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İtfaiye Hortumunun Alternatif Yöntemlerle Kurutulması ve Uygun Kurutucu Seçimi

Drying Of Fire Hose With Alternative Methods And Selection Of Optimal Dryer

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Öz

Bu çalışmada amaç, hortumların yıpranmasının geciktirilmesi ve içlerindeki suyun kurutularak, hortumların ağırlığını azaltmak ve bu sayede olay esnasında en hızlı kullanımın sağlanması için belirlenmiş tekniklerden olan serme toplama yöntemlerine göre hortumların depolanabilmesidir. Mevcut durumda kurutma işlemi için kullanılan doğal kurutma özellikle hava şartlarından çabuk etkilendiği ve yavaş olduğu için alternatif yöntemlere ihtiyaç duyulmaktadır. Bu çalışma ile enerjiden ve zamandan tasarruf ederek verimsiz çalışma saatlerinde de azalmaya gidilmesi hedeflenmiştir. Kurutma öncesi gerçek koşulları dikkate alarak 30, 60 ve 90 dakika boyunca yangın hortumuna su emmesi uygulanmıştır. Denemeler mikrodalga kurutucuda 120 W, 350 W ve 460 W güç değerlerinde ve bantlı tip tünel kurutucularda ise 50 ^{0}C, 60 ^{0}C ve 70 ^{0}C sıcaklık değerlerinde gerçekleştirilmiştir. Elde edilen sonuçlara göre nem analizi, mukavemet analizi, kuruma hızı, enerji tüketim, difüzyon katsayısı ve aktivasyon enerjisi hesaplamaları yapılmıştır. En az enerji tüketimi ve en kısa sürede kurutma 460 W güç değerinde mikrodalga kurutucu ile yapılan deneyde görülmüştür. Deneylere ait tüm sonuçlar değerlendirildiğinde iki tip kurutmanın da mekanizmaları farklı olduğu için farklı kuruma süreleri ile farklı enerji tüketimleri gözlendiği ancak genel sonuç olarak mikrodalga kurutmanın bantlı tip kurutmaya göre daha verimli gerçekleştiği görülmüştür.

Anahtar Kelimeler: *Yangın Hortumu, Mikrodalga Kurutucu, Konveyör Kurutucu, Difüzyon Katsayısı, Aktivasyon Enerjisi*

Abstract

The aim here is to delay the wearing of hoses and in order to store them and use them in the most efficient way that laying-rallying hoses are dried by decreasing their weight. With this study the objective is decreasing inefficient working hours while saving energy and time. Considering real world conditions, drying hoses are subjected to water absorption for 30, 60 and 90 minutes. Trials are executed in a microwave dryer at 120 W, 350 W and 460 W settings and in a conveyor dryer at temperatures 50 °C, 60 °C and 70 °C. Moisture analysis, strength analysis, drying rate, energy consumption, diffusion coefficient and activation energy calculations were made according to the results obtained. It has been observed that minimum consumption of energy and fastest drying occurred with the power level of 460 W in the microwave dryer. When all of the results are evaluated according to trials, it has been noted that since the mechanisms behind the two dryer systems are not similar and drying times and consumption of energies are different, the microwave dryer is more efficient than the conveyor dryer type.

Keywords: *Firefighting Hose, Microwave Dryer, Conveyor Dryer, Diffusion Coefficient, Activation Energy.*

1. Introduction

Hoses are being used in firefighting stations for pumping or draining water in order to respond to fires. There are many different types of hoses being manufactured that are intended for different types of use cases [1].

Hoses that are used in responding to a fire play a part in putting out the fire by transporting the pressurized water from fire fighting vehicles or hydrants. In the production of hoses, attention is paid to the quality of the materials they are manufactured, to be resistant to at least three atmospheres more pressure than the average pump pressure of the vehicle used, to not harden and lose its protective softness when wet, as well as to be resistant to rot and mold [2].

There are different types of hoses in the market. “A type” hoses are being used in flooding conditions or any other condition that requires water to be drained. “A type” hoses are 110 mm in diameter and are 1.6-3 m in length. “B type” hoses are manufactured to have a diameter of 75 mm and a length of 25 m. These types of hoses are used in firefighting and for water draining. Hoses that are 42-52 mm in diameter and 20 m in length are frequently used for firefighting and they are the “C type” hoses. There are no structural differences between B and C types except diameter and length. “D type” hoses are 25-28 mm in diameter and 40-60 m in length and are generally found in firefighting vehicles in a loop. They are used with nozzles for fast intervention [3, 4].

