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Some Theorems on Timelike Ruled Surfaces

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Abstract: In this study, we investigate the existence theorems for timelike ruled surfaces in Minkowski 3-space E_1^3. We obtain a general system and give the existence theorems for a timelike ruled surface according to Gaussian curvature, distribution parameter and strictional distance. Moreover, we give some special cases such as the directirx of the surface is a geodesic, an asymptotic line, a line of curvature or a general helix.

Key words: Frenet frame, Minkowski 3-space, Striction curve, timelike ruled surface.

Timelike Regle Yüzeyler Üzerine Bazı Teoremler

Öz: Bu çalışmada, E_1^3 Minkowski 3-uzayındaki timelike regle yüzeyler için varlık teoremleri araştırılmıştır. Genel bir sistem bulunmuş ve bir timelike regle yüzeyin varlık teoremleri, Gauss eğriliği, dağılma parametresi ve striksiyon uzaklığına bağlı olarak verilmiştir. Bundan başka, yüzeyin dayanak eğrisinin geodezik, asimptotik çizgi, eğrilik çizgisi ya da bir genel helis olması gibi bazı özel durumlar verilmiştir.

Anahtar kelimeler: Frenet çatısı, Minkowski 3-uzayı, Boğaz çizgisi, timelike regle yüzey.

1. Introduction

In the space, a continuously moving of a straight line generates a surface which is called ruled surface. Ruled surfaces have the most important positions and applications in the study of design problems in spatial mechanisms and physics, kinematics and computer aided design (CAD). So, these surfaces are one of the most important topics of surface theory. Because of this position of ruled surfaces, geometers have studied on these surfaces in Euclidean space and they have investigated many properties of the ruled surfaces [1-3].

Moreover, Minkowski space E_1^3 is more interesting than the Euclidean space. In this space, curves and surfaces have different casual Lorentzian characters such as timelike, spacelike or null (lightlike). For example, a continuously moving of a line along a curve generates a ruled surface which can be timelike, spacelike or null. Spacelike ruled surfaces are very similar to the ruled surfaces given in Euclidean 3-space E^3. Timelike ruled surfaces are more fascinating since there exist both timelike and spacelike curves on these surfaces. Timelike ruled surface with timelike rulings have been studied by Abdel-All, Abdel-Baky and Hamdoon [4]. Küçük has obtained some results on the developable timelike ruled surfaces in the same space [5]. Furthermore, Önder and Uğurlu have introduced Frenet frames and Frenet invariants of timelike ruled surfaces [6].

Furthermore, it is interesting to consider the existence of a timelike ruled surface in Minkowski 3-space. In global differential geometry, it is well-known that the existence and uniqueness of a surface with given first and second fundamental forms are given by Bonnet's theorem [7-9]. The theorem says that if the coefficients of these forms satisfy the Gauss equations and the Peterson-Codazzi equations, then there exists a surface, which is unique up to motions in space, for which these forms are, respectively, the first and the second fundamental forms. Of course, this is a global theorem for all surfaces and Lorentzian version of this theorem can be introduced by the similar way. But how can we give existence of a special ruled surface such as timelike ruled surface without considering its first and second fundamental forms? In this study, we try to give an answer for this question. We give some theorems for timelike ruled surfaces in Minkowski 3-space by using a similar procedure given in [10]. We obtain a general system giving the two parameter family of timelike ruled surfaces. Moreover, we give some special cases such as the directirx of the surface is a geodesic, an asymptotic line, a line of curvature or a general helix.

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2. Preliminaries

Let $\vec{x}=(x_1,x_2,x_3)$ and $\vec{y}=(y_1,y_2,y_3)$ be two vectors in E^3. The function defined by

$$<,>: E^3\times E^3 \to IR$$
$$(\vec{x},\vec{y}) \to <\vec{x},\vec{y}>= x_1y_1+x_2y_2-x_3y_3$$

is called Lorentzian inner product function. The affine space E^3 endowed with this function is called Minkowski 3-space and denoted by E_1^3. In this space, an arbitrary vector $\vec{v}=(v_1,v_2,v_3)$ in E_1^3 can have one of three Lorentzian causal characters; it can be spacelike if $\langle\vec{v},\vec{v}\rangle>0$ or $\vec{v}=0$, timelike if $\langle\vec{v},\vec{v}\rangle<0$ and null (lightlike) if $\langle\vec{v},\vec{v}\rangle=0$ and $\vec{v}\neq 0$. Similarly, an arbitrary curve $\vec{\alpha}=\vec{\alpha}(s)$ can locally be spacelike, timelike or null (lightlike), if all of its velocity vectors $\vec{\alpha}'(s)$ are spacelike, timelike or null (lightlike), respectively [11]. The norm of the vector $\vec{v}=(v_1,v_2,v_3)$ is given by $\|\vec{v}\|=\sqrt{|<\vec{v},\vec{v}>|}$.

For any vectors $\vec{x}=(x_1,x_2,x_3)$ and $\vec{y}=(y_1,y_2,y_3)$ in E_1^3, Lorentzian vector product of $\vec{x}$ and $\vec{y}$ is defined by

$$\vec{x}\times\vec{y}=\begin{vmatrix} e_1 & -e_2 & -e_3 \\ x_1 & x_2 & x_3 \\ y_1 & y_2 & y_3 \end{vmatrix}=(x_2y_3-x_3y_2,\, x_1y_3-x_3y_1,\, x_2y_1-x_1y_2),$$

(See [12,13]).

Definition 2.1.(See [14]) ***i) Hyperbolic angle:*** Let $\vec{x}$ and $\vec{y}$ be future pointing (or past pointing) timelike vectors in E_1^3. Then there is a unique real number $\theta\geq 0$ such that $<\vec{x},\vec{y}>=-\|\vec{x}\|\|\vec{y}\|\cosh\theta$. This number is called the *hyperbolic angle* between the vectors $\vec{x}$ and $\vec{y}$.

ii) Central angle: Let $\vec{x}$ and $\vec{y}$ be spacelike vectors in E_1^3 such that $sp\{\vec{x},\vec{y}\}$ is a timelike vector subspace. Then there is a unique real number $\theta\geq 0$ such that $|<\vec{x},\vec{y}>|=\|\vec{x}\|\|\vec{y}\|\cosh\theta$. This number is called the *central angle* between the vectors $\vec{x}$ and $\vec{y}$.

iii) Spacelike angle: Let $\vec{x}$ and $\vec{y}$ be spacelike vectors in E_1^3 that span a spacelike vector subspace. Then there is a unique real number $\theta\geq 0$ such that $<\vec{x},\vec{y}>=\|\vec{x}\|\|\vec{y}\|\cos\theta$. This number is called the *spacelike angle* between the vectors $\vec{x}$ and $\vec{y}$.

iv) Lorentzian timelike angle: Let $\vec{x}$ be a spacelike vector and $\vec{y}$ be a timelike vector in E_1^3. Then there is a unique real number $\theta\geq 0$ such that $|<\vec{x},\vec{y}>|=\|\vec{x}\|\|\vec{y}\|\sinh\theta$. This number is called the *Lorentzian timelike angle* between the vectors $\vec{x}$ and $\vec{y}$.

3. Timelike Ruled Surfaces in E_1^3

Let I be an open interval in the real line IR, $\vec{\gamma}=\vec{\gamma}(s)$ be a curve in E_1^3 defined on I and $\vec{q}=\vec{q}(s)$ be a unit direction vector of an oriented timelike line in E_1^3. Then we have following parametrization for a timelike ruled surface N

$$\vec{r}(s,v)=\vec{\gamma}(s)+v\,\vec{q}(s). \tag{1}$$

In particular, if the direction of $\vec{q}$ is constant, then the ruled surface is said to be cylindrical, and non-cylindrical otherwise. The distribution parameter (or drall) of N is given by

$$d=\frac{|\vec{\gamma}',\vec{q},\vec{q}'|}{\langle\vec{q}',\vec{q}'\rangle} \tag{2}$$

where $\vec{\gamma}'=\dfrac{d\vec{\gamma}}{ds}$, $\vec{q}'=\dfrac{d\vec{q}}{ds}$ (see [4,6]). If $|\vec{\gamma}',\vec{q},\vec{q}'|=0$, then normal vectors are collinear at all points of same ruling and at nonsingular points of the surface N, the tangent planes are identical. We then say that tangent plane contacts the surface along a ruling. Such a ruling is called a torsal ruling. If $|\vec{\gamma}',\vec{q},\vec{q}'|\neq 0$, then the tangent planes of the surface N are distinct at all points of same ruling which is called nontorsal [6].

Definition 3.1. ([6]) A timelike ruled surface whose all rulings are torsal is called a developable timelike ruled surface. The remaining timelike ruled surfaces are called skew timelike ruled surfaces. Then, from (2) it is clear that a timelike ruled surface is developable if and only if at all its points the distribution parameter $d=0$.

For the unit normal vector $\vec{m}$ of a timelike ruled surface we have

$$\vec{m}=\frac{\vec{r}_s\times\vec{r}_v}{\|\vec{r}_s\times\vec{r}_v\|}=\frac{(\vec{\gamma}'+v\vec{q}')\times\vec{q}}{\sqrt{\langle\vec{\gamma}',\vec{q}\rangle^2-\langle\vec{q},\vec{q}\rangle\langle\vec{\gamma}'+v\vec{q}',\ \vec{\gamma}'+v\vec{q}'\rangle}}.$$

Then, at the points of a nontorsal ruling $s=s_1$ we have

$$\vec{a}=\lim_{v\to\infty}\vec{m}(s_1,v)=\frac{\vec{q}'\times\vec{q}}{\|\vec{q}'\|}.$$

The plane of a skew timelike ruled surface N which passes through its ruling s_1 and is perpendicular to the vector $\vec{a}$ is called *asymptotic plane* α. The tangent plane γ passing through the ruling s_1 which is perpendicular to the asymptotic plane α is called *central plane*. The point C of the ruling s_1 where asymptotic plane is perpendicular to central plane is called *central point* of the ruling s_1. The set of central points of all rulings is called *striction curve* of the surface. The parametrization of the striction curve $\vec{c}=\vec{c}(s)$ on a timelike ruled surface is given by

$$\vec{c}(s)=\vec{\gamma}(s)+v_0\vec{q}(s)=\vec{\gamma}-\frac{\langle \vec{q}',\vec{\gamma}'\rangle}{\langle \vec{q}',\vec{q}'\rangle}\vec{q}$$

where $v_0=-\dfrac{\langle \vec{q}',\vec{\gamma}'\rangle}{\langle \vec{q}',\vec{q}'\rangle}$ is called strictional distance ([6]).

Theorem 3.1.(Chasles Theorem) ([6]): *Let the base curve of a timelike ruled surface be its striction curve. For the angle μ between tangent plane of timelike ruled surface at the point (s,v_0) of a nontorsal ruling s and central plane, we have $\tan\mu=v_0/d$ where d is the distribution parameter of ruling s, v_0 is strictional distance and central point has the coordinates $(s,0)$.*

4. Existence Theorems for Timelike Ruled Surfaces

Let N be a timelike ruled surface in E_1^3 given by the parametrization

$$\vec{r}(s,v)=\vec{\gamma}(s)+v\,\vec{q}(s) \tag{3}$$

where $\vec{\gamma}=\vec{\gamma}(s)$ is directrix of N, s is arc length of $\vec{\gamma}(s)$ and $\vec{q}(s)$ is a unit timelike vector field on N. The directrix $\vec{\gamma}(s)$ can be a timelike or spacelike curve. Let assume that $\vec{\gamma}(s)$ be a timelike curve. Then the Frenet formulae of $\vec{\gamma}(s)$ are given as follows

$$\begin{bmatrix}\vec{T}'\\ \vec{N}'\\ \vec{B}'\end{bmatrix}=\begin{bmatrix}0 & k_1 & 0\\ k_1 & 0 & k_2\\ 0 & -k_2 & 0\end{bmatrix}\begin{bmatrix}\vec{T}\\ \vec{N}\\ \vec{B}\end{bmatrix} \tag{4}$$

where $\vec{\gamma}'(s)=\vec{T}(s)$, $\langle \vec{T},\vec{T}\rangle=-1$, $\langle \vec{N},\vec{N}\rangle=\langle \vec{B},\vec{B}\rangle=1$, $\langle \vec{T},\vec{N}\rangle=\langle \vec{T},\vec{B}\rangle=\langle \vec{N},\vec{B}\rangle=0$, $\vec{T},\vec{N},\vec{B}$ are unit tangent, principal normal and binormal vectors, respectively, and k_1 and k_2 are curvature and torsion of timelike curve $\vec{\gamma}(s)$, respectively [13]. The unit normal vector $\vec{m}$ of the surface is a spacelike vector and can be given in the form

$$\vec{m}=\cos\varphi\vec{N}+\sin\varphi\vec{B} \tag{5}$$

where $\varphi=\varphi(s)$ is differentiable spacelike angle function between spacelike unit vectors $\vec{m}$ and $\vec{N}$. Let $\vec{A}$ be a spacelike unit vector in the tangent plane of the surface and be perpendicular to unit tangent $\vec{T}$. Then we can represent the timelike ruling $\vec{q}$ in the form

$$\vec{q}=\cosh\theta\vec{T}+\sinh\theta\vec{A} \tag{6}$$

where $\theta=\theta(s)$ is differentiable hyperbolic angle function between timelike unit vectors $\vec{q}$ and $\vec{T}$. It is clear that the vector $\vec{A}$ lies on the plane $Sp\{\vec{N},\vec{B}\}$. Then we can write

$$\vec{A} = -\sin\varphi \vec{N} + \cos\varphi \vec{B} \tag{7}$$

By differentiating (5) and (7) with respect to s it follows

$$\vec{m}' = k_1 \cos\varphi \vec{T} + (\varphi' + k_2)\vec{A}\,, \quad \vec{A}' = -k_1 \sin\varphi \vec{T} - (\varphi' + k_2)\vec{m} \tag{8}$$

respectively. Similarly, considering (7) and (8), the differentiation of (6) is obtained as follows

$$\begin{aligned}\vec{q}' = \sinh\theta(\theta' - k_1 \sin\varphi)\vec{T} + \left(\cosh\theta(k_1 - \theta'\sin\varphi) - (\varphi' + k_2)\sinh\theta\cos\varphi\right)\vec{N} \\ + \left(\theta'\cosh\theta\cos\varphi - (\varphi' + k_2)\sinh\theta\sin\varphi\right)\vec{B}\end{aligned} \tag{9}$$

and (9) gives us

$$\begin{aligned}(\vec{q}')^2 = \left\langle \vec{q}', \vec{q}' \right\rangle = \theta'^2 - 2k_1\theta'\sin\varphi + k_1^2(\cosh^2\theta\cos^2\varphi + \sin^2\varphi) \\ - 2k_1(\varphi' + k_2)\sinh\theta\cosh\theta\cos\varphi + (\varphi' + k_2)^2\sinh^2\theta\end{aligned} \tag{10}$$

After these computations we can give the following theorems.

Theorem 4.1. *For a timelike curve $\vec{\gamma}(s)$ as the directrix there exists a two-parameter family of timelike ruled surfaces with a given distribution parameter and a given strictional distance.*

Proof: The strictional distance and distribution parameter of a timelike ruled surface are given by

$$v_0 = -\frac{\left\langle \vec{\gamma}', \vec{q}' \right\rangle}{\left\langle \vec{q}', \vec{q}' \right\rangle}, \quad d = \frac{\left| \vec{\gamma}', \vec{q}, \vec{q}' \right|}{\left\langle \vec{q}', \vec{q}' \right\rangle} \tag{11}$$

respectively. Then from (6) and (9) it follows

$$v_0 = \frac{\sinh\theta(\theta' - k_1\sin\varphi)}{(\vec{q}')^2}, \quad d = \frac{\sinh\theta\left(k_1\cosh\theta\cos\varphi - (\varphi' + k_2)\sinh\theta\right)}{(\vec{q}')^2} \tag{12}$$

From (12) we have

$$\begin{aligned}\frac{d^2}{v_0^2} + 1 = \frac{\theta'^2 - 2k_1\theta'\sin\varphi + k_1^2(\cosh^2\theta\cos^2\varphi + \sin^2\varphi)}{(\theta' - k_1\sin\varphi)^2} \\ + \frac{-2k_1(\varphi' + k_2)\sinh\theta\cosh\theta\cos\varphi + (\varphi' + k_2)^2\sinh^2\theta}{(\theta' - k_1\sin\varphi)^2}\end{aligned} \tag{13}$$

From (10) and (13) it follows

$$(\vec{q}')^2 = (\theta' - k_1\sin\varphi)^2\left(\frac{d^2}{v_0^2} + 1\right) \tag{14}$$

Substituting (14) in (12) we have

$$\begin{cases} \theta' = \dfrac{v_0 \sinh\theta}{d^2 + v_0^2} + k_1 \sin\varphi \\ \varphi' = -k_2 + k_1 \coth\theta\cos\varphi - \dfrac{d}{d^2 + v_0^2} \end{cases} \tag{15}$$

which are the determining equations for timelike ruled surfaces with a timelike directrix $\vec{\gamma}(s)$, given distribution parameter and given strictional distance. That proves the theorem.

Corollary 4.1. *For any timelike directrix $\vec{\gamma}(s)$ as the strictional line, there exists a two-parameter family of timelike ruled surfaces with a given distribution parameter.*

Proof: If the directrix $\vec{\gamma}(s)$ is strictional line then $v_0 = 0$. Thus (15) becomes

$$\begin{cases} \theta' = k_1 \sin\varphi \\ \varphi' = -\dfrac{1}{d} - k_2 + k_1 \coth\theta\cos\varphi \end{cases} \tag{16}$$

that finishes the proof.

