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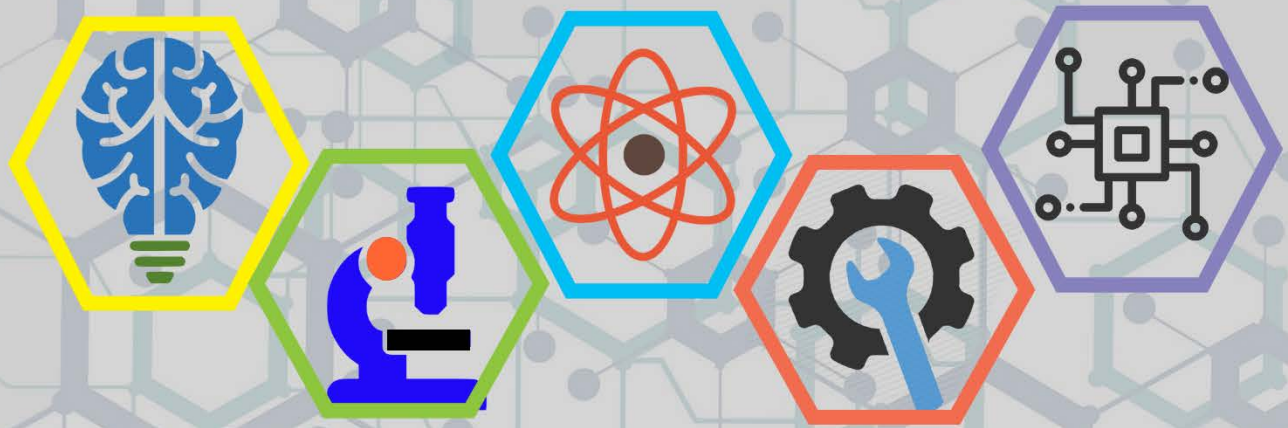

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HYDROGEOLOGICAL AND HYDROGEOCHEMICAL INVESTIGATION OF ILICA (BALIKESIR) GEOTHERMAL FIELD

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ABSTRACT: This study includes the first conceptual modeling studies in Ilıca Geothermal Region of Balıkesir Province. The hydraulic behavior and groundwater properties of the geothermal field were analyzed by conceptual modeling. For this purpose, he used Visual Modflow Flex software used in 3D modeling studies. Physical-chemical parameters and flow velocity from geothermal sources Faults and geological units in the field were mapped to describe the geothermal system. All data were digitized on a scale of 1/25000. Also, geothermal conceptual flow modeling is conceptually defined. The field perimeter is divided into 400 cells by 20 x 20 units. The area of each cell is designed to be 67.85 m x 67.85 m. Approximately 4.6 km^2 has been studied. According to the data obtained, the geothermal aquifer is fed from cracked and hollow sections of marble and schists. The geothermal heater body is thought to be the granite pluton found in the region. Cover rocks of the geothermal system are young sedimentary units. Existing meteoric waters enter the underground through the cracks of the rocks in the region, warm up with a short flow path and are carried to the surface by faults.

Keywords: Geothermal, Ilıca, Conceptual Modelling.

INTRODUCTION

In the study named Groundwater Flow Modeling of Kütahya Plain Shallow Aquifer, sampling was carried out in 2 different periods as dry and rainy seasons. As a result, the groundwater model was formed by evaluating the results of the analyzes made from the samples taken [1]. 3D Modeling of Salt Water Initiative in the Island Aquifer, 3D modeling was performed to control seawater mixture with groundwater on an example island in the Mediterranean region using SEAWAT software [2]. In the study titled Assessment of Hydrogeological Properties of Beyşehir Lake Basin Based on Groundwater Flow Modeling, the characteristics of 8 different basins were evaluated and grid networks and modeling features were proposed for the groundwater modeling of the study area. [3]. In the study of Modeling River-Aquifer Interactions with Visual Modflow, first, by creating a numerical modeling of groundwater, river-aquifer interaction, groundwater distribution and the effects on the flow direction of groundwater were revealed. [4]. In the article titled Time Changing Groundwater Flow Model of Torbalı Region, underground water modeling of Torbalı district of İzmir was created and it

was revealed that groundwater was in decline between 2000-2020. [5]. The difference between this study from the above-mentioned studies is a more detailed examination of the hydrogeological and hydrogeochemical properties of Ilıca (Balıkesir) geothermal resources and the creation of topographic 3D maps of groundwater in the Modflow Software.

2. MATERIALS AND METHODS

Conceptual modeling has been done for the first time in Ilıca Geothermal Field. The hydraulic behavior of the geothermal field and groundwater properties were investigated by a numerical modeling study. For this reason, Visual Modflow Flex Pro 6.1 software was used for 3D modeling. Physico-chemical parameters and flow rates were measured from geothermal sources in the study area. In addition, faults and geological units in the field were mapped to define the geothermal system. All data have been digitized on 1/25000 scale in Figure 2. As a result, the flow modeling of the geothermal system is conceptually defined.