In this study, B and C type hoses that are being used especially for firefighting in fire stations are studied. These hoses are cleaned with soap and water after every use. They are readied for their next use and they must be dried before storing. Presently, the hoses are dried by putting them outside the fire station in summer months, and in winter the hoses are dried by hanging them on reels inside the fire station [5].

Disadvantages of the present condition; In winters, drying times are very long, and hoses cannot be dried at the same time because drying poles cannot hold multiple hoses. This system is being used because of its lower costs and drying with natural ways do not harm structure of hoses. Cleaned hoses are dried in natural conditions. In order to not harm the structure, hoses cannot be dried under the extreme sun rays and they should not contact hot surfaces [3].

Nowadays, hose drying machines that are especially used in foreign countries are very costly and take too much space in fire stations. Machines that are being used for laying-rallying and drying process in different regions are examined in this study. The design of these machines are generally too big, and they also have a high cost, thus they are not preferred [6].

In this study, alternative drying methods are studied for hose drying. This way, time and energy can be saved, and the aim is to decrease inefficient working hours. Therefore, microwave and belt drying system are preferred. Drying procedure has been executed using microwave and conveyor dryers to firefighting hoses that have been subjected to water absorption for 30, 60 and 90 minutes. Energy consumption analysis and structure analysis has been evaluated for deciding the appropriate drying system. Also, drying time, diffusion coefficient and activation energy has been determined.

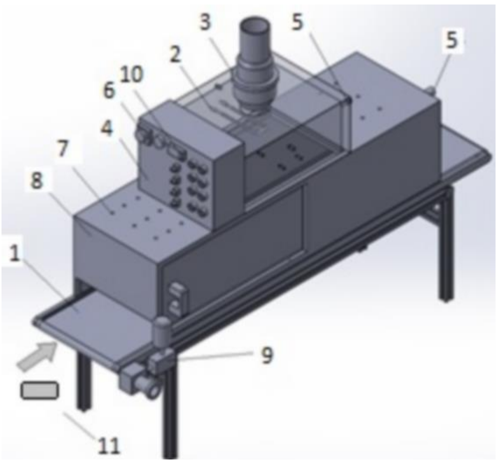
2. Materials and Methods

2.1 Firefighting hose and drying system

B type firefighting hoses (Figure 1.), are standard issue in firefighting stations, and outer material of hoses are fabric, and the inner material is rubber. In order to attach the rubber and the fabric together, a special glue is used. Rubber hoses can work between 10 and 40 bars of pressure. In this study, samples of hoses that have never been used before are used.

Figure 1. Fire hose

In this study, a conveyor dryer and a microwave dryer are used as shown in Figure 2 dimensions of conveyor dryer are 172×50×40 cm and its power rating is 2000 W. In this method, item is moved on the belt and it is subjected to a constant hot air flow. With this method, homogeneous drying of the fire hose is aimed. Microwave dryer (Arcelik MD554, Turkey) with maximum a maximum power of 1200 W at 2450 MHz was used for drying (Figure 2b).



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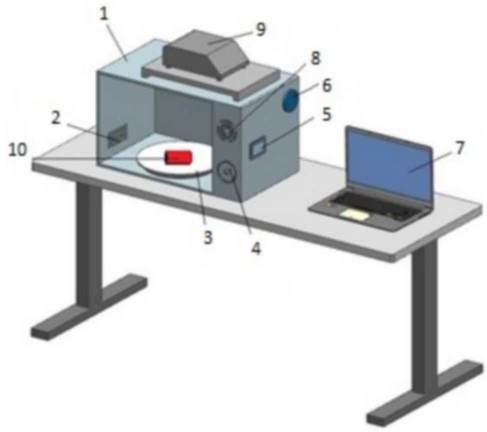


(b)

Figure 2. (a) Conveyor dryer (1: Belt, 2: Heating section, 3: Fan, 4: Main control panel, 5: Temperature probe, 6: Belt speed control, 7: Ventilation holes, 8: Drying room, 9: Electrical motor, 10: Energy counter, 11: Firehose (b) Microwave Dryer (1: Drying Room, 2: Moisture Outlet, 3: Plate, 4:Timer, 5: Electromagnetic Wave Generator, 6: Cooler Fan; 7: Data Recorder, 8: Electrical energy (on/off), 9: Balance, 10: Firehose)

2.2 Method

In this study, hoses that are sold as 20 m in length are used, and they are cut to be 20 cm long pieces [7]. Hoses are placed on the turntable. Before the experiments begin, nozzles on both ends have been removed and only the hose itself is used. Initial weights of hoses are measured via a precision scale (Precisa XB 620 M, Switzerland) that has a precision of 0.001 g.