Theorem 4.2. *For any timelike directrix $\vec{\gamma}(s)$ there exists a two-parameter family of timelike ruled surfaces with a given Gaussian curvature and a given angle between the tangent planes and central planes along $\vec{\gamma}(s)$.*

Proof: From Chasles theorem we have

$$\tan\mu = \frac{v_0}{d} \tag{17}$$

where μ is the spacelike angle between tangent plane and central plane of timelike ruled surface at the point (s, v_0). Furthermore, Gaussian curvature K of a timelike ruled surface is given by

$$K = \frac{d^2}{(d^2 + v_0^2)^2} \tag{18}$$

(See [15]). If we put

$$n = \sqrt{\frac{1}{K}} = \frac{d^2 + v_0^2}{d} \tag{19}$$

then K defines n uniquely and followings hold

$$d = n\sin^2\mu, \;\; v_0 = n\sin\mu\cos\mu \tag{20}$$

By using (20), system (15) can be given in the form

$$\begin{cases} \theta' = \dfrac{1}{n}\sinh\theta\cot\mu + k_1\sin\varphi \\ \varphi' = -\dfrac{1}{n} - k_2 + k_1\coth\theta\cos\varphi \end{cases} \tag{21}$$

that finishes the proof.

Theorem 4.3. *For any timelike directrix $\vec{\gamma}(s)$ there exists a two-parameter family of general developable timelike ruled surfaces with a given strictional distance.*

Proof: If the timelike ruled surface N is developable and not a cylinder we have $v_0 \neq 0,\ d = 0$. Then from (15) it follows

$$\begin{cases} \theta' = \dfrac{\sinh\theta}{v_0} + k_1\sin\varphi \\ \varphi' = -k_2 + k_1\coth\theta\cos\varphi \end{cases} \tag{22}$$

which shows that there exists a two-parameter family of general developable timelike ruled surfaces with a given strictional distance.

Theorem 4.4. *For any timelike directrix $\vec{\gamma}(s)$ there exists a two-parameter family of timelike cylinders.*

Proof: If the timelike ruled surface N is a cylinder then the direction of the ruling $\vec{q}$ is constant and from (9) we have

$$\begin{cases} \sinh\theta(\theta' - k_1\sin\varphi) = 0, \\ \cosh\theta(k_1 - \theta'\sin\varphi) - (\varphi' + k_2)\sinh\theta\cos\varphi = 0, \\ \theta'\cosh\theta\cos\varphi - (\varphi' + k_2)\sinh\theta\sin\varphi = 0, \end{cases}$$

that gives us

$$\theta' = k_1\sin\varphi, \quad \varphi' = -k_2 + k_1\coth\theta\cos\varphi \tag{23}$$

and (23) shows that there exists a two-parameter family of timelike cylinders.

5. Some Special Cases

In this section, we consider some special cases such as the directirx $\vec{\gamma}(s)$ is a geodesic, an asymptotic line or a line of curvature. Then we can give the followings.

Theorem 5.1. *For any timelike directrix $\vec{\gamma}(s)$ there exists exactly one timelike ruled surface with a given Gaussian curvature on which $\vec{\gamma}(s)$ is a geodesic.*

Proof: Let the directrix $\vec{\gamma}(s)$ be a geodesic. Then we have $\vec{N} = \pm\vec{m}$. By considering (5), we have $\varphi = a\pi,\ (a \in Z)$. From system (21) it follows

$$\tanh\theta = \frac{nk_1}{nk_2+1}$$

which shows that if the directrix $\vec{\gamma}(s)$ is a geodesic, then there exists exactly one timelike ruled surface with a given Gaussian curvature.

Theorem 5.2. *For any timelike directrix $\vec{\gamma}(s)$ there exists a one-parameter family of timelike ruled surfaces with a given angle between the tangent planes and corresponding central planes on which $\vec{\gamma}(s)$ is an asymptotic line.*

Proof: Assume that the directrix $\vec{\gamma}(s)$ is an asymptotic line. Then from (5), we have $\varphi = \pi/2$ and from the system (21) we have

$$\theta' = \frac{1}{n}\sinh\theta\cot\mu + k_1, \quad n = -\frac{1}{k_2}$$

which determines a one-parameter family of timelike ruled surfaces.

Theorem 5.3. *Let the angles θ and μ be constants. Then a timelike directrix curve $\vec{\gamma}(s)$ is an asymptotic line on a timelike ruled surface N if and only if $\vec{\gamma}(s)$ is a general helix.*

Proof: Let the directrix $\vec{\gamma}(s)$ be an asymptotic line on N. Then $\varphi = \pi/2$. Since the angles θ and μ are constants from (21) it follows

$$\frac{k_1}{k_2} = \sinh\theta\cot\mu$$

which is constant i.e. $\vec{\gamma}(s)$ is a general helix.

Conversely, if the angles θ and μ are constants and $\vec{\gamma}(s)$ is a general helix then from (21) we have $\varphi = \pi/2$ which shows that $\vec{\gamma}(s)$ is an asymptotic line on N.

Theorem 5.4. *A timelike curve $\vec{\gamma}(s)$ is a line of curvature on a timelike ruled surface N if and only if*

$$\varphi(s) = -\int k_2(s)ds + C \tag{24}$$

holds where C is a constant.

Proof: A curve $\vec{\gamma}(s)$ is a line of curvature if and only if surface normals generate a developable ruled surface along $\vec{\gamma}(s)$, i.e. iff

$$\left|\vec{k}', \vec{m}, \vec{m}'\right| = 0 \tag{25}$$

Then from (8), we have $\left|\vec{T}, \vec{m}, -(\varphi' + k_2)\vec{A}\right| = 0$ which gives $\varphi' = -k_2$ and (24) is obtained.

Theorem 5.5. *For any timelike curve* $\vec{\gamma}(s)$ *there exists a one-parameter family of timelike ruled surfaces with a given Gaussian curvature along* $\vec{\gamma}(s)$ *on which* $\vec{\gamma}(s)$ *is a line of curvature.*

Proof: Since $\vec{\gamma}(s)$ is a line of curvature, (24) holds and from (21) we have

$$nk_1 = \tanh\theta \sec\varphi \tag{26}$$

that finishes the proof.

Theorem 5.6. *If* θ *is constant and timelike directrix* $\vec{\gamma}(s)$ *is a line of curvature on a timelike ruled surface* N *then there exists the following relationship between the angles* φ *and* μ

$$\tan\varphi = -\cosh\theta \cot\mu \tag{27}$$

Proof: Since θ is constant and $\vec{\gamma}(s)$ is a line of curvature, from (21) and (24) we have

$$k_1 \sin\varphi = -\frac{1}{n}\sinh\theta \cot\mu, \quad k_1 \cos\varphi = \frac{1}{n}\tanh\theta \tag{28}$$

which gives (27).

6. Conclusions

The some theorems on the existence of timelike ruled surfaces are given by considering a timelike directrix. Furthermore, some special cases related to the directrix is introduced. Of course, one can obtain corresponding theorems for a ruled surface with null rulings or for a spacelike ruled surface.

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Simulation and Optimization of A Crude Oil Distillation Unit

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Abstract: In the present study simulation and optimization of a crude oil distillation unit of a refinery by Aspen HYSYS simulation program has been carried out with the aim of increasing the efficiency of the unit. The effects of the temperature of the kerosene removal plate, the cap temperature of the distilling tower, the stripping steam flow and the top pressure of the tower on the distillation products were determined for the aim of increasing yields of some valuable products. The yield of kerosene increased to be 5.98 % by varying the temperature of the kerosene removal plate from 202 ˚C to 206 ˚C. It was observed that the decrease in the cap temperature and the increase in both the stripping steam flow and the tower feeding temperature increase flow rates of both the kerosene and the naphtha cuts. It was noted that the adjustment such as the reduction of the tower pressure from 1.7 kg/cm^2 to 1.5 kg/cm^2 generates the greatest impact on the yields of the products with the highest commercial value without generating additional costs. The optimum operation conditions determined by the simulation increased the efficiency of the plant in terms of higher yields of both kerosene and naphtha.

Keywords: HYSYS, Simulation, Optimization, Crude distillation unit.

Ham Petrol Damıtma Ünitesinin Simülasyonu ve Optimizasyonu

Öz: Bu çalışmada, damıtma ünitesinin verimini arttırmak amacıyla bir rafinerinin ham petrol damıtma ünitesinin simülasyonu ve optimizasyonu HYSYS simülasyon programı ile yapıldı. Gazyağı uzaklaştırma raf sıcaklığının, kule tepe sıcaklığının, sıyırıcı buhar debisinin ve kule tepe basıncının damıtma ürünleri üzerindeki etkisi, değerli bazı ürünlerin verimlerini artırmak amacıyla, belirlendi. Gazyağı uzaklaştırma rafının sıcaklığı 202 °C'den 206 °C'ye değişmesiyle gazyağı verimi % 5.98 arttı. Tepe sıcaklığında düşme, hem sıyırma buharının debisinde hem de kule besleme sıcaklığında artma; hem gazyağı hem de nafta debilerini arttırdığı gözlendi. Ayarlamaların, kule basıncının 1.7 kg/cm^2'den 1.5 kg/cm^2'ye düşürülmesi gibi, ilave masraf çıkarmadan en yüksek ticari değere sahip olan ürünlerin verimleri üzerinde en büyük etkiyi oluşturdukları not edildi. Simülasyonla saptanan optimum işletme şartları, hem gazyağı hem de naftanın daha yüksek verimleri açısından, işletmenin verimini arttırdığı gözlendi.

Anahtar kelimeler: HYSYS, Simülasyon, Optimizasyon, Distilasyon ünitesi.

1. Introduction

Nowadays the process simulation can be applied in almost all the disciplines of chemical engineering and engineering in general. It is the inevitable part of the different disciplines such as the design of the process, the investigation and the development, the planning of the production, the optimization, the training and the education and the decision-making for a process.

Process simulation could be a model-based illustration of chemical, physical, biological, and alternative technical processes or unit operations in software package. Basic conditions are a radical information of chemical and physical properties such as pure parts and mixtures and even reactions. Furthermore, mathematical models permit the calculation of chemical and physical properties used in the method given in simulation program [1]. One can find a detailed description and comprehensive summary for the process simulation by the software packages in the book by Roses [2].

The dynamic models allow the chemical engineers to execute continuously the unit with a strategy of definite optimization, transforming the knowledge of the process into the form of the mathematical model hidden within the control algorithm [3].

Atmospheric and vacuum distillation is one of the first steps in crude oil refining. Fractions in the atmospheric distillation process are done based on the differences in volatility since this distillation process is performed using different boiling points of the components of crude oil [4]. According to Gomez [5], the majority of the products obtained in the different stages of distillation column are susceptible of reprocess; either for obtaining other fractions by processes of conversion and separation or for improving their quality.

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Nuhu et al. [6] performed a technical investigation of crude oil distillation unit of N'djamena Refinery Company in Chad Republic. They performed the second law analysis and ascertained efficiency to be 35.8 %. The investigation incorporated in the elements quality changing alongside design variation was done by Rahman and Kirtania [7] by using Aspen HYSYS 7.1 and a retrofit plan technique and simulation structure used to incorporate unrefined petroleum were carried out by Gadalla et al. [8] using HYSYS to simulate refinement of crude oil. The increase of gasoline production in every one of the refineries is the main goal. When focusing on the crude oil distillation unit is primary objective, optimizing the yield of gasoline and its intermediates affect positively on total inventory gasoline production. Okeke & Osakwe-Akofe [9] utilized HYSYS software to develop a simulation of a process and a strategy for the improvement and management systems and operability. The some software packages allow engineers or scientists to use their experience to resolve challenges distinctive to the industries in a way that it is very safe and virtual atmosphere. Moreover the software packages assists them to urge inform with the present management systems and to know the basics of the plant operation [10].

According to Matar [11], the organic compound intermediates are created by subjecting crude oils to varied process schemes. These embrace a primary distillation step to separate the oil-complicated mixture into less complicated fractions. According to the optimization [12], one or additional fractionating columns are used in atmospheric distillation units. Distilling a crude oil starts by preheating the feed by exchange heat with the new product streams. According to Perry et al. [13], a distillation is outlined as an equilibrium-staged separation method within a liquid or vapor mixture or each containing two or a lot of components which are separated into its component fractions of desired purity by the applying and/or removal of warmth.

Aspen HYSYS manual process simulation can be employed for the planning, development, analysis, and improvement of technical processes such as chemical plants and complicated chemical processes, environmental systems, power plants, advanced producing operations, biological processes, and similar technical functions [14]. The goal of a process simulation is to search out optimum conditions for a process unit being examined. This can be primarily an improvement drawback, which should be solved in a repetitive process [15, 16].

According to Rodriguez et al. [17], process simulation relies on models. A model ought to mirror the fact at the degree of accuracy needed by application. Having a decent information of the modelling background is mandatory for obtaining reliable results and victimizing the software package effectively. Estrada [18] established the event of models for a more robust illustration of real processes that was the core of the additional development of the simulation software package. Walters [19] indicated that process flow diagrams are often generated by linking modeling software package to simulators and process simulation is additionally inspired the additional development of mathematical models within the fields and Hough simulators offer information about the resolution of complicated issues. Quimitec [20] mentioned that if somebody links a process simulator to a system, the system itself would see what is an expected calculation from engineering thermodynamic models and choose what is a practical expectation for the behavior of a process, which will tell you the way profitable you are at any given moment. Michel [21] indicated that the simulator model would recognize a dangerous situation before operator's intuition, which leads to faster reactions and spending less time off spec.

The model can help interpret the pilot plant data and allow investigating process alternatives. Once the decision has been made to build a new plant or to modernize an existing plant, the HYSYS models may be used to study trade-offs, to investigate off design operations and to evaluate the flexibility of the plant to handle different feedstocks. Moreover, simulation studies during process design could avoid costly mistakes before committing to plant hardware [22].

2. Material and Method

Since the purpose is to simulate the distillation column, with aim of increasing flow rate of kerosene, by using Aspen HYSYS, the present study is theoretical and evaluative. Therefore, the study is represented in a clear way to evaluate the simulation of crude oil distillation unit by applying specialized Aspen HYSYS software. In this study, the Aspen HYSYS (V8.8 (License. HYAC9322456)) simulation program was used to simulate distillation column and investigate various operating parameters. According Hernandez et al. [23], evaluative study should be conducted to collect the necessary fundamentals of data to use for improving the process being simulated. For this reason, the current research focuses as field research referred to improve the performance of crude oil distillation unit by simulation. Tamayo [24] defined the field research as "a plan or strategy designed to get the information you want, in the same place and time when this occurs". Segovia [25] also indicate that evaluation studies aim precise study for accomplishment of event determination at standard conditions.

3. Results and Discusion

In order to check whether Aspen HYSYS Process modeling software for present situation works accurately or not, the product yields obtained from both the program and the real refinery compared one another. It was observed that the product yields in both HYSYS and the refinery are quite close to one another for a crude oil having the same properties (API grade of 34). This comparison indicated that in the present research the HYSYS program can be safely used to simulate the process at the hand.

3.1 Simulation of Refinery Process Diagram (PFD)

The flow diagram used to simulate process in Aspen HYSYS is shown in Figure 1. The diagram consists of preheat exchanger train. Here, various process streams leaving from the distillation tower exchange heat with the incoming crude oil. Typically, the charge stream is heated from 90 °F to 653 °F (32-325 °C).

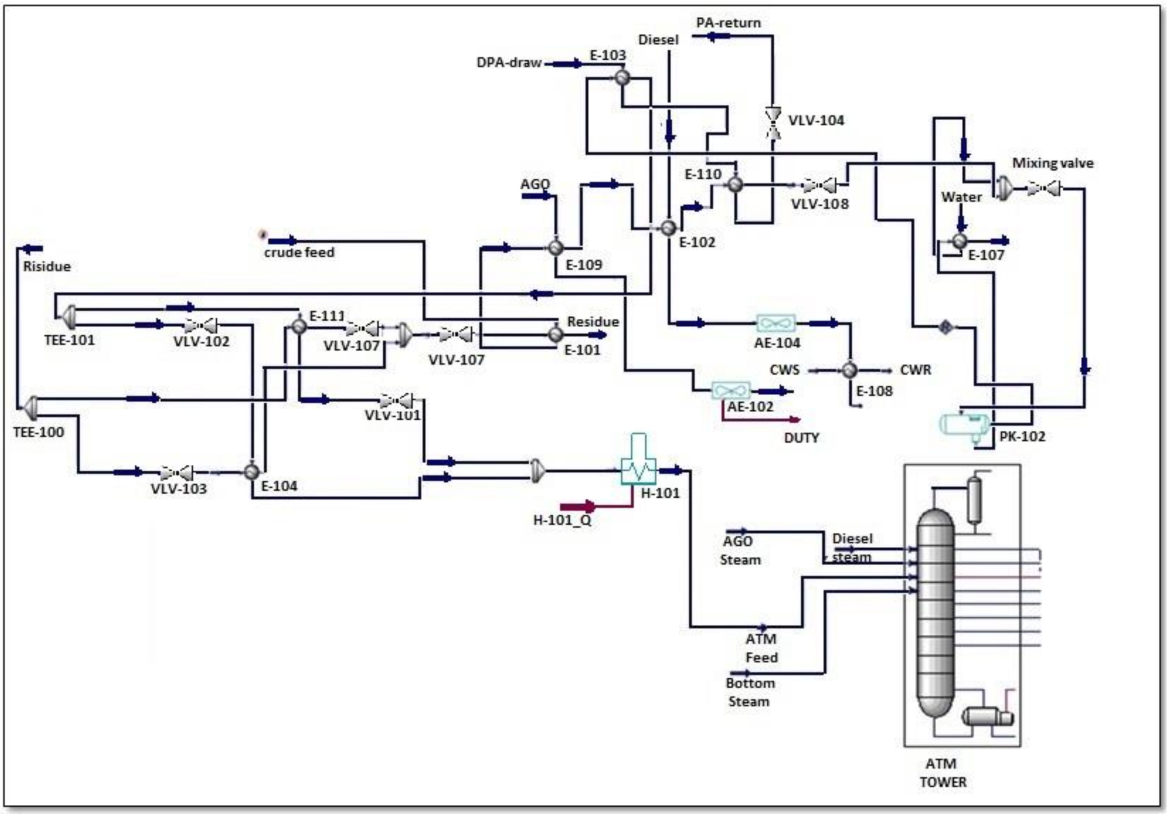

Figure 1. Process flow diagram for simulation in HYSYS.

