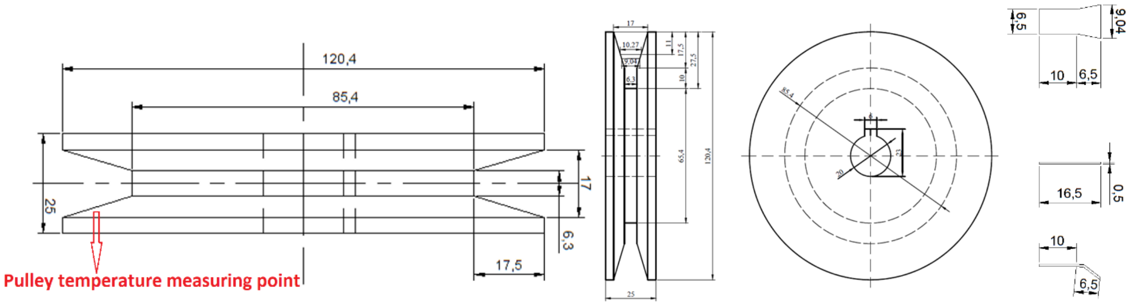
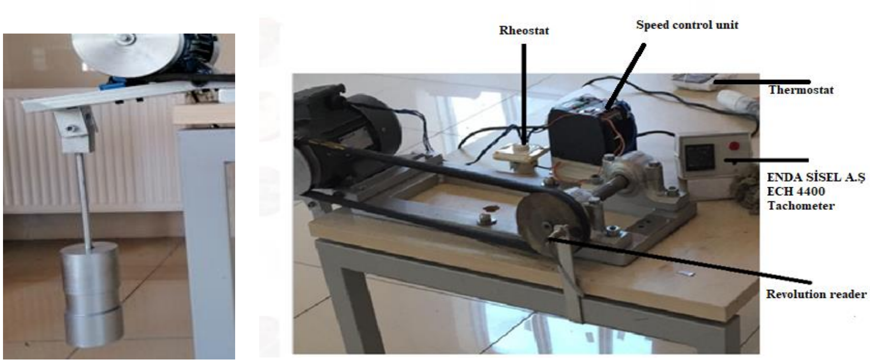


Figure 4. Pulley and vanes dimensions

a) b) c)



d) e)

Figure 5. a) Forward vane pulley, b) Normal pulley, c) Straight vane pulley, d) Experiment setup, e) Stretch weight system