Samples that are going to be used in the tests for determining the initial moisture level, are dried in a drying oven (MINGDA KIT-35A, China) for 24 hours at 105 °C. Moisture changes are calculated considering the product weights. The changes in the weights of the samples during the drying process have been noted down in different intervals. The weights have been measured in 15 minute periods for the conveyor dryer and 0.5, 1 and 3 minutes for the microwave dryer.

During the tests, momentary moisture and dimensionless moisture ratios have been calculated as shown in equations 1-3 [8]. m_e value is neglected because it is small compared to m and m_o [9, 10].

$$m_y = \frac{M_y - M_k}{M_y} \quad (1)$$

$$m_k = \frac{M_y - M_k}{M_k} \quad (2)$$

$$m_R = \frac{m - m_e}{m_o - m_e} \quad (3)$$

In these equations; m_y: moisture content based on wet, m_k: moisture content based on dry, M_k: dry weight of product (g), M_y: wet weight of product (g), m_R: dimensionless moisture ratio, m: moisture content of product at any given time ($g_{water}/g_{drymatter}$), m_e: balanced moisture content ($g_{water}/g_{drymatter}$), m_o: initial moisture content ($g_{water}/g_{drymatter}$).

2.3 Water bath

For this study, considering the use cases of the hoses, samples have been exposed to water different amount of times (30, 60 and 90 minutes). Samples that are used in the experiments are soaked in deep containers that are 17 cm in diameter and 28 cm in length that are filled water, after which wet weights of samples have been measured via a precise scale.

2.4 Conveyor dryer

Drying process is started for all the drying temperatures (50 °C, 60°C and 70 °C) after putting the samples that have been soaked in water in a conveyor dryer with a speed of 0.117 m/min. Hose samples are dried with hot air that blew at a rate of 1 m/s in to the tunnel. Sample item (fire hose) stayed in the drying tunnel for 15 minutes. Weight loss and energy consumption values have been measured every 15 minutes with thermal photographs throughout the experiment. During this experiment, ambient temperature is measured using temperature probes (Testo 650, Germany) that have been placed in different points of belt. Thermometers have been placed in the entry, middle and exit points of the tunnel and temperature fluctuations have been monitored. Drying process is ended when the desired moisture level is achieved.

2.5 Microwave dryer

Hose sample that is soaked in water beforehand is placed on the platform that is inside the microwave dryer. Microwave drying process is run at 250 Hz and power settings of 120 W, 350 W and 460 W. Measurement periods change with the powers implemented in the microwave dryer. When the power is set to 120 W, weight and energy measurements are taken at 3 minute intervals, when 350 W at 1 minute intervals and when 460 W, at 0.5 minute intervals. For the monitoring of the energy consumption of microwave dryer and conveyor dryer, 0.01 kW precision digital electric counter (Polaxtor PLX-15366, China) has been used.

2.6 Strength analysis

Effects of water absorption and drying on the strength of samples has been investigated with in study. Since laceration or rupture of hoses can affect the transportation of water, this is not an ideal situation. For this reason, samples that finished their drying process have been applied a tensile test to determine the elongation values and yield strengths. Hose samples are cut in latitudinal and longitudinal axes so tensile strength is determined in two ways. For the tensile test, T Universal Test Equipment (Tinius Olsen H10KS, England) is used. Tensile test for rubber materials, ASTM D 412, DIN 53 504 and ISO 37 standards can be used [11]. When ASTM D 412 standard is examined, samples must be cut according to ASTM D412-D before tensile test (Figure 3).

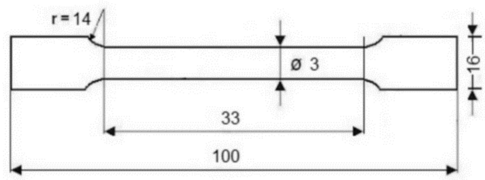


Figure 3. Sample dimensions for tensile test

Sample of hoses, as shown in figure 3, are acquired via latitudinal and longitudinal cuts inside the hose. This way, the relation between tension test data and strain can be examined in two axes [11]. Tensile strength of the samples that were tested along 2 axes are calculated using equation 4. Stress is calculated by dividing tensile force by cross sectional area [12].

$$\sigma = \frac{F}{A} \tag{4}$$

σ : Tensile Stress, F: Tensile Force and A: Cross sectional area of sample.