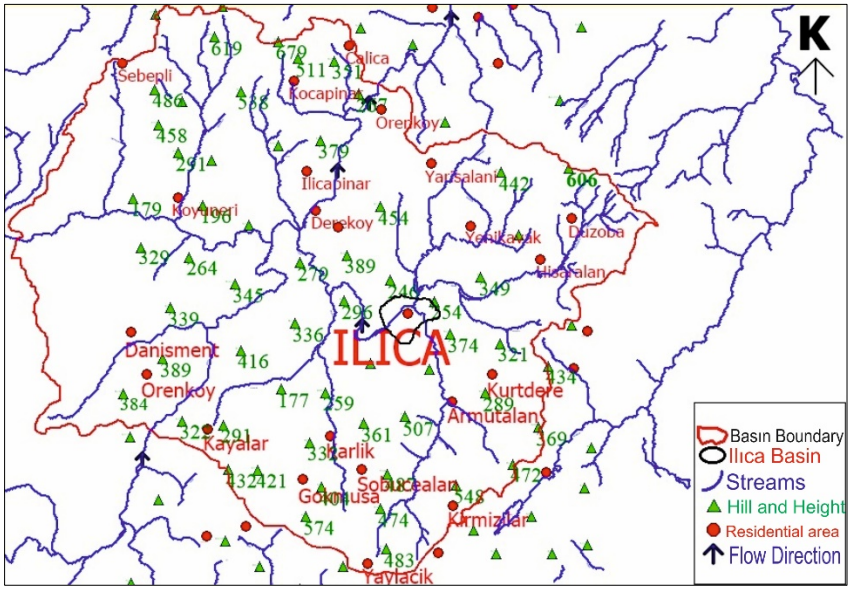

Figure 1. Morphology and hydrological boundaries of the study area.

The study area is located in the Susurluk Basin in the Southern Marmara Region. The study area called Ilıca Basin is located in an area of approximately 427 km^2 in a region close to the northwest border of this basin in Figure 1.

The surface waters of the Ilıca basin, which belongs to the Balya District of Balıkesir, are fed from Ilıca Pond, which is approximately 30 km away from the north of the settlement. Ilıca Pond was established in 1987 and is currently used for irrigation in that region. The water coming from the pond mixes with the Ilıca Stream, cuts the center of the village and flows into Koca Stream. The geothermal resource in the basin comes to the surface spontaneously from the pressurized aquifer.

2.1. Geology of the Study Area

The geology of the study area and its surroundings is taken from this study [6] in simplified form. The geological units in the study area from bottom to top consist of Fındıklı Formation, Altınoluk Marble Member, Oligocene-Miocene Granitoids, Bayramiç Formation, Hallaçlar Volcanite, and Alluvial deposits. Also, as can be seen on the map, it can be said that there are 5 faults in the study area. The reason for the formations is that the region is located between the western end of the North Anatolian Fault and the Horst-Graben systems in the Aegean region.

Due to the movement in the fault zones, the hot underground fluid is leaking from the spaces in between and goes up. The reason for this movement is the tectonic setting mentioned above.

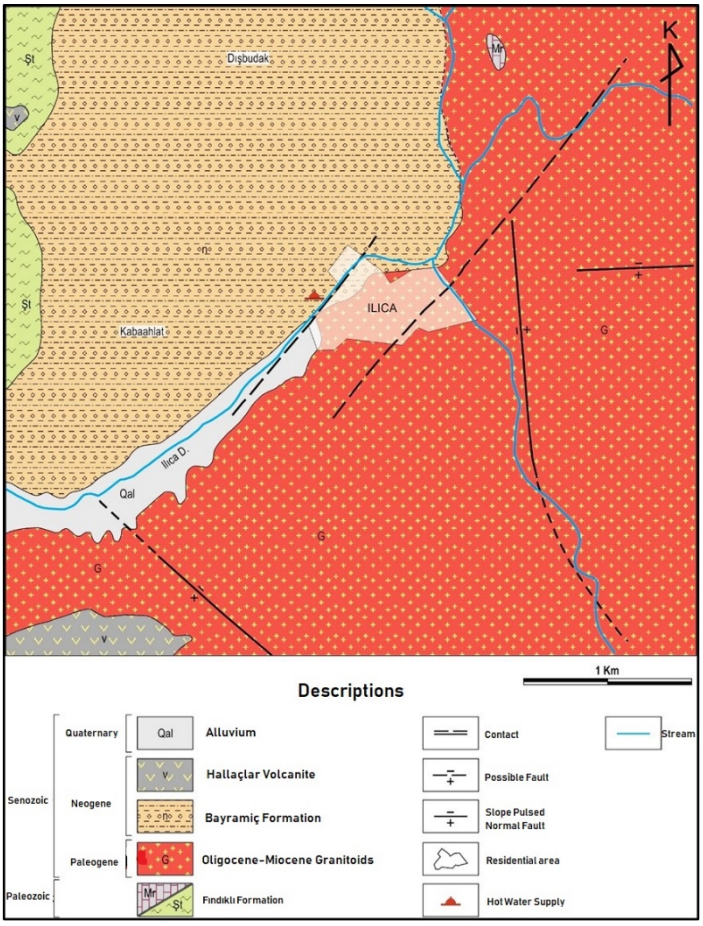

Figure 2. Geology of the study area.