After leaving the initial preheat exchangers (E-101A/B, -E-109, E-102 and E-110), the crude oil flows into desalters (PK-102). In the desalters, water and impurities that could cause corrosion in process piping and equipment are removed from crude oil. The crude oil leaves the desalters and passes through the heat exchangers (E-103 & E-104), then flows to the charge heaters (-H-101). After leaving the crude oil charge heaters, the streams enter the crude oil tower (T-101) at 653 °F (325 °C).

As shown in Figure 2 the column consists of 39 stages with a partial condenser, three side strippers and one pump around. The heated crude oil is sent into the tray 36. Side strippers comprising 3 stages have been utilized for kerosene, diesel and atmospheric gas oil (AGO).

3.2 Effect of Changing Parameters

3.2.1 Influence of increasing cut temperature of kerosene production

The effect of temperature on the optimization of the products from HYSYS Process modeling software that are of greater commercial value are is presented in Table 1. The results showed that an increase in temperature is proportional to a higher performance but sacrificing the performance of the heaviest product such as diesel. The optimum point has been defined by the ASTM D86 curve at different temperatures in each plate. It should be noted that the variables such as tower pressure, feed temperature, water vapor flow to the tower and load were kept constant while the cut temperature of kerosene changes.

Table 1 shows the results obtained for the different cases in which the behavior of some variables and qualities are orientated to produce the maximum product namely kerosene cut. When the crude oil distillation is done, the temperature is measured in the exit of the kerosene flow. The steams are rising across the trays where the contact is taken place between the vapor and liquid at about 202 °C that is the boiling point of the kerosene at atmospheric pressure. In this respect, the flow drawn from the distillation tower at this temperature possesses a chemical composition corresponding to the kerosene. The values of all the variables and qualities change as seen in Table 1 when the draw temperatures vary in ascending manner. Making an analysis of the behavior trends, it is possible to observe that as the draw temperature is increased, the flow of kerosene increases.

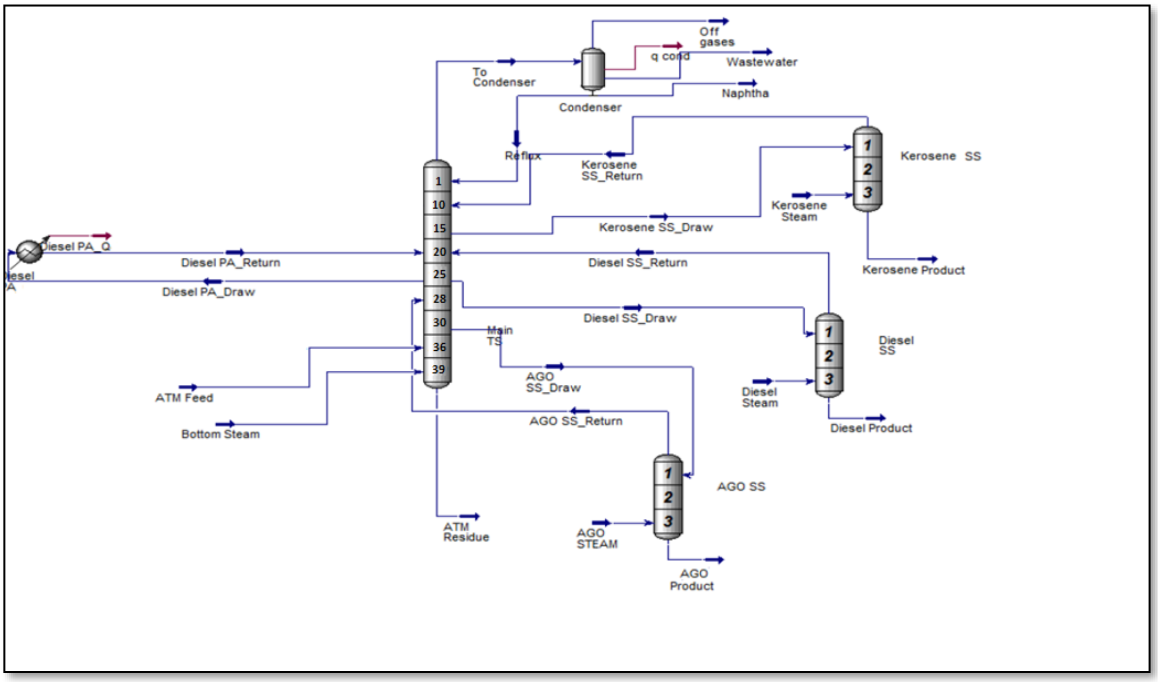

Figure 2. Flow diagram for the distillation tower in HYSYS.

It is obviously seen in Table 1 that the performance of the flow of diesel diminishes with the increase of the cut temperature of the kerosene. This is due to the fact that a part of this cut is dragged towards the tray of top retirement owing to lager vaporization of heavier components, which increases the flow rate of kerosene product and affects also the specific gravity of the kerosene due to the content of heavier components in this flow having

Table 1. The effect of increasing kerosene cut temperature on some variables**.**

Kerosene cut temperature ˚C	**Kerosene flow rate m^3/h**	**Sulfur content of kerosene wt %**	**Final boiling point of kerosene**	**Diesel sp.gr**	**Diesel flow rate m^3/h**
202	3.2	0.21	207	0.824	16.4
202.2	3.3	0.211	207.1	0.82395	16.35
202.4	3.4	0.212	207.2	0.8239	16.3
202.6	3.5	0.213	207.3	0.82385	16.25
202.8	3.6	0.214	207.4	0.8238	16.2
203	3.7	0.215	207.5	0.82375	16.15
203.2	3.8	0.216	207.6	0.8237	16.1
203.4	3.9	0.217	207.7	0.82365	16.05
203.6	4	0.218	207.8	0.8236	16
203.8	4.1	0.219	207.9	0.82355	15.95
204	4.2	0.22	208	0.8235	15.9
204.2	4.3	0.221	208.1	0.82345	15.85
204.4	4.4	0.222	208.2	0.8234	15.8
204.6	4.5	0.223	208.3	0.82335	15.75
204.8	4.6	0.224	208.4	0.8233	15.7
205	4.7	0.225	208.5	0.82325	15.65
205.2	4.8	0.226	208.6	0.8232	15.6
205.4	4.9	0.227	208.7	0.82315	15.55
205.6	5	0.228	208.8	0.8231	15.5
205.8	5.1	0.229	208.9	0.82305	15.45
206	5.2	0.23	209	0.823	15.4

increased the draw temperature, one notices that the content of sulfur increases due to heavier components dragged into kerosene cut. Drawing kerosene at higher temperature causes heavy components to depart from their tray to the tray of the kerosene. The variation of the sulfur content is directly proportional to increasing temperature of the kerosene plate. The flow rate of heavier components toward to lighter components increases with increasing tray temperature and then sulfur content in kerosene increase since some sulfur combined with heavier components will be carried with those components. It is necessary to keep the sulfur content under control in kerosene since it is one of the undesirable components and could cause the loss of quality due to being out of specification in terms of the standard or customer requirements. A high content of sulfur in the product will produce acidic gases and a high rate of corrosion in the equipment used.

By changing the withdrawal temperature of the tray, the final boiling point of the distillate (kerosene) changes by increasing the gap-overlap. When the tendency is to increase the gap, it can be said that the optimization of the product is good because it has a better separation (within 5% of the heavy product and 95% of the light cut); otherwise it will occur if the overlap increases. This is because a part of this cut is dragged towards the upper tray by virtue of the larger evaporation of heavier components, which increases the kerosene production flow and will affect the specific gravity of the kerosene owing to the content heavier components in the flow. This situation obeys the established mass and energy balance. An increase in sulfur content in kerosene indirectly affects flow of heavier products such as diesel since it is dragged with heavier components as expressed previously; therefore, the expenses of treatment to remove sulfur in diesel will be less since flow rate of diesel decreases from 16.4 m^3/h to 15.4 m^3/h. A certain amount of naphtha also changes into kerosene during the handling of the kerosene extraction at plate temperature, which increases flow rate of kerosene.

3.2.2 Influence of decreasing top tower temperature

Decreasing top temperature of the distillation tower, heavier naphtha products go towards the kerosene tray, which increases production of kerosene and decreases its distillation end point; therefore, kerosene product becomes lighter. The data about decreasing top temperature of the distillation tower were obtained in terms of volumetric flow rates of naphtha and kerosene and their properties. The results are illustrated in Table 2. As seen in the table, the kerosene flow rate increases as the uppercut temperature decreases since the naphtha becomes a part of the kerosene; therefore, the kerosene yield increases.

Table 2. The effect of decreasing top tower temperature on the some parameters.

Top Temperature ˚C	**Kerosene flow rate m^3/h**	**Sulfur content of kerosene wt %**	**Final boiling point kerosene**	**Naphtha flow rate m^3/h**	**Naphtha API**	**Naphtha RVP Psi**
153	3.2	0.21	207	32	64.8	7.2
152.8	3.3	0.209	206.8	31.9	64.82	7.3
152.6	3.4	0.208	206.6	31.8	64.84	7.4
152.4	3.5	0.207	206.4	31.7	64.86	7.5
152.2	3.6	0.206	206.2	31.6	64.88	7.6
152	3.7	0.205	206	31.5	64.9	7.7
151.8	3.8	0.204	205.8	31.4	64.92	7.8
151.6	3.9	0.203	205.6	31.3	64.94	7.9
151.4	4	0.202	205.4	31.2	64.96	8
151.2	4.1	0.201	205.2	31.1	64.98	8.1
151	4.2	0.2	205	31	65	8.2
150.8	4.3	0.199	204.8	30.9	65.02	8.3
150.6	4.4	0.198	204.6	30.8	65.04	8.4
150.4	4.5	0.197	204.4	30.7	65.06	8.5
150.2	4.6	0.196	204.2	30.6	65.08	8.6
150	4.7	0.195	204	30.5	65.1	8.7

It can be noted that the sulfur content in kerosene cut decreases with a decrease in the upper cutting temperature. This is because the lighter product returning to the kerosene has a very low sulfur content; the sulfur tends to remain in the heavier cuts such as light diesel and diesel.

The lowering of the temperature in the upper plate of the distillation tower causes a variation in the end point of the kerosene as part of the light product remains in the kerosene cut, which causes the final boiling point of the kerosene to decrease since it has a larger content of low molecular weight carbonate chains. On the other hand, it is observed that the flow rate of naphtha is directly proportional to the temperature variations of the upper cut. In present case, its decrease will produce a smaller withdraw of this cut, which decreases its yield and increases the yield of the kerosene production. Thus, having a lower molecular weight liquid current returning to the kerosene plate will generate a higher API.

When the temperature of the naphtha cut decreases, its heavier fractions remain in the lower tray. Therefore, the lighter product contents increase in the heavier cut such as the kerosene cut, producing an increase in the RVP in the naphtha.

3.2.3 Influence of increasing crude feed temperature

Increasing temperature of the crude oil fed to distillation tower increases the rate of process separation of the product and decreases time of process but increases the pressure of the tower. This causes high boiling points for components and thus, the heavier products that will go up in the distillation tower affect the quality of the products. This situation can be seen from data about increasing feed temperature of the crude oil. However, the data are not given here on account of limited pages.

The high temperature of feed increases the flow rate of elements with higher molecular weight from the flash or feed tray to upward in the distillation tower, mixing with the lighter fraction and increasing its final boiling point. Higher specific gravity corresponds to higher molecular weight components, which indicates that the increase in the specific gravity by virtue of higher feed temperature is results of the heavier components that flow to upper trays and thus, change the composition of light products. This condition generates a higher yield for products such as naphtha and kerosene with higher sulfur content and higher specific gravity and higher boiling point.

Higher temperature in the flash tray (feeding the tray) sends heavier components to the upper trays; therefore, a part of the sulfur content that should be deposited in the diesel tray is transferred to the upper cut, which causes an increase in sulfur content in the kerosene. The sulfur has to be removed to be in the specifications demanded by the client.

3.2.4 Influence of increasing steam flow rate

Increasing mass flow rate of steam to the distillation tower, partial pressures of products decrease; thus, heavier products will go up and also the percentages of sulfur in the cuts increases on account of the dragged sulfur with heavier compound. The data about variation of volumetric flow rates of cuts and their properties with increasing mass flow rate of stripping steam were obtained from the Aspen HYSYS. The variation of volumetric flow rate of kerosene and naphtha and sulfur content of kerosene with increasing flow rate of stripping steam are shown in Table 3. The stripping steam under conditions of 300˚C and 14 kg/m^2 in a range of 700 kg/h - 775 kg/h is supplied at the bottom of the distillation tower. The final boiling point of the cut/cuts increases as the steam flow at the bottom of the distillation tower increases. As can be seen in the table, the heavy components are dragged to the upper tray since the partial pressure of a component in the mixture decreases. Heavier components contain more sulfur because compounds with sulfur are usually heavier compounds; thereby, the sulfur content also increases. The rising volume of vapor carry light components to the upper trays in which they condense according to their partial pressure at the tray temperature. Thus, the performance of the naphtha will increase. The increase in the production of the different cuts such as naphtha and kerosene is due to the light components overlapped in the residue.

Table 3. The effect of increasing steam flow rate on some variables.

Steam kg/h	Final boiling point of kerosene	Sulfur content of kerosene wt%	Kerosene flow rate m^3/h	Final boiling point of naphtha	Naphtha flow rate m^3/h	Naphtha RVP Psi
700	207	0.21	3.2	189	32	7.2
705	207.15	0.2104	3.3	189.35	32.2	7.3
710	207.3	0.2108	3.4	189.7	32.4	7.4
715	207.45	0.2112	3.5	190.05	32.6	7.5
720	207.6	0.2116	3.6	190.4	32.8	7.6
725	207.75	0.212	3.7	190.75	33	7.7
730	207.9	0.2124	3.8	191.1	33.2	7.8
735	208.05	0.2128	3.9	191.45	33.4	7.9
740	208.2	0.2132	4	191.8	33.6	8
745	208.35	0.2136	4.1	192.15	33.8	8.1
750	208.5	0.214	4.2	192.5	34	8.2
755	208.65	0.2144	4.3	192.85	34.2	8.3
760	208.8	0.2148	4.4	193.2	34.4	8.4
765	208.95	0.2152	4.5	193.55	34.6	8.5
770	209.1	0.2156	4.6	193.9	34.8	8.6
775	209.25	0.216	4.7	194.25	35	8.7

3.2.5 Influence of decreasing tower pressure

A decrease in the partial pressures of products with decreasing pressure at the top of the distillation tower increases flow rates of cuts in upper trays; however, the quality of the products decreases since sulfur percentage in the upper cuts increases as evidenced in the obtained data that are given in Table 4. As the pressure in the distillation tower decreases, the separation of the products tends to improve and thus, the volumes of gases increases. Therefore, flow rates of the lighter cuts such as kerosene and naphtha tend to increase since the crude oil vaporizes more at the low pressure in the distillation column. The difficulty of separation decreases with increasing relative volatility. Thereby, the number of floors, reflux and consumption requirements in the condenser and the boiler decrease. The effect of the lowering of the tower pressure on the sulfur content in kerosene cut was examined by reducing tower pressure while other parameters were kept to be constant. The sulfur content in kerosene increases with decreasing tower pressure as the gas flow traffic increases and a part of the lower product (diesel) with its sulfur load flows into the upper product namely kerosene. As the upper pressure of the tower decreases, upper products increase due to the mobilization of heavy carbon chains to the upper plates, it is noted that a heavier cut has a higher final boiling point. The specific gravity of a raw cut depends on its components. The specific gravity of kerosene increases due to a part of diesel being in the kerosene since higher molecular weight causes the higher specific gravity in a mixture.

Table 4. The effect of decreasing tower pressure on some variables.

Column Pressure Bar	Kerosene flow rate m^3/h	Sulfur content of kerosene wt %	Final Boiling Point kerosene	Naphtha sp.gr	Naphtha flow rate m^3/h	Naphtha RVP Psi
1.7	3.2	0.21	207	0.7203	32	7.2
1.685	3.4	0.2111	207.24	0.7205	32.4	7.18
1.67	3.6	0.2122	207.48	0.7207	32.8	7.16
1.655	3.8	0.2133	207.72	0.7209	33.2	7.14
1.64	4	0.2144	207.96	0.7211	33.6	7.12
1.625	4.2	0.2155	208.2	0.7213	34	7.1
1.61	4.4	0.2166	208.44	0.7215	34.4	7.08
1.595	4.6	0.2177	208.68	0.7217	34.8	7.06
1.58	4.8	0.2188	208.92	0.7219	35.2	7.04
1.565	5	0.2199	209.16	0.7221	35.6	7.02
1.55	5.2	0.221	209.4	0.7223	36	7
1.535	5.4	0.2221	209.64	0.7225	36.4	6.98
1.52	5.6	0.2232	209.88	0.7227	36.8	6.96
1.505	5.8	0.2243	210.12	0.7229	37.2	6.94
1.49	6	0.2254	210.36	0.7231	37.6	6.92
1.475	6.2	0.2265	210.6	0.7233	38	6.9

The comparative data given in Table 5, it can be noted that the least favorable action for the process is to increase the temperature of feed. In order to increase temperature of feed, energy has to be given to heat up the crude oil fed to the distillation tower, which requires a higher operating cost in the use of fuel oil whose volumetric flow rate increases by 0.23 m^3/h for each additional burner that is required. On the other hand, the most recommended action is to lower the top pressure since it does not require an increase in operating expenses and maximizes the light products such as kerosene and naphtha. However, attention must be paid to the content of sulfur in kerosene that must not exceed the required specifications for the consumption/customers.

3.3 Optimum Operation Conditions Obtained by HYSYS

The summary of the present simulation are given in Table 6. The optimum results obtained from the simulation and the base values can be compared one another in the table. The optimized case showed improvements in naphtha and kerosene productions with volumetric flow rates of 35 m^3/h and 7 m^3/h over the base case, respectively.