The sample fire hoses were tested with the help of a tension equipment that pulled the hoses at 25 mm/min. The acquired results are compared with non-dried hoses and the changes between the results are evaluated.

2.7 Diffusion coefficient and activation energy

Evaluation of diffusion coefficient and activation energy depends on Fick's second law in the process of thin film drying [13]. In the case of symmetric boundary conditions, neglecting of material shrinkage and the assumption of the water being distributed in the material homogeneously, the moisture ratio can be determined as shown in Eq. 5 [14]. In equation 6, the activation energy is calculated from slope of 1/(T) and ln [15]. Temperature cannot be measured directly in microwave drying. Activation energy can be calculated by changing the Arrhenius equation. Activation energy is related to diffusion coefficient and the ratio of microwave power and weight of the sample item is shown in equation 7 [16].

$$m_R = \frac{8}{\pi^2} \exp\left(-\frac{\pi^2 D_{eff}\, t}{4L^2}\right) \tag{5}$$

$$D_{eff} = D_0 \exp\left(-\frac{E_a}{R(T+273,15)}\right) \tag{6}$$

$$D_{eff} = D_o . e^{-E.M/P} \tag{7}$$

m_R: Moisture level, D_{eff}: effective diffusion coefficient (m^2/s), L: sample half thickness (m), t: drying time (s), D_0 : equivalent constant at a infinite temperature (m^2/s), E_a: activation energy (J/kg mol K), R: gas constant (J/kg mol K) , T: drying temperature (K), M: sample weight (g) and P: microwave power (W).

2.8 Drying rate

Drying rate as shown in equation 9 is defined as moisture level change over time [17].

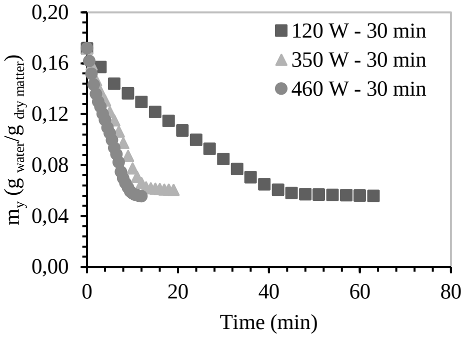
$$D_R = \frac{m_{t+\Delta t} - m_t}{\Delta t} \tag{8}$$

D_R : drying rate ($g_{water}/g_{drymatter}^{-1} min^{-1}$), m_t : moisture level based on dry at given time t, $m_{t+\Delta t}$: moisture level based on dry at given time Δt.

3. Results and discussions

3.1 Moisture change analysis

Moisture change obtained from the results for each parameter in microwave drying is given in Figure 4, conveyor drying results is given in Figure 5. After a 30-minute water bath microwave drying has been conducted at 120 W, 350 W and 460 W and it took the hose to dry 63, 19, and 12 minutes respectively. Similarly, microwave drying after a 60-minute water bath has been carried out at 60, 14 and 11 minutes respectively, and after a 90-minute water bath drying occurred at 54, 13 and 10.5 minutes respectively. The final moisture levels fluctuated between 0.0569-0.0635 $g_{water}/g_{drymatter}$. When the waiting time of the hose in the water bath is increased, the drying time decreases. The reason for this is that there is a higher amount of water to absorb microwave energy. This increases the amount of heat applied to the hose. The drying time decreased with the increase in the applied microwave power. Conveyor drying has been conducted after 30 minutes of water bath at 50 ^{0}C, 60 ^{0}C and 70 ^{0}C for 240, 195 and 180 minutes, respectively. Likewise, conveyor drying has been carried out after 60 minutes of water bath for 225, 180 and 105 minutes and for 90 minutes of water bath for 180, 165 and 90 minutes, respectively. In conveyor drying, the final moisture levels fluctuated between 0.0553-0.0648 $g_{water}/g_{drymatter}$. Drying time decreased with the increase of water bath time as was seen in microwave drying. It has been observed that the water evaporates faster from the hose surface. Drying time decreased with the increase in drying temperature.