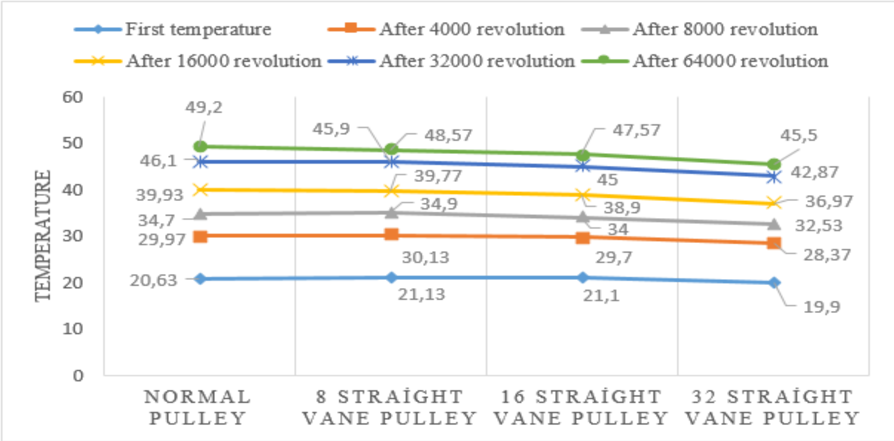


Figure 6. V-Belt temperature at straight vanes pulley

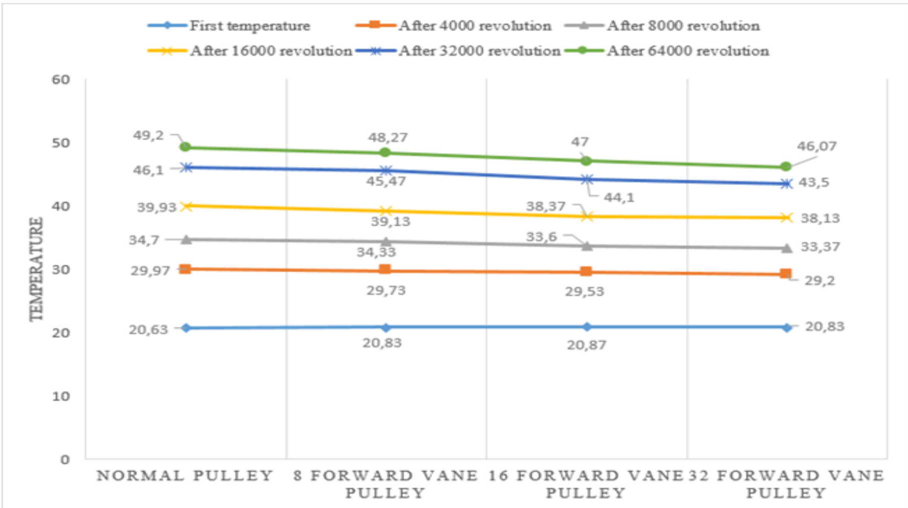


Figure 7. V-Belt temperature at forward vanes pulley

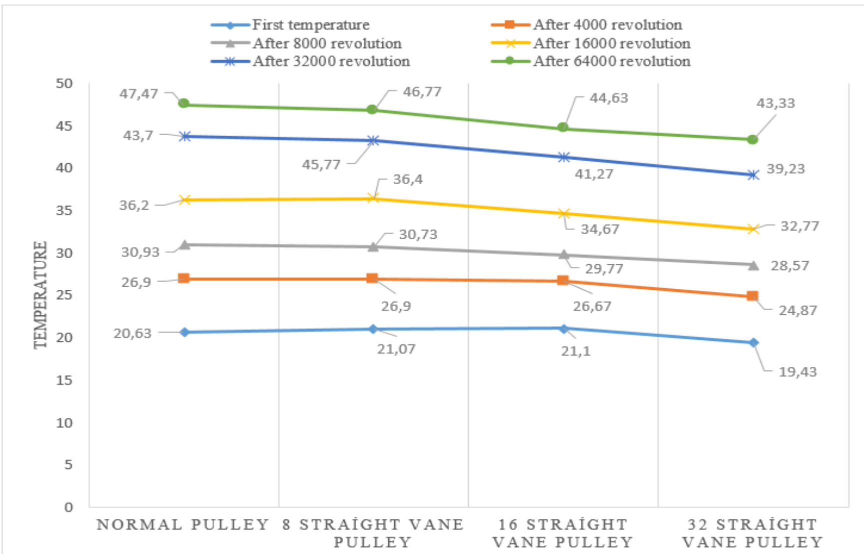


Figure 8. Pulleys temperature at straight vanes

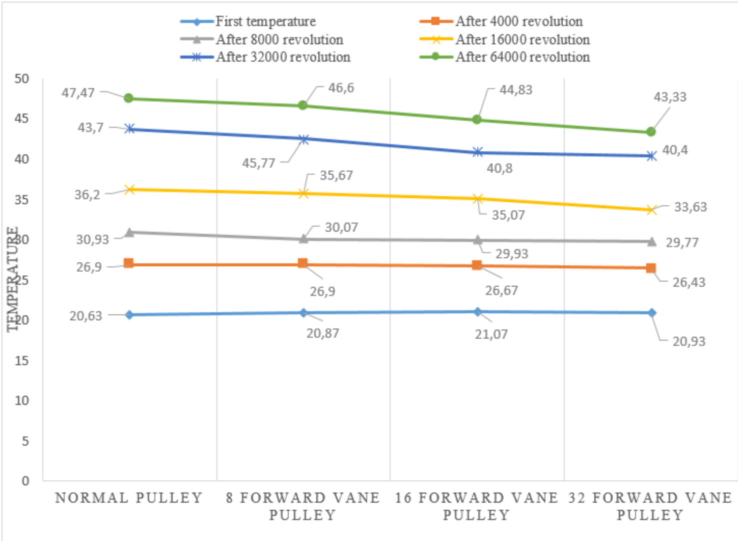


Figure 9. Pulleys temperature at forward vanes

Table 1. *Cooling percentages of straight and forward vane pulleys*

Total Number of Revolutions		**Straight vane numbers**			**Forward vane numbers**		
		8	16	32	8	16	32
After 4000 Revolutions	Belt	% 3.57	% 7.86	% 9.29	% 4.64	% 7.14	% 10.36
	Pulley	% 6.92	% 11.17	%13.30	% 3.72	% 10.64	% 12.23
After 8000 Revolutions	Belt	% 2.13	% 8.29	% 10.19	% 4.02	% 9.48	% 10.9
	Pulley	% 6.15	% 15.86	% 11.33	% 10.68	% 13.92	% 14.24
After 16000 Revolutions	Belt	% 3.45	% 7.77	% 11.57	% 5.18	% 9.33	% 10.36
	Pulley	% 1.5	% 12.85	% 14.35	% 4.93	% 10.06	% 18.42
After 32000 Revolutions	Belt	% 2.75	% 6.15	% 9.82	% 3.27	% 8.77	% 10.99
	Pulley	% 3.61	% 12.57	% 14.16	% 6.21	% 14.45	% 15.61
After 64000 Revolutions	Belt	% 3.97	% 7.35	% 10.39	% 3.97	% 8.52	% 11.67
	Pulley	% 4.22	% 12.30	% 10.93	% 4.10	% 11.43	%16.52