Table 6. Summary of optimized cases and optimum results of the base case.

Parameters	Units	Base case	Optimized case
Crude Feed Flow rate	m^3/h	117	117
Heater temperature	˚C	325	325
Column top temperature	˚C	153	157
Column top pressure	bar	1.7	1.5
Steam Flow rate	Kg/h	700	750
Kerosene Cut of temperature	˚C	202	206
Diesel Cut of temperature	˚C	251	260

The effects of increasing top temperature, decreasing top pressure, increasing temperatures of the kerosene and diesel trays in the distillation column and increasing stripping steam flow rate fed at bottom of the column were examined previously. An increase in the temperature of the diesel tray cause an increase in flow rate of the lighter components from diesel tray to kerosene tray. Thus, the end point temperature of this stream rises, which means better stripping and results in greater flow rate of ascending vapors that will be condensed in the upper trays, are mostly in the kerosene and other namely in naphtha stream.

The optimum values for those parameters are shown in Table 6. Those values cause the flow rates of kerosene and naphtha to increase significantly almost without causing extra production cost in especially the case of decreasing top pressure in the distillation tower.

4. Conclusions

In this study, crude oil distillation unit was simulated and verified using Aspen HYSYS simulation program to analyze the influence of variation of some parameters on products. In other words, the optimum operation conditions were determined to obtain maximum kerosene. The results indicated that the product yields were not stable and often changed according to the variation of operation parameters.

The simulation results were compared with a real refinery results. It is found that there have been several variations in yields of products between Aspen HYSYS simulation and the refinery results. The steady state simulation of the naphtha and kerosene processing plant was performed based on the design and physical properties of those compounds.

All distillation columns ought to be rigorously operated to attain the specified production rates and products quality. Process variables like temperatures, pressures, flow rates, levels and compositions should be monitored and controlled altogether in distillation processes. These process variables in a distillation system have an effect on one another whereby a modification in one process variable can lead to changes in different process variables. Thus, in column management one ought to be watching the entire column and not that specialized in any specific sections solely.

Each column contains a system that consists of many management loops. The loops regulate process variables required to catch up on changes because of disturbances throughout plant operation. Each process variable has its own management loop, which usually consists of a detector and transmitter, controller and control valve. Each control loop keeps track of the associated process variable. An adjustment is made to a process variable by varying the opening of its control valve. The stream flow rate is, therefore, adjusted and a desirable variable is being controlled.

It is possible to find the optimum operating conditions that maximize the production of naphtha and kerosene for a certain crude oil. The simulation indicates that the flow rates of the naphtha and kerosene can be increased to be from 27.36% to 29.91% and from 2.74% to 5.98%, respectively. Both simulation and optimization were tested for different operating conditions and it was observed that program achieved a rapid convergence of the used models. This leads to the same models can be applied to other distillation towers with different designs.

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Comparison of Maximum Likelihood and Bayes Estimators Under Symmetric and Asymmetric Loss Functions by means of Tierney Kadane's Approximation for Weibull Distribution

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Abstract: In this study, it is considered the problem of comparing the performances of the Maximum Likelihood (ML) and Bayes estimators under symmetric and asymmetric loss function for the unknown parameters of Weibull distribution. ML estimators are computed by using the Newton Raphson method. Bayesian estimations under Squared, Linex and General Entropy loss functions by using Jeffrey's extension prior are introduced with Tierney Kadane approximation for Weibull distribution. For different sample sizes, estimators are compared to obtain the best estimator in terms of mean squared errors using a Monte Carlo simulation study.

Key words: Tierney-Kadane's approximation, Bayes estimation, Weibull distribution, Maximum likelihood estimation, Loss functions.

Weibull Dağılımı için Tierney Kadane'in Yaklaşımı ile Simetrik ve Asimetrik Kayıp Fonksiyonları Altında En Çok Olabilirlik ve Bayes Tahmin Edicilerinin Karşılaştırılması

Öz: Bu çalışmada, Weibull dağılımının bilinmeyen parametreleri için simetrik ve asimetrik kayıp fonksiyonları altında Bayes tahmin edicileri ve en çok olabilirlik tahmin edicilerinin karşılaştırılması problemi düşünülmüştür. En çok olabililirlik tahmin edicileri Newton Raphson methodu ile hesaplanmıştır.Weibull dağılımı için Tierney Kadane'in yaklaşımı ile Karesel, Linex ve Genel entropy kayıp fonksiyonları altında Bayes tahmin edicileri Jeffrey'in genişletilmiş önseli kullanılarak elde edilmiştir.Farklı örnek boyutları için Monte Carlo Simulasyon çalışması ile en iyi tahmin ediciyi elde etmek için tahmin ediciler hata kareler ortalamaları bakımından karşılaştırılmıştır.

Anahtar Kelimeler: Tierney Kadane'in yaklaşımı, Bayes tahmini, Weibull dağılımı, En çok olabilirlik tahmin edicisi, Kayıp fonksiyonları.

1.Introduction

Weibull distribution has become a popular tool for modeling life data and improving growth in the field of reliability. The Weibull distribution is generally used in reliability. The Weibull distribution can be used to model a variety of life behaviors. A Weibull distribution is the values of the shape parameter β, and the scale parameter α, affects the characteristics life of the distribution, the failure rate, the reliability function [1]. There are many studies about parameters for Weibull Distribution. Some of articles Nadarajah et.al. [2], Zhang et.al. [3], Guure et.al [4], Rasheed et.al [5], Pandey and Rao [6], Rasheed and F.Naji [7], Arshad and Abdalghani [8], Meena et.al [9] and Arshad and Misra [10]. The main advantage of Weibull analysis provides accurate failure analysis and failure forecasts with extremely small samples. ML estimation has been the most generally used method for estimating the parameters of the Weibull distribution. Bayes estimator for exponential distribution with an extension of Jeffreys' prior information was considered [11]. [1]The cumulative distribution function (CDF), probability density function (pdf), reliability function and hazard function of an X random variable having $W(\alpha,\beta)$ are as follows.

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$$F(x) = 1 - e^{-\left(\frac{x}{\alpha}\right)^{\beta}} \qquad \alpha > 0\,,\ \beta > 0\,,\ x > 0 \tag{1}$$

$$f(x) = \beta\alpha^{-\beta} x^{\beta-1} e^{-\left(\frac{x}{\alpha}\right)^{\beta}} \qquad \alpha > 0\,,\ \beta > 0\,,\ x > 0 \tag{2}$$

$$R(x) = e^{-\left(\frac{x}{\alpha}\right)^{\beta}} \tag{3}$$

$$h(x) = \beta\alpha^{-\beta} x^{\beta-1} \tag{4}$$

,where

- *for β<1 h(t)* is decreasing,
- *for β>1 h(t)* is increasing,
- *for β=1 h(t)* is constant.

As in almost all branches of science, one of the main objectives of statistics is to have information about the working population. In other words, knowing the unknown (parameters) of the population. That is, to make estimates about the parameters of the population. If so, it may be desirable to have the best estimator. There are many methods used in the literature.In this article, it is considered ML and Bayes estimators.

The aim of the study is to compare the ML and Bayes estimators under three loss functions by means of Tierney Kadane approximation using Jeffrey' s extension prior. The plan of the manuscript is as follows. In section 2, ML estimates of the parameters of Weibull distribution are reviewed. In section 3, Bayes estimators under Squared, Linex and General Entropy loss functions by using Tierney-Kadane approximation are obtained. In section 4, the simulation study is given. Finally, in section 5, the conclusion part is presented.

2.Preliminary

F(x): Distribution function
f(x): Probability density function
L(θ): The likelihood function depending on θ
ℓ(θ): The log-likelihood function depending on θ
π(θ): The prior distribution function depending on θ
π(θ/x): The posterior distribution function depending on θ
L(.,.):Loss function
$\hat{\alpha}$: Maximum likelihood estimation of α parameter

3.Material and Method

The ML Method the basic principle of the likelihood method is the selection of the sampling value corresponding to the values with the highest probability of obtaining the sampling values (or probability densities) as an estimate for the unknown parameter by looking at the sample values. The ML method is a method used to find predictors. The Bayesian approach is fundamentally different from other methods. In this approach, it is assumed in addition that θ is itself a random variable (though unobservable) with a known distribution. This prior distribution (specified according to the problem) is modified in light of the data to determine a posterior distribution (the conditional distribution of θ given the data), which summarizes what can be said about θ on the basis of the assumptions made and the data [12]. In addition to the primary distribution, a posterior distribution is used that reflects the sample information. The Bayesian estimation is considered to be the expected value of the posterior distribution under the lost function of interest.

4.Proposed Method

4.1.Tierney Kadane's approximation

Tierney and Kadane [13] is one of the methods to find the approximate value of the mathematical explanations as the ratio of two integrals given in Equations (19), (22) and (25). Although the Lindley approach plays an important role in the prediction of Bayes, this approach can only be used to obtain derivatives 1 and 2. For this reason, Tierney and Kadane proposed a new approach in 1986 (Tierney-Kadane approach) which makes it possible to take the 3rd derivative of the log-likelihood function. In this approach, there is a faster convergence than Lindley approximation [14]. This approximation can be written as follows for a case with two parameters. $u(\alpha,\beta)$ is any function of α and β, $\ell\left(\alpha,\beta\middle|\underset{-}{x}\right)$ is defined in Eq., (10), $\rho\left(\alpha,\beta\right)$ is logarithm joint prior distribution and defined as follows. For details see Tierney and Kadene [13].

$$\rho\left(\alpha,\beta\right)=\ln\left(\pi\left(\alpha,\beta\right)\right)=-c\ln(\alpha)-c\ln(\beta) \tag{5}$$

$$l(\alpha,\beta)=\frac{1}{n}\{\rho(\alpha,\beta)+\ell(\alpha,\beta)\} \tag{6}$$

$$l^{*}(\alpha,\beta)=\frac{1}{n}\log u(\alpha,\beta)+l(\alpha,\beta) \quad . \tag{7}$$

Then Tierney Kadane's Bayes estimator of $u(\alpha,\beta)$ is defined as follows.

$$\hat{u}_{BS}(\alpha,\beta)=E\left(u(\alpha,\beta)\middle|\underset{-}{x}\right)=\frac{\int e^{nl^{*}(\alpha,\beta)}d(\alpha,\beta)}{\int e^{nl(\alpha,\beta)}d(\alpha,\beta)} \quad . \tag{8}$$

$$=\left(\frac{\det\Sigma^{*}}{\det\Sigma}\right)^{1/2}\exp\left[n\left(l^{*}\left(\hat{\alpha}_{l^{*}},\hat{\beta}_{l^{*}}\right)-l\left(\hat{\alpha}_{l},\hat{\beta}_{l}\right)\right)\right]$$

$\left(\hat{\alpha}_{l^{*}},\hat{\beta}_{l^{*}}\right)$ and $\left(\hat{\alpha}_{l},\hat{\beta}_{l}\right)$ maximize $l^{*}\left(\alpha,\beta\right)$ and $l\left(\alpha,\beta\right)$, respectively. Σ^{*} and Σ are minus the inverse Hessians of $l^{*}\left(\alpha,\beta\right)$ and $l\left(\alpha,\beta\right)$ at $\left(\hat{\alpha}_{l^{*}},\hat{\beta}_{l^{*}}\right)$ and $\left(\hat{\alpha}_{l},\hat{\beta}_{l}\right)$, respectively. Σ is defined as follows;

$$\Sigma=\begin{bmatrix}-\partial^{2}l/\partial\alpha^{2} & -\partial^{2}l/\partial\alpha\partial\beta\\ -\partial^{2}l/\partial\alpha\partial\beta & -\partial^{2}l/\partial\beta^{2}\end{bmatrix}^{-1} \tag{9}$$

4.2.Maximum likelihood estimation

Let $X_1,X_2,...,X_n$ be independent random variables having W distribution with α, β parameters. Then the log-likelihood function is given by

$$\ell\left(\alpha,\beta|\underline{x}\right)=\ln\left(L\left(\alpha,\beta|\underline{x}\right)\right)$$
$$=n\ln\left(\beta\right)-n\beta\ln\left(\alpha\right)-\left(\sum_{i=1}^{n}\left(\frac{x_i}{\alpha}\right)^{\beta}\right)+\left(\beta-1\right)\left(\sum_{i=1}^{n}\ln x_i\right) \tag{10}$$

Differentiating the log-likelihood function $\ell\left(\alpha,\beta\middle|\underset{-}{x}\right)$ partially with respect to α, β parameters and then equating to zero, following non-linear equations is obtained and these equations can be solved with the Newton-Raphson method [15].

$$\frac{\partial\ell\left(\alpha,\beta|\underline{x}\right)}{\partial\alpha}=-\frac{n\beta}{\alpha}-\left(\sum_{i=1}^{n}\left(\frac{\left(\frac{x_i}{\alpha}\right)^{\beta}\beta}{\alpha}\right)\right)=0 \tag{11}$$

$$\frac{\partial\ell\left(\alpha,\beta|\underline{x}\right)}{\partial\beta}=\frac{n}{\beta}-nl\,\text{n}\left(\alpha\right)-\left(\sum_{i=1}^{n}\left(\frac{x_i}{\alpha}\right)^{\beta}\ln\left(\frac{x_i}{\alpha}\right)\right)+\sum_{i=1}^{n}\ln\left(x_i\right)=0 \tag{12}$$

4.3.Bayesian estimation symmetric and asymmetric loss functions

Let $X=(X_1,X_2,...,X_n)$ is a random sample taken from Weibull(α,β) distribution. For Bayesian estimation of the parameters, it is needed for prior distributions for these parameters. In this study, as a prior distribution, Jeffrey's extension priors are used and these are as follows [16].

$$\pi_1(\alpha)\propto\left(\frac{1}{\alpha}\right)^c \tag{13}$$

$$\pi_2(\beta)\propto\left(\frac{1}{\beta}\right)^c \tag{14}$$

Prior and posterior distributions of $\alpha,\ \beta$ parameters are

$$\pi(\alpha,\beta)\propto\left(\frac{1}{\alpha}\right)^c\left(\frac{1}{\beta}\right)^c\propto\left(\frac{1}{\alpha\beta}\right)^c \tag{15}$$

$$\pi(\alpha,\beta|\underline{x})=\frac{f\left((\alpha,\beta);\underline{x}\right)}{f\left(\underline{x}\right)} = \frac{\beta^n\alpha^{-n\beta}e^{-\left(\left(\sum_{i=1}^{n}x_i\right)/\alpha\right)^{\beta}}\prod_{i=1}^{n}x_i^{\beta-1}\left(\frac{1}{\alpha\beta}\right)^c}{\int_0^\infty\int_0^\infty\beta^n\alpha^{-n\beta}e^{-\left(\left(\sum_{i=1}^{n}x_i\right)/\alpha\right)^{\beta}}\prod_{i=1}^{n}x_i^{\beta-1}\left(\frac{1}{\alpha\beta}\right)^c d\alpha d\beta} \tag{16}$$

respectively.

The Squared error loss function is a symmetric function and introduced by [17] and [18]. Let any function of α and β is $u(\alpha,\beta)=u$. The squared loss function is as follows:

$$L_1(\hat{u}_{BS}-u)=(\hat{u}_{BS}-u)^2 \tag{17}$$

The value which is minimize the expected value of squared loss function is

$$\hat{u}_{BS}(\alpha,\beta)=E\left[u(\alpha,\beta)|\underline{x}\right] \tag{18}$$

In this case, Bayes estimator of $u(\alpha,\beta)$ under squared error loss function which is a symmetric loss function is obtained as follows.

$$\begin{aligned}\hat{u}_{BS}(\alpha,\beta)&=E\left[u(\alpha,\beta)|\underline{x}\right]\\&=\int_0^\infty\int_0^\infty u(\alpha,\beta)\pi\left(\alpha,\beta\middle|\underline{x}\right)d\alpha d\beta\\&=\frac{\int_0^\infty\int_0^\infty u\left(\alpha,\beta/\underline{x}\right)e^{\left[\ell\left(\alpha,\beta/\underline{x}\right)+\rho(\alpha,\beta)\right]}d\alpha d\beta}{\int_0^\infty\int_0^\infty e^{\left[\ell\left(\alpha,\beta/\underline{x}\right)+\rho(\alpha,\beta)\right]}d\alpha d\beta}\end{aligned} \tag{19}$$

$\ell\left(\alpha,\beta\middle|\underline{x}\right)$ is log-likelihood function, $\rho\left(\alpha,\beta\middle|\underline{x}\right)$ is the logarithm of a joint prior distribution. The Linex loss function is an asymmetric function and introduced by Varian [19]. Zellner [20] is studied about Bayes estimation under linex loss function. Let any function of α and β is $u(\alpha,\beta)$ and "a" arbitrary constant. The Linex loss function is defined as follows.

$$L_2(\Delta)\ \alpha\ \exp(a\Delta)-a\Delta-1;\quad a\neq 0, \tag{20}$$

$\Delta=\hat{u}(\alpha,\beta)-u(\alpha,\beta)$. Then, posterior mean of Linex loss function is given as;

$$E_\theta\left[L_2\left(\hat{u}-u\right)\right]\propto \exp\left(a\hat{u}\right)E_\theta[\exp(-au)]-a\left(\hat{u}-E_\theta(u)\right)-1 \tag{21}$$

$\hat{u}=\hat{u}(\alpha,\beta)$ and $u=u(\alpha,\beta)$, $\hat{u}_{BL}$ which minimize this posterior mean is Bayes estimator of u and is obtained as follows,

$$\hat{u}_{BL}(\alpha,\beta)=-\frac{1}{a}\ln E\left[\exp\left(-au(\alpha,\beta)\right)\middle|\underline{x}\right]$$

$$=-\frac{1}{a}\ln\left(\frac{\int_0^\infty\int_0^\infty \exp\left(-au(\alpha,\beta)\right)e^{\left[\ell\left(\alpha,\beta\middle|\underline{x}\right)+\rho(\alpha,\beta)\right]}d\alpha d\beta}{\int_0^\infty\int_0^\infty e^{\left[\ell\left(\alpha,\beta\middle|\underline{x}\right)+\rho(\alpha,\beta)\right]}d\alpha d\beta}\right) \tag{22}$$

General Entropy loss function is an asymmetric function and suggested by Calabria and Pulcinia [21]. Dey and Liao [22] are studied with Bayes estimation under the General Entropy loss function. Let any function of α, β is $u(\alpha,\beta)$ and "k" arbitrary constant. General Entropy loss function is defined as follows.

$$L_3(\hat{u},u)\propto\left(\frac{\hat{u}}{u}\right)^k-k\ln\left(\frac{\hat{u}}{u}\right)-1 \tag{23}$$

Then, posterior mean of General Entropy loss function is given as;

$$E_\theta\left[L_3\left(\hat{u},u\right)\right]\propto E\left(\frac{\hat{u}}{u}\right)^k-kE\left[\ln\left(\hat{u}\right)-\ln(u)\right]-1 \tag{24}$$

$\hat{u}=\hat{u}(\alpha,\beta)$ and $u=u(\alpha,\beta)$. Then, $\hat{u}_{BGE}$ which minimize this posterior mean is Bayes estimator of u and is obtained as follows.

$$\hat{u}_{BGE}(\alpha,\beta)=\left\{E\left\{\left[u(\alpha,\beta)\right]^{-k}\middle|\underline{x}\right\}\right\}^{-\frac{1}{k}}$$

$$=\left\{\frac{\int_0^\infty\int_0^\infty\left[u(\alpha,\beta)\right]^{-k}e^{\left[\ell\left(\alpha,\beta\middle|\underline{x}\right)+\rho(\alpha,\beta)\right]}d\alpha d\beta}{\int_0^\infty\int_0^\infty e^{\left[\ell\left(\alpha,\beta\middle|\underline{x}\right)+\rho(\alpha,\beta)\right]}d\alpha d\beta}\right\}^{-\frac{1}{k}} \tag{25}$$

It is very difficult to solve the equations (19), (22) and (25) in closed-form. Because of this reason, the Bayes Estimators of $u(\alpha,\beta)$ can be obtained using Tierney-Kadane's approximation.