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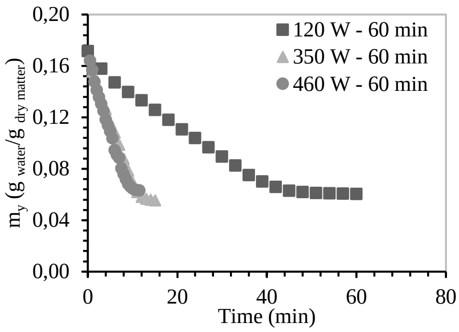

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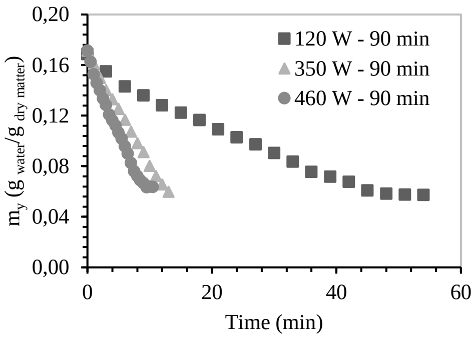

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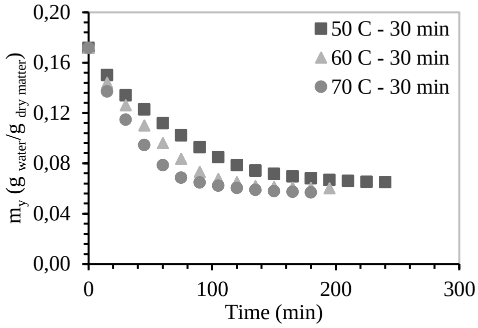
Figure 4. Moisture change for sample that bath times such as a) 30 minutes b) 60 minutes c) 90 minutes for different powers



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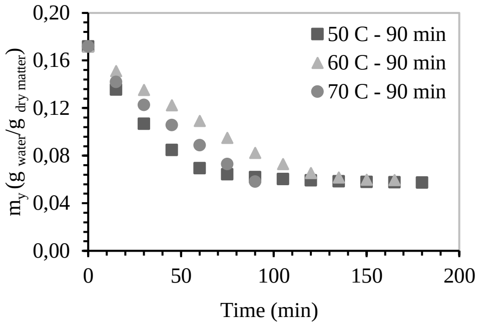

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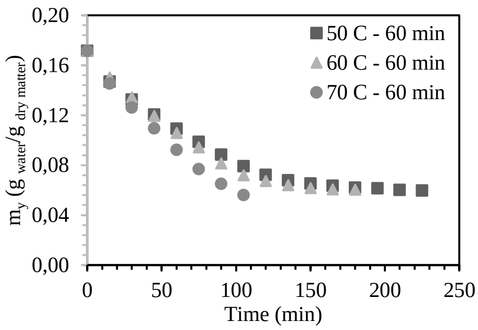

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Figure 5. Moisture change for sample that bath times such as a) 30 minutes b) 60 minutes c) 90 minutes for different drying temperatures

3.2 Energy consumption analysis

Energy consumption values are shown in Table 1 for the hose that was dried under different conditions. Energy consumption in conveyor drying consists of 2 phases unlike microwave drying. First phase is the consumption that takes time to reach the desired drying temperature (E_0). This phase also applies to conveyor drying. Second phase is the consumption that starts from the beginning of the drying process to end (E_t). Table 1 consists of phase one and total energy values. Energy consumption decreased as microwave energy increased because of the drying time. In conveyor drying, the energy consumption has increased with the drying temperature. Similar results were observed for both microwave and conveyor drying in the studies conducted by Çelen et al., 2017; 2015 [14, 16].

3.3 Strength analysis

At the end of this test, tensile force for the samples that have been cut latitudinal is calculated as 1253 N, strain is calculated as 42.4%, tensile force for the samples that have been cut longitudinal is calculated as 1485 N, strain is calculated as 56.7%. Tensile force and strain for the dried pre-treatment hoses are shown in Table 2.

Table 1. Energy consumption values of dried hose

	30 min			60 min			90 min		
Drying Power/ Drying Temperature	E_o (kWh)	E_t (kWh)	D.T. (min)	E_o (kWh)	E_t (kWh)	D.T. (min)	E_o (kWh)	E_t (kWh)	D.T. (min)
120 W	0	0,216	63	0	0,2	60	0	0,19	54
350 W	0	0,189	19	0	0,146	14	0	0,133	13
460 W	0	0,156	12	0	0,152	11	0	0,142	10,5
50 °C	0,51	4,01	240	0,93	4,16	225	1,12	4,9	180
60 °C	0,94	4,27	195	1,52	4,51	180	1,82	4,85	165
70 °C	1,45	5,39	180	1,8	3,92	105	1,95	3,88	90

D.T: drying time (min)