Table 2. *The correlation test of belt temperatures*

Correlations

Control Variables			8 Straight vane pulley	8 Forward vane pulley	16 Straight vane pulley	16 Forward vane pulley	32 Straight vane pulley	32 Forward vane pulley	Normal Pulley
Number of Revolutions	8 Straight vane pulley	Correlation	1.000	1.000	0.947	0.971	0.955	0.804	0.942
		Significance (2-tailed)	-	0.000	0.000	0.000	0.000	0.000	0.000
		df	0	15	15	15	15	15	15
	8 Forward vane pulley	Correlation	1.000	1.000	0.947	0.971	0.955	0.804	0.942
		Significance (2-tailed)	0.000	-	0.000	0.000	0.000	0.000	0.000
		df	15	0	15	15	15	15	15
		Correlation	0.947	0.947	1.000	0.985	0.906	0.840	0.856

16 Straight vane pulley	Significance (2-tailed)	0.000	0.000	-	0.000	0.000	0.000	0.000
	df	15	15	0	15	15	15	15
16 Forward vane pulley	Correlation	0.971	0.971	0.985	1.000	0.922	0.856	0.896
	Significance (2-tailed)	0.000	0.000	0.000	-	0.000	0.000	0.000
	df	15	15	15	0	15	15	15
32 Straight vane pulley	Correlation	0.955	0.955	0.906	0.922	1.000	0.650	0.853
	Significance (2-tailed)	0.000	0.000	0.000	0.000	-	0.005	0.000
	df	15	15	15	15	0	15	15
32 Forward vane pulley	Correlation	0.804	0.804	0.840	0.856	0.650	1.000	0.801
	Significance (2-tailed)	0.000	0.000	0.000	0.000	0.005	-	0.000
	df	15	15	15	15	15	0	15
Normal pulley	Correlation	0.942	0.942	0.856	0.896	0.853	0.801	1.000
	Significance (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	-
	df	15	15	15	15	15	15	0

SPSS T-Test analysis;

V-belt temperatures were compared with SPSS T-Test analysis (95% confidence). It was seen that the standard deviation values were in acceptable values. Sig 2-tailed values were used to decide whether the obtained results were meaningful results. The values taken as equal variances gave the following result;

When the results of 4000-8000 revolutions are compared, a significant temperature drop started to occur. The highest value was seen with 0.003 at 32 straight vane pulleys. Values are close to each other and meaningful since it is not higher than the confidence interval. Cooling amounts are not of high value.

When the results of 8000-16000 revolutions were compared, a significant temperature drop occurred. The highest value was seen with 0.014 at 32 forward vane pulley. It has moved slightly from the confidence interval.

When the 16000-32000 revolutions results were compared, a significant temperature drop occurred. Sig 2-tailed values were checked. The highest value was seen with 0.006 at 32 forward vane pulleys. It is a meaningful result, as a value close to the confidence interval is seen.

When the 32000 and 64000 revolutions results were compared, it was seen that the highest value was 0.007. Considering the results completely, it is seen that the temperature difference values gradually decrease as the number of vanes increases. In addition, we can say that forward vanes types cool better with a little difference compared to straight vane types.

4. Conclusions and Recommendations

In this research, the V-belts; It has been observed that the temperature of the cast material can be automatically reduced in flat and inclined blade pulleys. The highest efficiency occurred at forward wings. As the vanes used dissipate the heat especially in the pulleys, the belt temperature also decreased. Shear stress also decreases due to the decrease in temperature. Belt life is also extended as temperature affects belt life. Also, Sundararaman et al. (2009) and Uçar and Cengiz (2004) claim the effect of temperature on stress and shear. In our experiment, the belt temperature of 50 degrees was reduced by about 4 degrees. Efficiency will increase if higher revs are reached and blades are attached to the drive pulley. Even if the efficiency is given a similar percentage value, it will reduce the belt temperature by approximately 8.5 degrees. this degree will provide a significant increase in tensile strength and a decrease in shear. This will make a significant contribution to belt life.

Suggestions;

1. Experiments should be made by attaching fins to the drive pulley. It will greatly increase the yield.

2. It is recommended to repeat the experiments at higher rpm (128000-256000-512000 etc.) by changing and improving the wing profiles.

3. The temperature change should be observed by placing a load on the experimental set.

5. Acknowledge

The Author report no conflict of interest relevant to this article. The author declares that this study complies with research and publication ethics.

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