4.4. Mathematical equations

The partial derivatives related to $l^*(\alpha,\beta)$, $l(\alpha,\beta)$, Σ^* and Σ are defined as follows;

$$l(\alpha,\beta)=\frac{1}{n}\left[n\ln(\beta)-n\beta\ln(\alpha)-\left(\sum_{i=1}^{n}\left(\frac{x_i}{\alpha}\right)^{\beta}\right)+(\beta-1)\left(\sum_{i=1}^{n}\ln x_i\right)-c\ln(\alpha)-c\ln(\beta)\right] \tag{26}$$

$$\frac{\partial^2 l}{\partial\alpha^2}=\frac{\frac{n\beta}{\alpha^2}-\left(\sum_{i=1}^{n}\left(\frac{\left(\frac{x_i}{\alpha}\right)^{\beta}\beta^2}{\alpha^2}+\frac{\left(\frac{x_i}{\alpha}\right)^{\beta}\beta}{\alpha^2}\right)\right)+\frac{c}{\alpha^2}}{n} \tag{27}$$

$$\frac{\partial^2 l}{\partial\alpha\beta}=\frac{-\frac{n}{\alpha}-\left(\sum_{i=1}^{n}\left(\frac{\left(\frac{x_i}{\alpha}\right)^{\beta}\ln\left(\frac{x_i}{\alpha}\right)\beta}{\alpha}+\frac{\left(\frac{x_i}{\alpha}\right)^{\beta}}{\alpha}\right)\right)}{n} \tag{28}$$

$$\frac{\partial^2 l}{\partial\beta^2}=\frac{-\frac{n}{\beta^2}-\left(\sum_{i=1}^{n}\left(\frac{x_i}{\alpha}\right)^{\beta}\ln\left(\frac{x_i}{\alpha}\right)^2\right)+\frac{c}{\beta^2}}{n} \tag{29}$$

Bayes estimators for α, β parameters using Eq. (9) are found as follows.

i. If $u(\alpha,\beta)=\alpha$

$$\Sigma_1^*=\begin{bmatrix}-\partial^2 l_1^*/\partial\alpha^2 & -\partial^2 l_1^*/\partial\alpha\partial\beta\\ -\partial^2 l_1^*/\partial\alpha\partial\beta & -\partial^2 l_1^*/\partial\beta^2\end{bmatrix}^{-1} \tag{30}$$

$$\hat{\alpha}_B=\left(\frac{\det\Sigma_1^*}{\det\Sigma}\right)^{1/2}\exp\left[n\left(l_1^*\left(\hat{\alpha}_{l_1^*},\hat{\beta}_{l_1^*}\right)-l\left(\hat{\alpha}_l,\hat{\beta}_l\right)\right)\right] \tag{31}$$

$$l_1^*(\alpha,\beta)=\frac{1}{n}\log\alpha+l(\alpha,\beta) \tag{32}$$

The partial derivatives related to l_1^* are given as,

$$\frac{\partial^2 l_1^*}{\partial\alpha^2}=-\frac{1}{n\alpha^2}+\frac{\frac{n\beta}{\alpha^2}-\left(\sum_{i=1}^{n}\left(\frac{\left(\frac{x_i}{\alpha}\right)^{\beta}\beta^2}{\alpha^2}+\frac{\left(\frac{x_i}{\alpha}\right)^{\beta}\beta}{\alpha^2}\right)\right)+\frac{c}{\alpha^2}}{n} \tag{33}$$

$$\frac{\partial^2 l_1^*}{\partial\alpha\beta}=\frac{-\frac{n}{\alpha}-\left(\sum_{i=1}^{n}\left(-\frac{(\frac{x_i}{\alpha})^{\beta}\ln(\frac{x_i}{\alpha})\beta}{\alpha}-\frac{(\frac{x_i}{\alpha})^{\beta}}{\alpha}\right)\right)}{n} \tag{34}$$

$$\frac{\partial^2 l_1^*}{\partial\beta^2} = -\frac{1}{n\beta^2} + \frac{-\frac{n}{\beta^2} - \left(\sum_{i=1}^{n}\left(\frac{x_i}{\alpha}\right)^{\beta} \ln\left(\frac{x_i}{\alpha}\right)^2\right) + \frac{c}{\beta^2}}{n} \tag{35}$$

ii. If $u(\alpha,\beta) = \beta$

$$\Sigma_2^* = \begin{bmatrix} -\partial^2 l_2^* / \partial\alpha^2 & -\partial^2 l_2^* / \partial\alpha\partial\beta \\ -\partial^2 l_2^* / \partial\alpha\partial\beta & -\partial^2 l_2^* / \partial\beta^2 \end{bmatrix}^{-1} \tag{36}$$

$$\hat{\beta}_{B} = \left(\frac{\det\Sigma_2^*}{\det\Sigma}\right)^{1/2} \exp\left[n\left(l_2^*\left(\hat{\alpha}_{l_2^*}, \hat{\beta}_{l_2^*}\right) - l\left(\hat{\alpha}_l, \hat{\beta}_l\right)\right)\right], l_2^*(\alpha,\beta) = \frac{1}{n}\ln\beta + l(\alpha,\beta) \tag{37}$$

The partial derivatives related to l_2^* are given as,

$$\frac{\partial^2 l_2^*}{\partial\beta^2} = -\frac{1}{n\beta^2} + \frac{-\frac{n}{\beta^2} - \left(\sum_{i=1}^{n}\left(\frac{x_i}{\alpha}\right)^{\beta} \ln\left(\frac{x_i}{\alpha}\right)^2\right) + \frac{c}{\beta^2}}{n}, \quad \frac{\partial^2 l_2^*}{\partial\alpha\partial\beta} = \frac{-\frac{n}{\alpha} - \left(\sum_{i=1}^{n}\left(-\frac{(\frac{x_i}{\alpha})^{\beta}\ln(\frac{x_i}{\alpha})\beta}{\alpha} - \frac{(\frac{x_i}{\alpha})^{\beta}}{\alpha}\right)\right)}{n} \tag{38}$$

5.Appendix

In this section, ML and approximate Bayes Estimators by Tierney-Kadane' approximation are obtained under Squared error loss function, Linex loss function and General Entropy loss function for unknown parameters of W distribution and results are compared in terms of mean squared error by using Monte Carlo simulation method. Mean squared error (MSE) is defined as follows;Let θ is the true parameter value and $\hat{\theta}_{(i)}\left(i=1,2,...,10000\right)$ is the estimation value in i^{th} replication. Then the MSE for Tierney-Kadane approximations can be written as,

$$MSE = \frac{1}{10000}\sum_{i=1}^{10000}\left(\hat{\theta}_{(i)} - \theta\right)^2 \tag{39}$$

Simulation steps are as follows:Step1: It is generated data from W distribution with $\alpha = 1, 1.5,\ \beta = 1.3, 1.7$ for the sample size n=20, 30, 50, 100.Step 2: ML estimates for parameters are computed by a solution of non-linear Eqs. (11-12) by using the Newton-Raphson method.Step 3: Tierney-Kadane Bayes estimates are computed for parameters under Squared error, Linex $a=\pm 0.8, \pm 1.5$ and General entropy $k=\pm 0.8, \pm 1.5$ loss functions using Jeffrey's extension prior (c=0.2).Step 4: Means squared errors are computed over 10000 replications by using Eq. (39).

6.Conclusion

In this study, approximate Bayes estimators under Squared error, Linex and General entropy loss functions obtained by using the Tierney-Kadane's method and ML's for W distribution with parameters are compared. The ML's of the unknown parameters are computed by using the Newton Raphson method. The approximate Bayes estimators are compared with the ML's in terms of MSE by using the Monte Carlo simulation method. As seen from Table 1 and Table 2, the performances of Bayes estimates for parameters and general entropy loss function are generally better than others in terms of MSEs. In addition, MSEs of ML and approximate Bayes estimates obtained under different loss functions are decreased when n is increased. Furthermore, MSEs of estimators are close to each other for large n values.İt is seen that the minimum MSE is reached even if the parameter values change when looking at Figures 1 and 2.In general, the ML estimators and estimators are obtained under the quadratic loss function are almost the same as MSE, and in some cases the linex loss function has the same MSE with general entropy loss function, while general entropy loss function often has a smaller MSE.

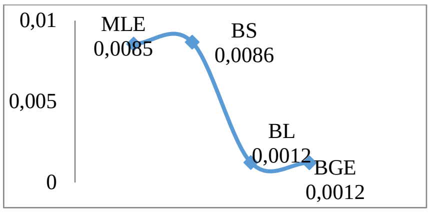

Figure 1. MSEs values for α=1.5 and β=1.7

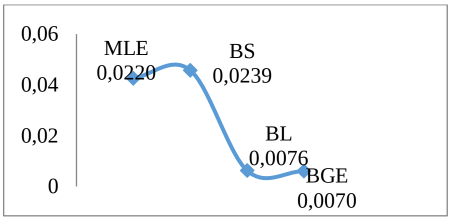

Figure 2. MSEs values for α=1 and β=1.3

Table 1. Mean estimates and MSEs for parameters of Weibull distribution $(a, k \pm 0.8)$

n	α	c	β	α ,	ML	BS	BL	BGE	ML	BS	BL	BGE
					$a = k = 0.8$				$a = k = -0.8$			
30	1	0.2	1.3	α_{MSE}	**0.022004**	**0.023935**	**0.007610**	**0.007089**	0.021749	0.023826	0.007772	0.006984
				α_{ME}	1.000476	1.033536	1.029985	1.020257	1.002649	1.035844	1.043469	1.032701
				β_{MSE}	0.046422	0.045170	**0.008289**	**0.006964**	0.046640	0.045415	0.008809	0.007107
				β_{ME}	1.364397	1.355320	1.347874	1.338887	1.363272	1.354210	1.370014	1.350367
	1.5	0.2	1.7	α_{MSE}	0.028945	0.030532	0.004226	0.004118	0.028336	0.030021	0.004380	0.004034
				α_{ME}	1.499102	1.531427	1.520957	1.516731	1.500584	1.533068	1.544775	1.530689
				β_{MSE}	0.080435	0.078229	0.008121	0.007032	0.077744	0.075671	0.008789	0.006926
				β_{ME}	1.788931	1.778696	1.754710	1.748446	1.783719	1.773503	1.800806	1.769439
50	1	0.2	1.3	α_{MSE}	0.012859	0.013555	0.004334	0.004115	**0.013030**	**0.013757**	**0.004447**	**0.004146**
				α_{ME}	1.000961	1.020859	1.019286	1.013165	1.001479	1.021337	1.025957	1.019487
				β_{MSE}	0.024779	0.024334	**0.004512**	**0.004090**	0.025153	0.024688	**0.004752**	**0.004157**
				β_{ME}	1.337451	1.331815	1.327961	1.322621	1.339448	1.333842	1.342863	1.331561
	1.5	0.2	1.7	α_{MSE}	0.017565	0.018109	0.002539	0.002490	0.017126	0.017705	0.002557	0.002444
				α_{ME}	1.498704	1.518280	1.512414	1.509669	1.499594	1.519100	1.526108	1.517694
				β_{MSE}	0.042597	0.041880	**0.004467**	**0.004129**	0.041346	0.040578	**0.004640**	**0.004015**
				β_{ME}	1.746877	1.740578	1.727203	1.723297	1.750987	1.744673	1.760201	1.742276
100	1	0.2	1.3	α_{MSE}	**0.006377**	**0.006567**	0.002105	0.002038	**0.006410**	**0.006578**	**0.002117**	**0.002047**
				α_{ME}	1.001266	1.011215	1.010638	1.007478	1.000161	1.010111	1.012450	1.009195
				β_{MSE}	0.011376	0.011256	0.002109	0.002000	0.011323	0.011212	0.002142	0.002006
				β_{ME}	1.319785	1.316903	1.315156	1.312507	1.318482	1.315603	1.319924	1.314472
	1.5	0.2	1.7	α_{MSE}	0.008430	0.008578	**0.001210**	**0.001198**	**0.008551**	**0.008667**	**0.001242**	**0.001220**
				α_{ME}	1.499987	1.509782	1.507014	1.505567	1.498607	1.508401	1.511918	1.507702
				β_{MSE}	0.019095	0.018908	**0.002055**	**0.001963**	**0.019217**	**0.019037**	**0.002139**	**0.001993**
				β_{ME}	1.724503	1.721269	1.714866	1.712890	1.723307	1.720076	1.727521	1.718894

Table 2. Mean estimates and MSEs for parameters of Weibull distribution $(a, k \pm 1.5)$

n	α	c	β	α β	ML	BS	BL	BGE	ML	BS	BL	BGE
					$a = k = 1.5$				$a = k = -1.5$			
20	1	0.2	1.3	α_{MSE}	0.031708	0.035951	0.038618	0.035970	0.032481	0.037079	0.044535	0.036985
				α_{ME}	0.999643	1.049293	1.027367	1.013366	1.002285	1.052084	1.080924	1.062769
				β_{MSE}	0.082520	0.079692	0.051532	0.039886	0.077694	0.074972	0.053068	0.037289
				β_{ME}	1.398143	1.385038	1.348326	1.339240	1.395629	1.382525	1.433962	1.395356
	1.5	0.2	1.7	α_{MSE}	0.042242	0.045765	0.021244	0.021252	0.043484	0.047233	0.025538	0.021656
				α_{ME}	1.499223	1.547709	1.514314	1.512944	1.500617	1.549138	1.585814	1.557600
				β_{MSE}	0.138847	0.133927	0.044144	0.039669	0.143650	0.138642	0.060878	0.039865
				β_{ME}	1.832416	1.817573	1.742855	1.747999	1.835069	1.820249	1.906590	1.835203
30	1	0.2	1.3	α_{MSE}	0.022542	0.024529	0.027120	0.025402	0.021511	0.023501	0.027633	0.024488
				α_{ME}	1.001508	1.034497	1.021067	1.011375	1.001393	1.034568	1.053076	1.041488
				β_{MSE}	0.046899	0.045606	0.028794	0.025092	0.045804	0.044595	0.031058	0.024463
				β_{ME}	1.366987	1.357906	1.335148	1.328881	1.362667	1.353607	1.385489	1.361996
	1.5	0.2	1.7	α_{MSE}	0.028042	0.029417	0.014015	0.014109	0.028327	0.029834	0.015692	0.014197
				α_{ME}	1.496258	1.528779	1.507386	1.506154	1.498274	1.530752	1.554361	1.536279
				β_{MSE}	0.077124	0.075157	0.026333	0.024567	**0.079072**	**0.077009**	0.032630	0.024385
				β_{ME}	1.779187	1.768993	1.722547	1.725018	1.782831	1.772606	1.824999	1.782292
50	1	0.2	1.3	α_{MSE}	**0.012965**	**0.013626**	0.015186	0.014596	0.013297	0.014032	0.016086	0.014812
				α_{ME}	1.000247	1.020112	1.012661	1.006556	1.001272	1.021225	1.032093	1.025302
				β_{MSE}	0.025682	0.025224	0.016344	0.014963	0.024191	0.023777	**0.016282**	**0.014135**
				β_{ME}	1.338425	1.332813	1.320102	1.316247	1.334954	1.329338	1.347366	1.334284
	1.5	0.2	1.7	α_{MSE}	0.017214	0.017837	0.008670	0.008626	0.016956	0.017379	0.008946	0.008523
				α_{ME}	1.501041	1.520582	1.508192	1.507317	1.495978	1.515490	1.529296	1.518751
				β_{MSE}	0.043107	0.042340	0.015477	0.014722	0.042769	0.042030	0.017263	0.014501
				β_{ME}	1.750684	1.744389	1.717540	1.718807	1.748588	1.742281	1.771790	1.747976
100	1	0.2	1.3	α_{MSE}	0.006467	0.006627	0.007423	0.007281	0.006479	0.006639	0.007546	0.007273
				α_{ME}	0.999718	1.009684	1.006190	1.003023	0.999741	1.009707	1.015036	1.011711
				β_{MSE}	0.011125	0.011022	**0.007212**	**0.006964**	0.010893	0.010792	**0.007310**	**0.006836**
				β_{ME}	1.317081	1.314195	1.308198	1.306236	1.316845	1.313959	1.322612	1.316400
	1.5	0.2	1.7	α_{MSE}	0.008538	0.008688	0.004291	0.004268	0.008427	0.008561	0.004339	0.004206
				α_{ME}	1.500520	1.510306	1.504310	1.503789	1.499575	1.509369	1.516190	1.510981
				β_{MSE}	**0.019582**	**0.019384**	0.007306	0.007112	0.019062	0.018878	**0.007567**	**0.006923**
				β_{ME}	1.725885	1.722650	1.709719	1.710240	1.723895	1.720668	1.734779	1.723475

ML:Maximum likelihood estimation
BS:Bayes estimation under squared error loss function
BGE:Bayes estimation under general entropy loss function
BL:Bayes estimation under linex loss function
α_{MSE} :MSEs for α parameter
β_{MSE} : MSEs for α parameter
α_{ME} : Mean estimate for α parameter
β_{ME} : Mean estimate for β parameter

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Seasonal Variations of Zooplankton in Nazik Lake (Turkey)

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Abstract: In this study, zooplankton community of Nazik Lake studied seasonally. Zooplankton samples were collected from three different stations with standart hydro-bios plankton net, both horizontally and vertically. In the lake 25 zooplankton species were identified. Zooplankton samples were consisted of 14 Rotifera, 8 Cladocera, and 3 Copepoda, respectively. Rotifera was the dominant group of zooplankton with regard to species numbers and densities

Key words: Rotifera, Cladocera, Copepoda, Nazik Lake

Nazik Gölü Zooplanktonunun Mevsimsel Değişimi (Türkiye)

Öz: Bu çalışmada, Nazik Gölü'nün zooplankton yoğunluğu mevsimsel olarak çalışıldı. Zooplankton örnekleri standart Hydro-bios plankton net ile hem horizontal hem de vertikal olarak 3 farklı istasyondan toplandı. Gölde 14 Rotifera 8 Cladocera, 3 Copepoda olmak üzere toplam 25 zooplankton teşhis edildi. Rotifera tür sayısı ve yoğunluğu bakımından zooplanktonun en baskın grubudur**.**

Anahtar kelimeler: Rotifera, Cladocera, Copepoda, Nazik Gölü

1. Introduction

The lakes comprise the one of the most productive ecosystems. Lake ecosystems are made up of physical, chemical and biological properties contained within these water bodies [1]. Zooplankton community always acts as a key component which transfers the energy in different trophic level in an aquatic ecosystem and it helps to regulate the productivity of the water body.