Table 2. Strength data for the dried hose

		30 min		60 min		90 min	
Drying Power/ Drying Temperature	Dimension	Force (N)	Strain (%)	Force (N)	Strain (%)	Force (N)	Strain (%)
120 W	Longitudinal	1443	44,5	1332	41,6	1601	47,5
	Latitudinal	1794	56,1	1904	56,1	1905	52,7

350 W	Longitudinal	1489	40,3	1603	48,1	1537	45,5
	Latitudinal	1957	55,3	1574	46,3	1880	55,9
460 W	Longitudinal	1726	51,9	1443	42,7	1588	49,2
	Latitudinal	1558	45,5	1788	57,9	1404	41,6
50 °C	Longitudinal	1519	44,7	1445	42,9	1386	39,7
	Latitudinal	1878	56,1	1736	54,6	1371	52,7
60 °C	Longitudinal	1525	44,4	1452	44,5	1478	42,5
	Latitudinal	1489	44,9	1950	60,9	1907	54,4
70 °C	Longitudinal	1439	44,01	1534	45	1502	43,9
	Latitudinal	1761	54,1	1848	59,4	1760	55,5

3.4 Diffusion coefficient and activation energy analysis

Effective diffusion coefficients and activation energy values are calculated for hose samples that have been submerged in water and dried in microwave and conveyor dryers with different times are given in Table 3. Activation energy (E_a) is known as the essential energy required to initiate the moisture diffusion from the internal regions of the drying product. The water inside of the material is evaporated by the diffusion and therefore mass of drying product, hose, decreases. Activation energy values are calculated and found out as; 1.733, 1.900 and 1.735 W/g respectively, and 5.093, 45.553 and 32.081 kJ/mol respectively. The lower activation energy translates to higher moisture diffusivity in the drying process [18]. The diffusivity of the hoses increased linearly with increasing power levels. At higher microwave powers and drying temperatures, more collisions between material molecules produce higher kinetic energy levels and increase moisture distribution within the product. The effective diffusion coefficient is higher at high microwave power levels. This provides shorter drying time. This may indicate that as the moisture content decreases, the permeability to vapor increases, provided the pore structure remained open [19].

Table 3. Estimated Deff values of the dried fire hoses

	D_{eff} (m^2/s)		
Drying Power/ Drying Temperature	30 Minutes	60 Minutes	90 Minutes
120 W	1,80E-08	1,76E-08	1,92E-08
350 W	5,64E-08	7,92E-08	6,89E-08

460 W	9,38E-08	8,96E-08	9,31E-08
50 °C	3,65E-09	5,65E-09	4,92E-09
60 °C	7,65E-09	6,92E-09	7,20E-09
70 °C	5,29E-09	9,30E-10	1,07E-08

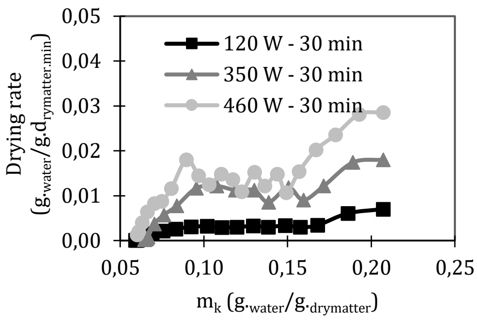
3.5 Drying rate analysis

Relation between moisture level and drying rates with respect to a dry base for the samples that were soaked in water for 30 minutes are shown in Figure 6a. Microwave dryer rate values for the sample that was dried with a power setting of 120 W are between 7.010×10^{-3}–4.373×10^{-5} $g_{water}/g_{drymatter.\ min}$, with a power setting of 350 W are between 1.8021×10^{-2}–2.132×10^{-4} $g_{water}/g_{drymatter.\ min}$ and with a power setting of 460 W are between 2.855×10^{-2}–4.784×10^{-3} $g_{water}/g_{drymatter.\ min.}$

Relation between moisture level and drying rates with respect to a dry base for the samples that were soaked in water for 60 minutes are shown in Figure 6b. Microwave dryer rate values for the sample that was dried with a power setting of 120 W are between 6.619×10^{-3}–1.844×10^{-5} $g_{water}/g_{drymatter\cdot min}$, with a power setting of 350 W are between 2.295×10^{-2}–9.061×10^{-4} $g_{water}/g_{drymatter.min}$ and with a power setting of 460 W are between 2.188×10^{-2}–8.946×10^{-4} $g_{water}/g_{drymatter.\ min.}$

Relation between moisture level and drying rates with respect to a dry base for the samples that were soaked in water for 90 minutes are shown in Figure 6c. Microwave dryer rate values for the sample that was dried with a power setting of 120 W are between 6.457×10^{-3}–1.159×10^{-4} $g_{water}/g_{drymatter.\ min}$, with a power setting of 350 W are between 1.340×10^{-2} $g_{water}/g_{drymatter.min}$–$6.668\times10^{-3}$ $g_{water}/g_{drymatter.\ min}$ and with a power setting of 460 W are between $1.56\times10^{-2} g_{water}/g_{drymatter.min}$–$8.814\times10^{-4}$ $g_{water}/g_{drymatter.\ min.}$

The rate of moisture content change (dry base) over a given time interval represents the drying rate. As can be seen in Figure 6, the drying time and drying rate decreased with the decreasing moisture content. When the moisture value is high in the first phase of drying, the absorbed power is also high. The higher the microwave power, the more the polar molecules in the product will get affected and generate a higher heat [17]. Therefore, first stages of drying process were fast, but after the moisture decreased, drying also slowed down [20]. Drying rate increased with the increase in microwave power. Doymaz [21], Chahbani et al [22] and Hanif et al [23] have also stated in their own studies that the drying rate increased with the increase of microwave power.



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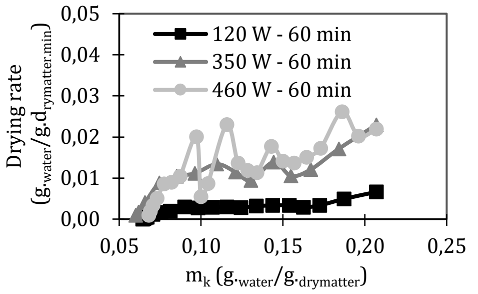

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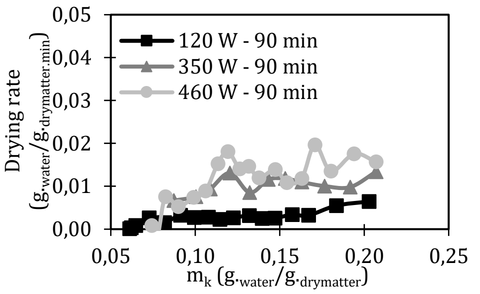


(c)

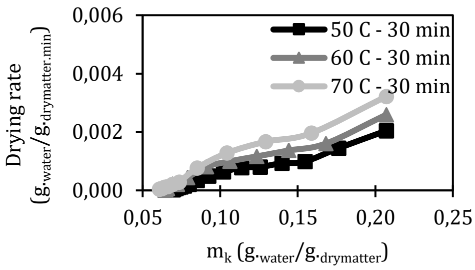
Figure 6. Drying rates of a fire hose for different drying powers and bath times a) 30 minutes b) 60 minutes c) 90 minutes Drying Rate for Conveyor Dryer Tests

Relation between moisture level and drying rates with respect to a dry base for the samples that were soaked in water for 30 minutes are shown in Figure 7a. Conveyor dryer rate values for the sample that was dried with a temperature of 50 °C are between 2.044×10^{-3}-2.227×10^{-5} $g_{water}/g_{drymatter.min}$, with a temperature of 60°C are between 2.593×10^{-3}-1.308×10^{-5} $g_{water}/g_{drymatter.min}$ and with a temperature of 70°C are between 3.220×10^{-3}-3.842×10^{-5} $g_{water}/g_{drymatter.\ min}$.

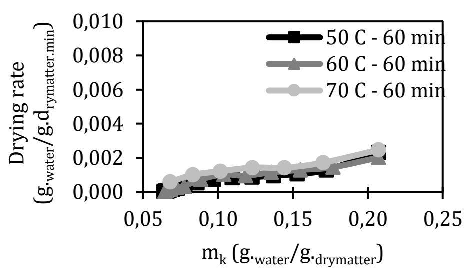
Relation between moisture level and drying rates with respect to a dry base for the samples that were soaked in water for 60 minutes is shown in Figure 7b. Conveyor rate values for the sample that is dried with a temperature of 50 °C are between 2.315×10^{-3}-4.039×10^{-5} $g_{water}/g_{drymatter.min}$, with a temperature of 60 °C are between 2.017×10^{-3}-3.219×10^{-5} $g_{water}/g_{drymatter.min}$ and with a temperature of 70 °C are between 2.464×10^{-3}-5.897×10^{-4} $g_{water}/g_{drymatter.\ min}$.