The primary function of freshwater zooplankton is an important component in aquatic ecosystems, which act as primary and secondary links in the food chain. Zooplankton community structure is affected by physical and chemical environment. These communities are also affected by biological interactions, predation and their competition for food resources [2]. Most groups of zooplankton have been used as a bioindicator for monitoring aquatic ecosystems and the integrity of water. Copepoda, Cladocera and Rotifer are filter feeding organisms, they play a significant role in food chain by transforming the phytoplankton to animal protein. Zooplankton community may be considered as a bioindicators of eutrophication, because they are coupled to environmental conditions, responding more rapidly to changes than do fishes, and are easier to identify than phytoplankton. Therefore, they are potential value as water quality indicators [3-4]. The aim of this study was to determine the zooplankton distribution of Nazik Lake qualitatively and quantitatively and to evaluate the zooplankton community.

2. Materials and Methods

Nazik Lake was located 25 km far from Van Lake and 16 km from northwest Ahlat. It is one of the volcanic set origin lakes of Eastern Anatolia Region. Lake has got 40-50 m deep. This freshwater lake is fed with melted snow and rain water, and can even be used as a road in winter due to the ice layer formed in the lake. Lake is also used for irrigation. In the lake, pearl mullet (*Alburnus tarichi*), mirrored carp (*Cyprinus carpio*) and *Capoeta cosswigi* have been caught economically. The irrigation of agricultural lands reduces the water level of the lake, the number of birds and fish species decreases due to illegal hunting. The disappearance of reeds due to unconscious animal grazing puts the existence of many living creatures in the lake in danger [5].

Zooplankton samples were taken seasonally between January 2014 - February 2015 from three different stations with 55µ mesh sized Hydro-bios plankton net and preserved with 4% formaldehyde solution (Fig, 1).

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Counting slide and Leitz brand inverted microscope were used to indicate the number of zooplankton per unit volume. For counting, the jar was shaken gently and 1 ml was taken by pipette and this process was repeated 10 times.

The number of organisms in m^3 was calculated by first comparing the results with the volume of the jars and then with the amount of water filtered through the plankton bucket. For detailed identification of organisms, Nikon scanning microscope was used. Some physico-chemicals parameters such as temperature, pH and dissolved oxygen have been measured in situ. Temperature and dissolved oxygen values were measured by an Oxi 315i/SET oxygen-meter, pH by a Lamotte (pH 5-WC) model pHmeter. The species were identified by using relevant literature [6-12].

Figure 1. Sampling stations in Nazik Lake [13].

3. Results

In Nazik Lake totally 25 zooplankton species have been identified. From these species 14 species from Rotifera, 8 species from Cladocera and 3 species from Copepoda have been identified. In the lake the most number of species have been recorded from station I st (15 species) (Table 1). Rotifera was the most recorded group with 56%, followed by Cladocera with 32% and Copepod with 12% (Figure 2).

The highest numbers of individuals (ind/m^3) was at spring at 2nd station (312224 ind/m^3), the least numbers of individual in winter at 2nd stations (1020 ind/m^3) (Figure 3).

Table 1. Distribution of zooplankton species in the stations of Nazik Lake

Species name	Stations		
	I	II	III
Rotifera			
Ascomorpha saltans Bartsch, 1870	-	-	+
Asplachna priodonta Gosse 1850	+	+	+
Asplanchna sieboldi (Leydig, 1854)	-	-	+
Cephalodella forficula (Ehrenberg 1830	-	+	+
Encentrum saundersia (Hudson, 1885)	-	+	-
Euclanis dilatata Ehrenberg 1832	-	-	+
Filinia longiseta (Ehrenberg, 1834)	-	+	-
Flinia terminalis (Plate, 1886)	-	+	-
Keratella quadrata (Müller, 1786)	+	+	+
Lecane ohioensis (Herrick, 1885)	+	-	-
Philodina roseola Ehrenberg, 1832	+	-	+
Polyarthra dolichoptera Idelson 1925	+	+	+
Polyarthra remata Skorikov 1896	+	-	-
Trichotria tetractis (Ehrenberg, 1830)	+	-	-
Cladocera			
Alona rectangula Sars, 1862	+	-	+
Bosmina coregoni (Baird, 1857)	+	-	-
Bosmina longirostris (Müller 1785)	+	-	+
Daphnia cucullata Sars, 1862	+	-	-
Daphnia galaeta Sars, 1864	-	+	-
Daphnia longispina Müller, 1785	+	-	-
Daphnia magna (Straus, 1820)	-	+	-
Diaphaosoma birgei Korinek, 1981	+	-	+
Copepoda			
Acanthodiaptumus denticornis (Wierzejski, 1887)	+	-	-
Cyclops vicinus Uljanin 1875	+	+	+
Nitokra hibernica (Brady, 1880)	-	+	-
Total taxa number	**15**	**11**	**12**

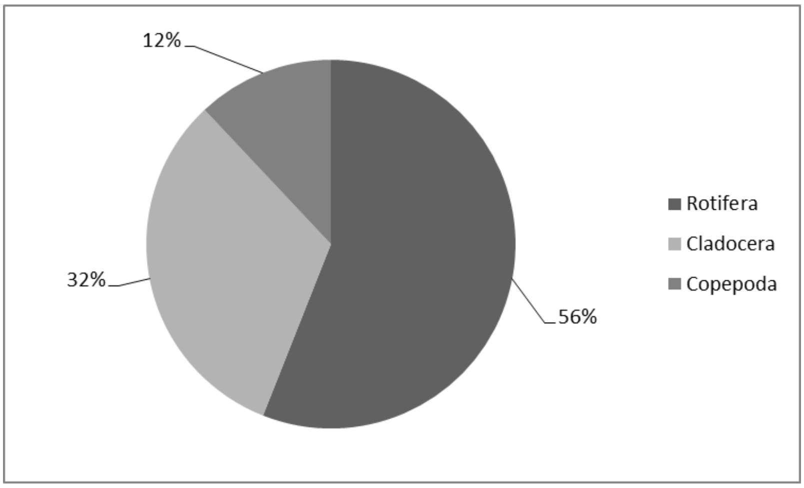

Figure 2. Relative densities of zooplankton species according to groups

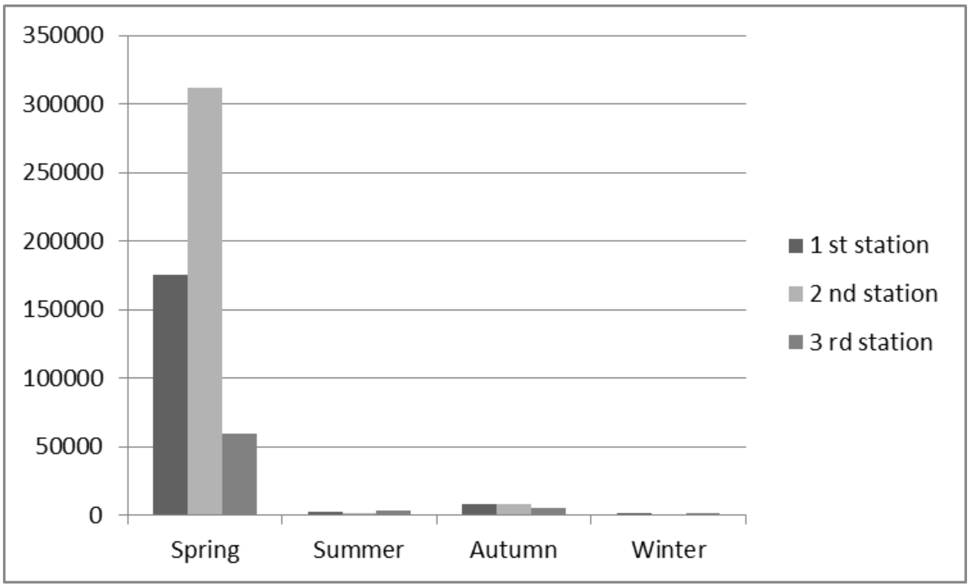

Figure 3. Number of individuals in the stations (ind/m^3) in Nazik Lake.

In the Lake, temperature ranged from 7.50°C to 28.6°C. The highest water temperature values was measured at station 3 (28.6 °C), whereas the lowest value was observed at station 1 (7.5 °C). The pH values varied from 9.1 to 9.6. The highest DO value was measured at 2 nd station with 10.5 mg/L the lowest at 1 st station with 7.5 mg/L (Table 2).

Table 2. Temperature, pH and dissolved oxygen values of Nazik Lake

Parameters	1st station			2nd station			3th station		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Water temperature (°C)	7.5	27.6	16.4	8.7	28.2	16.9	9.1	28.6	17.2
pH	9.1	9.3	9.2	9.0	9.4	9.2	9.1	9.6	9.4
Dissolved Oxygen (mg/L)	7.5	10.5	9.05	8.0	10.4	9.58	7.6	10.2	9.30

4. Discussion

In this study, totally 25 species were recorded. 14 species from Rotifera, 8 species from Cladocera and 3 species from Copepoda were recorded. According to the results of this study, Rotifera is recorded as the dominant zooplankton group. The family Brachionidae was found to the most dominant group (with 3 species, *Asplanchna priodonta Keratella quadrata*, *P. dolichoptera* and *C. vicinus* was observed in all stations in every seasons. The number of zooplankton species showed an increase in spring and autumn, decrease in winter.

Dumont and De Ridder [14]. stated some species as *Lecane luna*, *Keratella cochlearis*, *Keratella quadrata* have got high tolerance to some factor as pH, salinity, oxygen and temperature. From these species K. quadrata observed in all stations. The species that are observed in almost all seasons such as *K. quadrata* and *A. priodonta* have a wide temperature tolerance [6]. It is reported that the pH is significantly effective in the distribution of zooplankton and that the alkali limit in density is pH 8.5 [15]. In Nazik Lake pH levels are over alkali limit. But zooplankton species has showed adaptation to these pH values. The oxygen tolerances of most Rotifera species are quite wide [7-8]. In the study area dissolved oxygen level changed between 7.5-10.5 mg/L. These values had not got negative effect on zooplankton distribution.

Studies in Ladik Lake [16] and Ulaş Lake [17] demonstrated that Rotifera group was dominant over other zooplankton groups with respect to both species diversity and individual numbers as in Nazik Lake.
The zooplankton structure of, Hancağız, Kalecik, Beyhan, Uzunçayır, İkizcetepeler and Keban Dam Lakes were showed similarities with this study's findings [18-23]. In all of these dam lakes, rotifers were found to be the dominant species as species richness and frequency of occurrence. In Nazik Lake also species from Rotifer took first place as frequency of occurrence and individual numbers among the other zooplankton groups.

In Van Lake [24] a total of 20 species (14 belonged to genus of Rotifera, 4 to Copepoda and 2 Cladocera) in Ulaş Lake (Sivas) [17] 30 species (18 belonged to genus of Rotifera, 8 to Cladocera and 4 to Copepoda) in Mogan Lake (Ankara) [25] 33 species (25 belonged to genus of Rotifera, 7 to Cladocera and 1 to Copepoda) have been identified. In all of these lakes Rotifers were dominant as species richness and diversity like Nazik Lake. All of the identified zooplankton species are the first record for Nazik Lake.

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Difficulty of Learning English Language by Turkish Nationalities and Learning Turkish Language by Foreign Students in Turkey: A Case Study for Elazig Metropolis

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Abstract: Learning any language as a second language is generally considered difficult due to some contributing factors. English language being the top global language, has made it a necessity for Turkish natives to learn the language at all levels of Education. Foreign students in Turkey on the other hand, has to learn the Turkish language and present a proficiency certificate before they are being absorbed into their respective course of study departments. This study hypothesized that, the factors determining difficulty in learning English by Turkish natives are the same factors causing difficulty in learning Turkish language by foreign students in Turkey. Paired sample t-test was used as a statistical measure to investigate the statistical significance between variables of interest that aid the difficulty in learning these two languages.

Key words: Second language, English language, Turkish language.

Türk Uyrukluların İngilizceyi Öğrenme Zorluğu ve Türkiye'deki Yabancı Uyruklu Öğrencilerin Türkçeyi Öğrenme Zorluğu: Elazığ Şehri Örneği

Öz: Herhangi bir dili ikinci bir dil olarak öğrenmek, bazı katkıda bulunan faktörler nedeniyle genellikle zor olarak kabul edilir. En iyi küresel dil olan İngilizce, Türk yerlilerinin dili tüm eğitim seviyelerinde öğrenmelerini zorunlu kılmıştır. Öte yandan, Türkiye'deki yabancı öğrenciler, Türkçe dilini öğrenmek ve kendi çalışma bölümlerine girmeden önce bir yeterlilik belgesi sunmak zorundadır. Bu çalışma, Türk yerlileri tarafından İngilizce öğrenmede zorluk çeken faktörlerin, Türkiye'deki yabancı öğrenciler tarafından Türkçe öğrenmede zorluk çeken faktörlerle aynı olduğu varsayılmıştır. Eşleştirilmiş örneklem t-testi, bu iki dili öğrenmede zorluk çeken ilgi değişkenleri arasındaki istatistiksel önemi araştırmak için istatistiksel bir ölçüt olarak kullanılmıştır.

Anahtar kelimeler: İkinci dil, İngilizce dili, Türkçe dili.

1. Introduction

Learning any language other than mother's tongue or native language by any individual is generally considered a challenging task by most of the researchers in the field [1]. Although children have the advantage of acquiring (learning to read, write, and speak), second language termed L2 in the literature by far faster with little or no noticeable hitch, the case is always different with adults [2]. Eventually, globalization has made it a lifestyle for individuals especially in adulthood to travel around the world for either knowledge acquisition, business collaboration or even attaining medical health fitness [3]. It is apparently not a debating issue that, learning a second language, for communication purpose amongst other subjects is a necessity. However, factors such as first language influence [1 - 4], age, gender [5], individual difference in auditory processing [3], language grammatical judgement, time constraints and learning anxiety [5 - 7], and many other factors are a major constraint in learning a second language. This study intend to evaluate the difficulty similarities, even factors, and major challenges in learning English Language by Turkish nationalities as compared to learning Turkish language by foreign students in Turkey.

2. Learning English as a Foreign Language by Turkish Nationalities

English language being the number one lingua franca largely spoken by almost all countries in the world and most especially in westernized schools, it is one becoming almost impossible for students to take lesson in other language besides English. Turkey is one of the countries that conducts its instructional lessons in their native language. As English turned into the built up language of science, innovation and exchange its utilization as the

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vehicle of guidance at tertiary training has expanded in Turkey [8]. The new world has make it a necessity for Turkish to learn English at almost every level of Education system. One of the functions of Turkish academic system is to organize enough and qualified economists. To open ways for these qualified hands, for economic and social improvement, it is an added advantage to understand even over one foreign language, English especially [9]. For these, the Turkish people in learning English as a second language face a number of difficulties and challenges.

2.1. Factors affecting Learning English Language by Turkish Nationalities

Amongst the major factors that make learning English a challenge includes age, individual socio-economic class, approach, teaching methods and techniques, teaching-learning environment and cultural differences, and attitude [10]. Other factors may include individual interest, anxiety [6], zeal and determination to learn. Social interaction of a person that is ability to communicate freely with other English learning students or English native speakers constitutes a great role towards learning English. Other factors may include gender.