Relation between moisture level and drying rates with respect to a dry base for the samples that were soaked in water for 90 minutes is shown in Figure 7c. Conveyor rate values for the sample that is dried with a temperature of 50 °C are between 3.354×10^{-3}-1.840×10^{-5} $g_{water}/g_{drymatter.min}$, with a temperature of 60 °C are between $1.962.10^{-3}$-2.776×10^{-5} $g_{water}/g_{drymatter.min}$ and with a temperature of 70 °C are between 2.793×10^{-3}-1.125×10^{-3} $g_{water}/g_{drymatter.\ min}$.

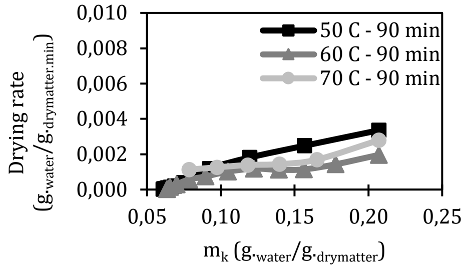
As can be seen in Figure 7, the moisture content decreases rapidly at the beginning and then the rate of decrease slows down. In the low rate period, there is diffusion of moisture through the material towards the surface. Firstly, the drying rate decreases rapidly and as time progresses it decreases more slowly [24].



(a)



(b)



(c)

Figure 7. Drying rates for sample that bath times such as a) 30 minutes b) 60 minutes c) 90 minutes for different drying powers

4. Conclusions

• Weight increases of hose samples are approximately between 12% and 15% and the changes are not significantly affected by the amount of time they spend in water. However drying process times are decreased by exposing the sample to water longer durations.

• Drying process time decreased by increasing the power of the microwave dryer. The shortest drying time occurred with the sample that was soaked in water for 90 minutes when microwave power was set to 460 W for 10.5 minutes.

• The shortest drying time for conveyor dryer occurred with the sample that was soaked in water for 90 minutes with a temperature of 70 °C.

• When the energy consumption values are evaluated, the minimum energy consumption for the microwave dryer resulted as 0.142 kW with the sample that was soaked in water for 90 minutes and dried with 460 W microwave power. This might mean that drying time and energy consumption is directly proportional, but inversely proportional with microwave power.

• In the conveyor dryer, it has been established that decreasing the drying time also decreases energy consumption. Minimum energy consumption was measured as 3.88 kW with a sample that was soaked in water for 90 minutes at a temperature of 70 °C.

• Tensile force for the samples that have been cut latitudinally and microwave dried was 1751 N, strain was 51.9%, tensile force for the samples that have been cut longitudinally was 1529 N, strain was 45.7%. Tensile force for the samples that have been cut latitudinally and conveyor dried was 1774 N, strain was 54.7%, tensile force for the samples that have been cut longitudinally was 1475 N, strain was 43.5%. When all the results were evaluated, strength of hose samples did not change drastically with microwave or conveyor dryer.

• When the effective diffusion coefficients were examined for the process of microwave dryer, while drying power increased, effective diffusion coefficient also increased. Highest effective diffusion coefficients were acquired by drying the sample that was soaked in water for 30, 60 and 90 minutes by drying at a 460 W microwave power. When evaluating based on the time samples spent subjected to water, effective diffusion coefficients have been calculated for 30 minutes as 9.38×10^{-8}, for 60 minutes as 8.96×10^{-8} and for 90 minutes as 9.31×10^{-8}. This situation can be explained by the fact that when microwave power increases, interaction on molecular level also increases thus effective diffusion coefficient increases.

• In conveyor dryer, effective diffusion coefficient change is irregular with respect to temperature increase. This situation might have happened because of the waiting time of samples in water.

• When comparing activation energies, the highest activation energy in microwave dryer was calculated as 1.9 for 60 minutes holding in water, 1.734 for 30 minutes holding in water and 1.735 for 90 minutes exposure to water. Also, the highest activation energy in conveyor dryer was calculated as 45.553 for 60 minutes exposure to water, 5.093 for 30 minutes exposure to water and 32.08 for 90 minutes exposure to water.

• Since there is quite a lot moisture in the first phases, samples absorb more energy in short amounts of time, thus drying rates are higher. By continuing the drying process, moisture is reduced and with that drying rate also decreased. While there are deviations and fluctuations with the drying rate curves in microwave drying, drying rate decreased consistently with decreasing moisture level in conveyor dryer.

• In conclusion the best suitable drying method for fire hoses when all tests and calculations are considered is the microwave drying process.

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