2.2. Learning Turkish as a Foreign Language by Foreigners in Turkey

It will be imprudent of any foreigner to migrate to any country of choice for whatsoever reason and not learn the language of those people. Foreign students in most of the Turkish institutions have it mandatory to learn Turkish because quiet a number of Turkey institutions still offer their lessons using native tongue. However, threat of learning a second language is inevasible in the course of learning Turkish by any foreign student. Although, it would have been made easier to learn if Turkish was an option and not compulsory upon foreign students who attend lessons in English language. This comes to picture due to the fact that, self-regulated learning seems by far fun learning, persistent and more enduring. It allows students to build-up knowledge by pinpointing their learning targets, self-steering their learning progression and self-assessing their achievement counter to targeted goals [11].

2.3. Factors affecting Learning Turkish Language by Foreign Students

Unless for Arabic natives, especially those around the Syrian side that have many phonological similarities with Turkish, other foreign students will find it difficult learning Turkish language within a short period.

As stated in their work, [4] explained that Theoretical models altercate that listeners' perception of second language sounds is massively determined by their native language phonology. In addition to that, foreign students learning Turkish will face another obstacle taking the fact that, they are learning in a group of people from different demographic region, different native accent and different ways of acquiring knowledge in school. With this hindrance, the advantage of cooperative learning as introduced by [12] that cooperative learning in the foreign language classroom is conceived to maximize target language use, revamp intercommunication proficiency, construct confidence and enhance learner self-determination. This is because, majority of the students do not understand their individual native tongues alas the new language they are acquiring. Therefore, tendency of facing a great challenge during the period of learning Turkish is inescapable.

3. Methodology

Data sampling was conducted in two phases using an online questionnaire including open-ended and close-ended questions. The variables used in conducting the research include, interest of learning the second language, degree of difficulty, proficiency level, first learning environment, relevance of the second language to actual course of study, duration of learning as well as age group.

Phase I questionnaire was circulated across Turkish natives in Elazig metropolis learning English Language within the age group of 15-26. Thirty (30) randomly selected responses across both gender was collected. This sample was used to evaluate the difficulties students face while learning English language. The second phase questionnaire was distributed among international/foreign students living within Elazig metropolis. Thirty responses were randomly selected and used for evaluating the difficulty faced by the students in learning Turkish language.

3.1. Participants Measurens

Phase I: Thirty participants of both gender collectively responded to the questionnaire, 33.3% were male students where as 66.7% were female. 52.4% belong to 18-20 years, 19% 15-17 years, 19% 21-23 years and 9.5%

belong to 24-26 age group respectively. The first environment of learning English was in the proportion of 47.6%, 23.8% for the first two, and 9.5% for three other environments. Al participants stated high interest of learning English language. Duration of learning of the participants was recorded in the proportion of 10% for one year of learning, 6.6% for two years, 6.6% for three years, and 70% for duration longer than three years.

Phase II: Thirty responses was recorded in proportion of 64% male and 36% female foreign students. The age grouping as in phase I was in the proportion of 4%, 32%, 24%, 12% and 28% respectively. Duration of learning was apportioned in the ratio of 60%, 16%, 4%, 4%, and 16% respectively for just starting, 1 year, 2 years, 3 years and others category. All participants showed positive interest of learning Turkish language.

3.2. Findings

Headings, Paired sample T-Test was conducted on the sample dataset to correlate whether there is significant difference in the difficulty level experienced by Turkish natives while learning English in comparison to the difficulty faced by foreign students learning Turkish language. The findings were based on null and alternative hypothesis developed for the study.

Null Hypothesis H0: Factors determining difficulty in learning English language are the same with factors determining difficulty in learning Turkish language.

H0: FDDE = FDDT

Alternative Hypothesis H1: Factors determining difficulty in learning English language are not the same with factors determining difficulty in learning Turkish language.

H1: FDDE ≠ FDDT

If significance is > 0.05 we fail to reject our null hypothesis otherwise we reject.

The following tables show the results of the findings computed by the statistical tests.

3.3. Results

Table 1 below illustrates the paired sample statistics for the paired groups based on variables of interest. The statistics determines the t- value used for the actual paired samples tests. Only at P (3) where interest level of the participants to learn the respective languages is zero. This is because, all participants show the same interest towards learning a second language, hence, no significant difference in the interest and therefore no t-value is computed for the paired variables because standard error of the difference between the paired variables is 0.

Table 1. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Gender_T	1.57	30	.504	.092
	Gender_E	1.23	30	.430	.079
Pair 2	Age group_T	3.20	30	1.243	.227
	Age group_E	1.97	30	.890	.162
Pair 3	Learning Interest_T	1.00a	30	.000	.000
	Learning Interest_E	1.00a	30	.000	.000
Pair 4	Learning Duration_T	1.96	28	1.453	.274
	Learning Duration_T	4.46	28	1.036	.196
Pair 5	Proficiency Level_T	1.63	30	1.033	.189
	Proficiency Level_E	3.97	30	.556	.102
Pair 6	Difficulty Level	3.90	30	.885	.162
	Difficulty Level_E	2.50	30	.861	.157
Pair 7	Difficulty Factor	1.83	30	.986	.180
	Difficulty Factor_E	2.30	30	1.208	.221
Pair 8	Mandate Turkish	1.67	30	.479	.088
	Mandate English	1.10	30	.305	.056
Pair 9	Turkish Relevancy	3.17	30	1.763	.322
	English Relevancy	1.13	30	.346	.063

a. The correlation and t cannot be computed because the standard error of the difference is 0.

Table 2 on the other hand illustrates the paired sample correlations. Negative correlations as in the case of P(4), P(5), P(6), and P(9) indicate that as one of the pair increase, the other variable decreases therefore they are negatively correlated. However, All significant differences are greater than 0.05 therefore we fail to reject our null hypothesis and accept that factors determining the difficulty in learning English language are the same with factors determining difficulty in learning Turkish language.

Table 2. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Gender_T & Gender_E	30	.164	.385
Pair 2	Age group_T & Age group_E	30	-.087	.646
Pair 4	Learning Duration_T & Learning Duration_T	28	-.186	.345
Pair 5	Proficiency Level_T & Proficiency Level_E	30	-.022	.908
Pair 6	Difficulty Level & Difficulty Level_E	30	-.204	.280
Pair 7	Difficulty Factor & Difficulty Factor_E	30	.188	.319
Pair 8	Mandate Turkish & Mandate English	30	.000	1.000
Pair 9	Turkish Relevancy & English Relevancy	30	-.207	.271

Table 3 is the depiction of the actual paired sample test taking a confidence level of 95%.With alpha value of 0.5%, none of the resultant significant differences lie within the critical region all values are in the range of ±1.96 Z score. We therefore have statistical evidence of not rejecting the null hypothesis. At P(5), the t-value is negative in relation to the hypothesized mean, which is also -2.333. In spite of that, we fail to reject our null hypothesis since t-value is lower than the mean hypothesis.

Table 3. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Gender_T - Gender_E	.333	.606	.111	.107	.560	3.010	29	.005
Pair 2	Age group_T - Age group_E	1.233	1.591	.290	.639	1.827	4.247	29	.000
Pair 4	Learning Duration_T - Learning Duration_T	-2.500	1.934	.366	-3.250	-1.750	-6.840	27	.000
Pair 5	Proficiency Level_T - Proficiency Level_E	-2.333	1.184	.216	-2.776	-1.891	-10.792	29	.000
Pair 6	Difficulty Level - Difficulty Level_E	1.400	1.354	.247	.894	1.906	5.662	29	.000
Pair 7	Difficulty Factor - Difficulty Factor_E	-.467	1.408	.257	-.992	.059	-1.816	29	.080
Pair 8	Mandate Turkish - Mandate English	.567	.568	.104	.354	.779	5.461	29	.000
Pair 9	Turkish Relevancy - English Relevancy	2.033	1.866	.341	1.337	2.730	5.969	29	.000

4. Conclusion

From indication of the results, learning any language as a second language especially for adults is very challenging. The paired sample t-test used, is statistically evident that we fail to reject our null hypothesis. Although two different languages were, measured standing on the same difficulty variables, the factors hindering the efficient learning of any non-native language can be mostly controlled if not for the effect of first language influence. Looking at the responses from the participants learning English language it can be said that learning English language in Turkey is still premature although the efforts applied in improving this barrier cannot be over looked, learning English language by Turkish natives is developing day by day.

All of the participants have high interest of learning the language yet, even those that have spent years learning find it difficult acquiring expertise in the language. As a suggestion, instructional materials should be made simple for students to understand, especially in the language structure contents as most of participants claimed grammar and vocabulary as the most tedious aspect of it. Although teachers' attitude towards teaching was not evaluated in this study, it is recommended that teachers improve especially in those areas students find difficulty in learning the language.

Improving the English-medium especially for students from high school and above will help Turkish nationalities attain the ultimate goal of academics. Foreign students on the other hand, having shown a positive interest of learning Turkish as a second language, majority do not support making the language compulsory for them. This is because, pressure and demand of high expectation in the language proficiency outcome becomes a burden for students.

Undoubtedly, majority of the lessons learnt are being taught in English language, hence most foreign students will find it difficult to learn the Turkish almost perfectly if it were a compulsion. Learning language is faster through communication and especially through cooperative learning therefore making learning Turkish language should be an option for the foreign students. Otherwise, the learning methods should be integrated with lots of fun learning by introducing frequent presentations and extracurricular activities such as drama.

To sum it up, difficulty in learning a second language should not be a barrier to learning the language. Having additional language to speak and communicate with besides native language or first language is amazing. Second language use will fast break the bridge of inter cultural/racial variance and differences and would help boost economy, as globalization is vast.

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Determination of Mechanical Properties of the Concrete Affected by High Temperature by Destructive and Non-Destructive Test Methods

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Abstract: In this study, the effects of the elevated temperature on concrete specimens prepared with different aggregate types were investigated. For this purpose, 4 different series were prepared by using CEM I 42,5 (N) type Portland Cement and four different types of aggregates (basaltic crushed aggregate, stream aggregate, limestone and pumice as lightweight aggregate). 100 mm and 150 mm cube concrete samples were prepared for each series. When reached the specified curing age, prepared each concrete specimen was taken from the curing pool and exposed to high temperatures of 300 ºC, 600 ºC and 900 ºC respectively. Control specimens of each series were stored at room temperature. The compressive strengths, ultrasonic pulse velocity and the adherence strength of the concrete samples exposed to these temperatures were examined. At the end of this study, the compressive strengths of the series exposed to high temperature are compared. It is observed that the series which is produced with basaltic crushed aggregate is least affected and the series which is produced with lightweight aggregate is the most affected from the elevated temperature. Pull-out tests were carried out to the all prepared series and it was found that the adherence strength between the concrete and the reinforcement decreased as the temperature increased.

Key words: High temperature, adherence strength, pull-out, ultrasonic pulse velocity, concrete.

Yüksek Sıcaklıktan Etkilenen Betonun Mekanik Özelliklerinin Tahribatlı ve Tahribatsız Muayene Yöntemleri ile Belirlenmesi

Öz: Bu çalışmada, yüksek sıcaklıkların farklı agrega tipleri ile hazırlanan beton örnekler üzerindeki etkileri araştırılmıştır. Bu amaçla, CEM I 42.5 (N) tipi Portland Çimentosu ve dört farklı tipte agrega (bazaltik agrega, dere agregası, kireçtaşı ve hafif agrega olarak pomza) kullanılarak 4 farklı seri hazırlanmıştır. Her seri için 100 mm ve 150 mm küp beton örnekleri hazırlanmıştır. Belirtilen kürlenme yaşına geldiğinde, hazırlanan her bir örnek kürleme havuzundan alınmış ve sırasıyla 300ºC, 600 ºC ve 900 ºC yüksek sıcaklıklara maruz bırakılmıştır. Her serinin kontrol örnekleri ise oda sıcaklığında bekletilmiştir. Basınç dayanımı, ultrasonik ses hızı ve bu sıcaklıklara maruz kalan beton numunelerin yapışma dayanımı incelenmiştir. Bu çalışmanın sonunda, yüksek sıcaklığa maruz kalan serilerin basınç dayanımları karşılaştırılmıştır. Bazaltik agrega ile üretilen beton serilerinin yüksek sıcaklıktan az etkilendiği buna karşın hafif agrega (pomza) ile üretilen beton serilerinin yüksek sıcaklıktan çok daha fazla etkilendiği görülmüştür. Hazırlanan tüm beton serilere çekip-çıkarma (pull-out) testi yapılmış ve sıcaklık arttıkça beton ile donatı arasındaki yapışma kuvvetinin azaldığı saptanmıştır.

Anahtar kelimeler: Yüksek sıcaklık, aderans dayanımı, çekip-çıkarma, ultrasonik ses hızı, beton.

1. Introduction

Fire hazards cause extensive damage to structures built without sufficient resistance to high temperatures. Therefore, it is very important to build structures resistant to high temperatures. It is only possible to provide resistance to high temperatures with the use of structural material resistant to high temperature. Concrete is known to be the most commonly preferred structural material for construction operations. Reasons such as abundance of the concrete raw material in nature, ease of giving shape to it, its extended life cycle, and its convenience in terms of its strength and cost-effectiveness make concrete an indispensible building material. With the rapidly increasing population and advancements in the construction technologies, the importance of this material ever increases as it is commonly used in structures such as residences, factories, bridges, dams, roads, etc.

Concrete is a structural material, a mix of cement, aggregates, water along with additives and is the final form of cement which is initially hydrated and in a plastic-like concentration- after setting[1]. Properties of the

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materials used to produce concrete and their ratios affect the quality and performance of concrete [2,3]. Each one of the materials used has an impact on the concrete. It is known that aggregates are one of the main elements influencing the properties of concrete as constituent materials. The strength of concrete produced using different aggregates are not the same under high temperatures [4, 5]. This can be accounted for the mineral content of the aggregates. When considered as a whole, the components of concrete are known to have different thermal expansion coefficients. For this reason, temperature change in concrete will lead to different volumetric changes in its constituents which will lead to the formation of cracks and therefore, reduced concrete strength. This can be referred to as "thermal incompatibility of concrete components" [6, 7].
According to the research, high temperatures affect the durability of a structure and cause significant damage. Such an effect may cause permanent damage in the structure which may even result in material and immaterial damages [8].

As an example, the fires in the Great Belt Tunnel and Channel Tunnel in 1994 and 1996, respectively, led to explosions and destruction of the concrete profile due to high temperature and the fire building caught after the planes hit WTC in 9/11 claimed many lives in New York, USA. As it is clear from these examples, the thermal resistance of structural material is of utmost importance [9,10,11].

Concrete may explode under high temperatures. Such an explosion leads to or triggers other threats in addition to the fire hazard itself. Research attempted to estimate the behavior of the structural material during and after a fire hazard in terms of its structural safety and its integrity [12]. Previous studies often focused on the effects of high temperature on the "normal-strength concrete" [13]. However, modern structures of our time use "high-performance and high-strength concrete" with the addition of chemicals and minerals designed for industrial structures, tunnels or custom structures. The reason behind this preference is the economical, architectural and structural advantages such material has to offer. High-strength concrete is advantageous when compared to normal-strength concrete. Provision of appropriate fire safety measures is a necessary aspect of any construction design. The concrete used needs to be identified for its behavior under the effects of high temperature. As the porosity of high-strength concrete is lower in comparison and as it has a more compact structure, the performance of such concrete under the effect of high temperature is poor when compared to normal-strength concrete [14].

This study explores the effects of high temperature on the mechanical properties of concrete produced using different types of aggregates. For this purpose, properties of different types of fresh and hardened concrete produced using four types of aggregates were investigated using destructive and nondestructive methods.

2. 2. Materıals and Methods

2.1. Materials

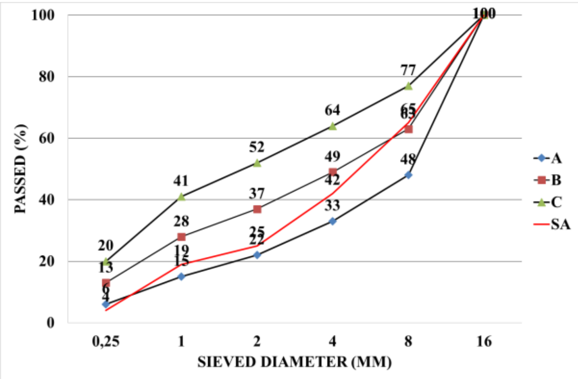
2.1.1.Aggregate

A total number of four different types of aggregates, namely, basaltic crushed stone, stream aggregate, limestone, and natural aggregate, were used in the experimental study. Fine and coarse aggregate were used the same type raw material in the each mix design. Physical properties of the aggregates are shown in Table 1.

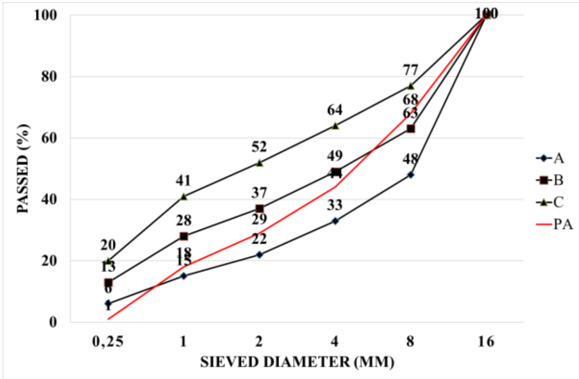
Table 1. Physical properties of the aggregates subjected to the test.

Aggregate Type	Specific Gravity (kg/dm^3)	Water Absorption (%)
Basaltic Crushed Stone	2,70	1,12
Natural (stream)	2,79	0,93
Pumice	1,91	22,33
Limestone	2,66	1,33

The results of the sieve analysis for natural (stream) aggregate, pumice, limestone and basaltic crushed stone aggregate are shown in Figure 1. In this study, aggregate D max is taken as 16 mm (Figure 1). Fine and coarse aggregate were proportions of 0-4 and 4-16 for each concrete.



(a)



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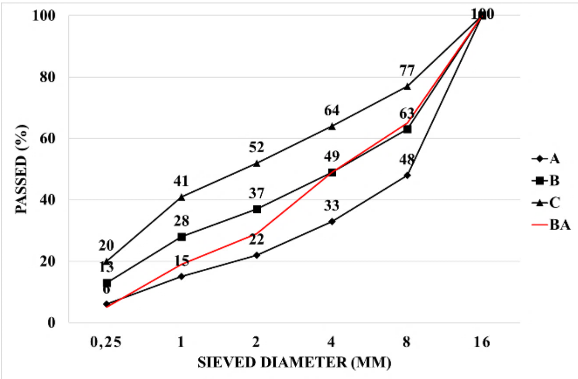

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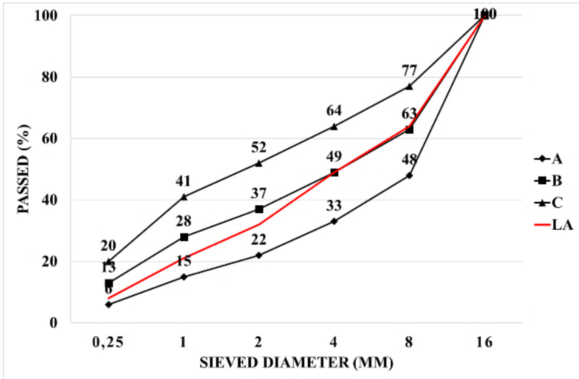

(d)

Figure 1: Aggregate granulometry: (a) Stream (Natural) Aggregate (SA); (b) Pumice (PA); (c) Basaltic Crushed Stone (BA); (d) Limestone (LA)

2.1.2. Cement

The type of cement used in the experiments was CEM I 42,5 N cement obtained from the Elazig Cement Factory. Dosage was constant in this study and it was defined as 400 kg/m^3. Physical and mechanical properties and chemical composition of the cement are shown in Table 2.

Table 2. Physical -mechanical properties and chemical composition of the cement

CEM I			
Chemical composition (%)		**Physical and mechanical properties**	
CaO	62,94	Specific gravity (kg/dm^3)	3,07
SiO_2	21,12		
Al_2O_3	5,62	Specific surface (cm^2/g)	3382
Fe_2O_3	3,24		
MgO	2,73		
SO_3	1,79	Compressive strength at 28th day (MPa)	51,7
Loss on ignition	1,78		

2.1.3. Mixing water

Mains water provided for the city was used as the mixing water in accordance with the TS EN 1008 standard for the concrete mix obtained.

2.2. Methods

Coding and definition of each one of the four series are shown in Table 3. Produced in accordance with this table and placed in casts of 100x100x100 mm and 150x150x150 mm (Figure 2) in size, concrete samples were then removed from casts and placed into a curing tanks which is saturated with lime at 23±2 °C to be taken out at the end of the specified curing time. Fresh concrete tests and destructive and nondestructive hardened concrete tests were performed on the samples as per the standards.

Table 3. Definitions and codes of concrete samples

Sample code	Definition of the sample	Aggregate type	Sample size (mm)
NC-1	100 mm^3 concrete sample with natural aggregate	Natural (Stream) aggregate	100x100x100
NC-2	150 mm^3 concrete sample with natural aggregate		150x150x150
PC-1	100 mm^3 concrete sample with pumice aggregate	Pumice aggregate	100x100x100
PC-2	150 mm^3 concrete sample with pumice aggregate		150x150x150
BC-1	100 mm^3 concrete sample with crushed stone aggregate	Basaltic crushed stone	100x100x100
BC-2	150 mm^3 concrete sample with crushed stone aggregate		150x150x150
LC-1	100 mm^3 concrete sample with limestone aggregate	Limestone aggregate	100x100x100
LC-2	150 mm^3 concrete sample with limestone aggregate		150x150x150

Figure 2. Cubic concrete samples produced using four different types of aggregates in two sizes (100x100x100 mm & 150x150x150 mm)

Slump test was conducted on the concrete samples in order to test the placeability of concrete before casting the concrete. Slump test was conducted in accordance with the TS EN 12350-5 standard in order to obtain information on the placeability of fresh concrete. In this study, flow diameter range of 420-480 mm was taken for the F3 class available in Table 4.

Table 4: Slump test class table

Class	Flow diameter (mm)	Tolerance
F1	< 340	+ 30
F2	350 - 410	
F3	420 - 480	
F4	490 - 550	
F5	560 - 620	
F6	>630	

Temperature tests were conducted only for samples cured for 28 days. Samples were subjected to high temperatures of 300 ºC, 600 ºC and 900 ºC [11] using a Protherm HLF 150 lab type furnace with a capacity of 1200 ºC and a heating speed of 6 ºC/min located in the Construction Lab of Fırat University. Baradan et al. (2002) reported that the strength of concrete is not affected by temperatures below 250°C. Therefore, the first test temperature was selected as 300°C which was then increased by 300°C for other tests. Having exposed to high temperatures, samples were then kept in a drying oven at 100±5 ºC until they reached saturated surface dry condition before they were treated in the stove. The furnace was set to automatically turn off after 1 hour having provided the specific testing temperature and the samples were then stored to cool down at room temperature. All the samples were subjected to destructive and/or nondestructive compressive strength tests and the data obtained was compared with that of the samples treated under room temperature (18-22°C).

Cubic samples were then subjected to destructive uniaxial compressive strength test using an automated press with the capacity of 3000 kN in accordance with the TS EN 12390-3 standard. Adhesive strength of the samples was also tested using the pull-out test method, another destructive method. However, this test was only conducted on the samples with 15x15x15 cm dimensions as thickness is an important variable for this test. INSTRON 8503 Pull-Out Device was used for the pull-out test having the speed set to 2 mm/min.

Ultrasonic pulse velocity test was performed on all the samples as per ASTM C 597-09 standard using an ultrasound measuring device with the sensitivity at 0.1 µs. 2 readings, from four opposing surfaces, were taken and the averages of the results obtained were used.

3.Results

3.1 Assessment of the Ultrasonic Test Results

Samples were investigated using the ultrasonic test method, a nondestructive test method, and implications were derived having assessed the effect of high temperature on the pore structure of concrete (Figure 3). As the ultrasound traveling time will be longer in concrete with higher porosity, natural (stream) and crushed stone aggregates showed similar properties, while the ultrasonic pulse velocity of the concrete produced using limestone and pumice were relatively higher (Figure 3). Among the control aggregates, the lowest ultrasonic pulse velocity was found for concrete with lightweight (pumice) aggregate with 3,4 mm/µs while the highest ultrasonic pulse velocity was found for concrete with crushed stone aggregate with 4,83 mm/µs (Figure 3). A closer look into the ultrasonic pulse velocity of concrete subjected to high temperatures showed that the velocity decreases by 21% at 300 ºC, by 65% at 600 ºC, and by 85% at 900 ºC. The results showed that the thermal incompatibility between aggregate and cement paste under the effect of high temperature increases the porosity, therefore decreases the ultrasonic pulse velocity (Figure 3) Kristensen and Hansen (1994) reported similar findings in their study.

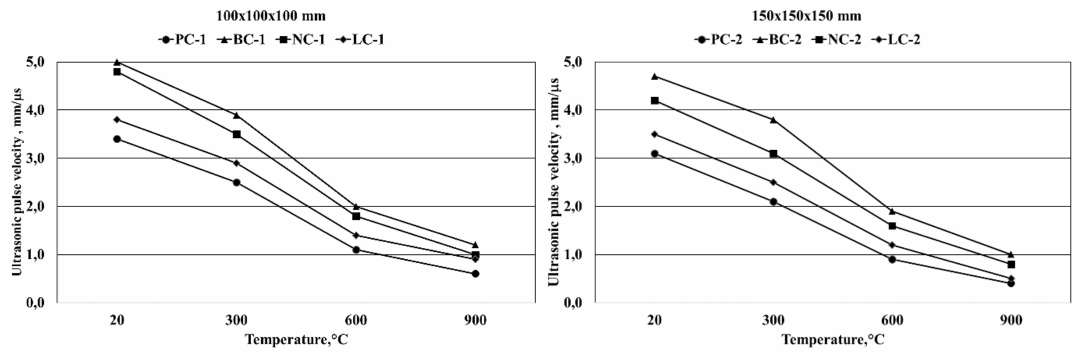

Figure 3. The relationship between ultrasonic pulse velocity (UPV) and temperature for the samples of 100x100x100 mm and 150x150x150 mm in size.

3.2. Assessment of the Compressive Strength Results

Each hardened concrete sample was subjected to compressive strength test. These tests revealed the relationship between high temperature and compressive strength of the concrete. The results showed that series with crushed stone aggregate offers the highest compressive strength while series with lightweight aggregate offers the lowest (Figure 4). It was detected that the loss of strength of the concrete subjected to high temperatures was 5%, 45% and 70%, respectively, for 300 ºC, 600 ºC and 900 ºC (Figure 4). The solid elements of the calcium silicate hydrate (CSH) which makes up the gel texture of the cement paste binds with the help of adsorption water. Adsorption water of the gel and chemically bound water in hydrates start to evaporate at 300 ºC, while the water available in capillary voids may start to evaporate at around 100 ºC. Evaporated water results in retreat. The retreat and the vapor pressure building up in concrete results in cracks in the concrete and therefore material removal. Thus, it leads to decreased compressive strength for the concrete subjected to high temperature. Nevertheless, compressive strength of the concrete produced using three different aggregates (pumice, limestone and stream aggregate) was found to be 10 MPa at 900 ºC. (Figure 4)

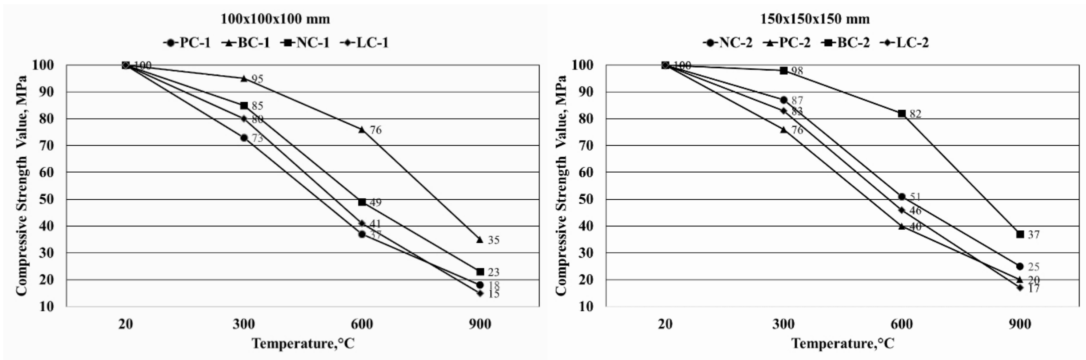

Figure 4. The relationship between compressive strength and temperature for the samples of 100x100x100 mm and 150x150x150 mm in size.

In this study, the relationship between the concrete sample size and high temperature on its compressive strength was also investigated. In addition, the effect of concrete sample size difference on its compressive strength was also investigated under high temperature. The cubic samples of 15 cm^3 in size are found to have a higher compressive strength when compared to the cubic samples of 10 cm^3 in size produced using the same aggregates and methods (Figure 5). Temperature was able to affect the center of small samples when compared to large samples which in return reduced the compressive strength further (Figure 5). Nevertheless, it was found that the concrete produced with different sizes under constant environmental conditions and 900 ºC showed a reduced difference in their compressive strength (Figure 5).

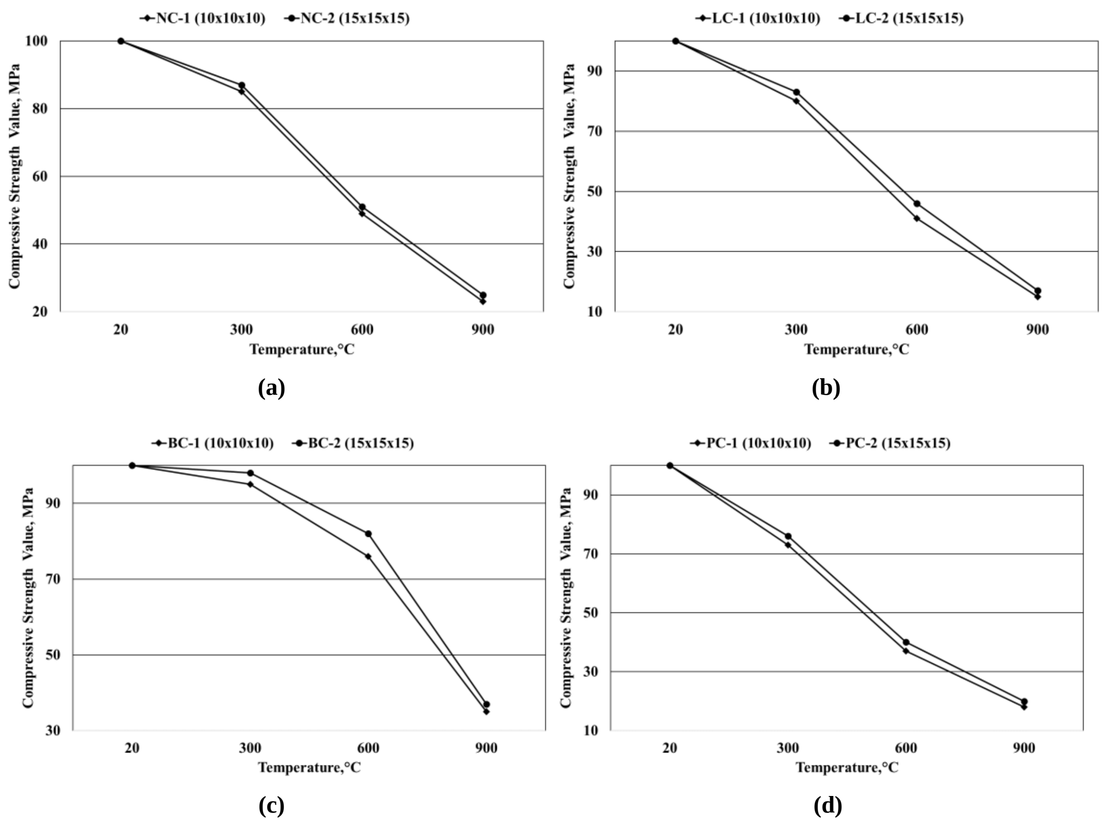

Figure 5. The effect of high temperature on the compressive strength (CS) of concrete produced using the same types of aggregates but in different sizes: (a) naturel aggregate (NC); (b) limestone (LC); (c) basaltic crushed stone aggregate (BC); (d) pumice (PC)

3.3. Assessment of the Pull-Out Test Results

Concrete samples of 150x150x150 mm in size were subjected to pull-out test in order to investigate the effect of high temperature on the adherence strength of concrete. The fact that the cracks in the concrete expand under the effect of temperature and that concrete cannot enclose the equipment sufficiently reduces the adherence strength between concrete and the equipment. The failure of the samples after the pull-out test as shown in Figure 6 offers a better picture of the findings.

Figure 6. Failures in the samples after the Pull-Out Test.

The decrease in adherence strength is evident in Figure 10 which shows the adherence strength with respect to temperature. It was found that the adherence strength of concrete produced with crushed stone was higher for each temperature point when compared to other concrete mixes and that adherence strength of concrete with stream aggregate follows concrete with crushed stone. It was found that adherence strength of concrete with limestone and lightweight aggregate are lower (Figure7).

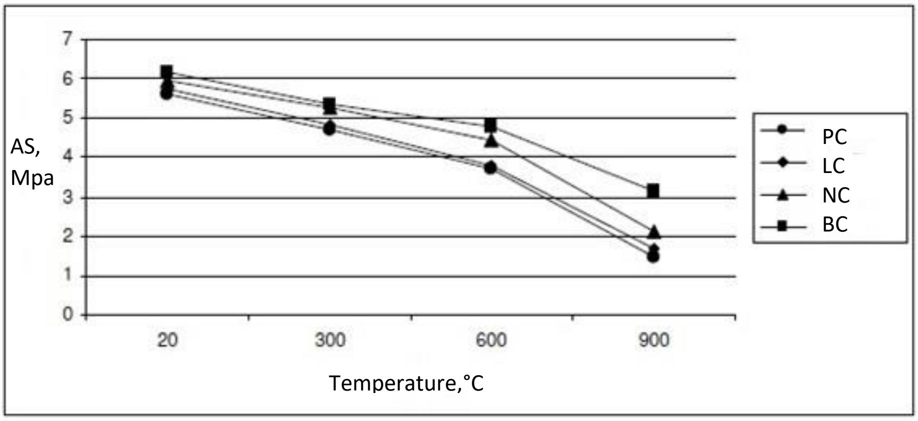

Figure 7. The relationship between adherence strength (AS) and temperature for samples of 150x150x150 mm in size

4. Conclusions

The results of this study, in which the effects of high temperature was investigated for concrete produced using different types of aggregates, as follows:

- In comparison with the control samples, ultrasonic pulse velocity of concrete with crushed stone and stream aggregate were similar, while it was lower for concrete with limestone and lightweight aggregate.
- As the thermal incompatibility between cement paste and aggregate increases the total pore volume of the concrete under the effect of high temperature, ultrasonic pulse velocity of the concretes with aggregate were lower than that of control samples.
- According to the compressive strength results, it was found that concrete produced with lightweight aggregate showed reduced loss in strength due to aggregate structure and it was lower than the remaining three aggregates.

- The size difference of concrete samples was found to affect the compressive strength under the effect of high temperature. As the impact of high temperature to the core of all the concrete samples (of 15 cm^3) was delayed, the effect of high temperature was reduced with the increasing size and they gave higher compressive strength results when compared to the samples of 10 cm^3.
- Compressive strength of the samples of 10 cm^3 and 15 cm^3 was found to be different at a range between 0.90 to 0.93.
- The results of the pull-out test showed that increased temperature results in reduced adherence strength between concrete and the equipment.

According to the results of this study, concrete produced with crushed stone aggregate was found to offer the optimal yield under high temperature. It was found that there is a relationship between increased/decreased durability of concrete with respect to high temperature and the concrete size. We believe this study will pave the way for future studies in this field.

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