3. HYDROGEOLOGY

3.1. Hydrogeochemistry

In order to examine the chemical and temperature conditions of the geothermal water in the study area and to determine the water-rock relationship and the properties of the source, samples were taken from the places for 2 periods in a year, where the 3-spring water in the field came out and then were sent to the chemical analysis. The analyzes were made in the central laboratory of COMU and the Bureau Veritas laboratory in Canada shown on Table 1.

Table 1. Results of analysis of water samples from Bureau Veritas laboratory for June-November (2020).

Elements	Unit	Lowest Level of Determination	Sample Name				
			HK-1-1	HK-1-2	JK-1-1	JK-1-2	JK-2
			June	November	June	November	November
Ag	PPB	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Al	PPB	1	7	36	18	37	31
As	PPB	0.5	89.8	87.8	85.8	82.8	88.8
Au	PPB	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
B	PPB	5	2078	2054	2159	1938	1998
Ba	PPB	0.05	40.90	15.99	35.04	14.24	16.57
Be	PPB	0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Bi	PPB	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Br	PPB	5	259	240	304	246	234
Ca	PPM	0.05	16.48	16.6	16.10	16.2	15.72
Cd	PPB	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ce	PPB	0.01	<0.01	0.02	<0.01	0.02	0.01
Cl	PPM	1	65	68	67	68	70
Co	PPB	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cr	PPB	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cs	PPB	0.01	61.63	58.8	61.52	57.22	58.29
Cu	PPB	0.1	2.4	0.9	1.0	0.8	0.9
Dy	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Er	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Eu	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fe	PPB	10	<10	<10	<10	<10	<10
Ga	PPB	0.05	1.40	1.63	1.70	1.6	1.38
Gd	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ge	PPB	0.05	7.81	7.93	8.56	7.79	7.63
Hf	PPB	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Hg	PPB	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ho	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
In	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K	PPM	0.05	4.30	3.91	4.34	3.88	3.74
La	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Li	PPB	0.1	503.3	457.4	517.4	439.2	435.2
Lu	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mg	PPM	0.05	0.07	0.07	<0.05	0.06	0.07
Mn	PPB	0.05	12.09	9.6	6.27	9.26	5.18
Mo	PPB	0.1	97.3	95	99.9	87.1	87.2
Na	PPM	0.05	268.67	256.38	271.59	254.77	254.68
Nb	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nd	PPB	0.01	<0.01	0.01	<0.01	0.01	<0.01
Ni	PPB	0.2	<0.2	<0.2	<0.2	<0.2	<0.2
P	PPB	10	<10	<10	<10	<10	<10
Pb	PPB	0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Pd	PPB	0.01	<0.01	0.02	<0.01	0.03	0.05
Pr	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pt	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Rb	PPB	0.01	41.01	41.81	42.00	41.51	42.05
Re	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Rh	PPB	0.01	<0.01	0.01	0.01	0.01	0.01
Ru	PPB	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
S	PPM	1	122	119	121	119	114
Sb	PPB	0.05	1.34	0.98	1.27	1.09	1.23
Sc	PPB	1	<1	<1	<1	<1	<1
Se	PPB	0.5	0.9	0.9	0.8	0.9	0.9
Si	PPB	40	29639	28489	28095	27938	27997
Sm	PPB	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Sn	PPB	0.05	0.98	0.06	0.79	0.07	0.22
Sr	PPB	0.01	450.98	454.41	455.59	425.84	413.54
Ta	PPB	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Tb	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Te	PPB	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Th	PPB	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ti	PPB	10	<10	<10	<10	<10	<10
Tl	PPB	0.01	0.10	0.08	0.08	0.06	0.08
Tm	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
U	PPB	0.02	0.14	0.24	0.03	<0.02	0.15
V	PPB	0.2	0.5	0.7	0.4	0.5	0.7
W	PPB	0.02	486.68	462.96	487.16	443.98	469.5
Y	PPB	0.01	<0.01	0.01	<0.01	<0.01	<0.01
Yb	PPB	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zn	PPB	0.5	9.3	6.2	4.2	6.8	4.5
Zr	PPB	0.02	0.07	<0.02	<0.02	<0.02	<0.02

3.2. Major Anion-Cation Analysis and Evaluation of Results

Major anion-cation analyzes of the geothermal spring waters taken from the study area were made in the Bureau Veritas Laboratory in Canada in accordance with ASTM and TSE

standards. The pH, T, and EC parameters were measured in-situ. Ca and Mg analyzes were made by ICP-MS, Na and K analysis by flame photometry method, SO_4 analysis by gravimetric method, Cl, HCO3, and CO_3 analyze by titrimetric method, and the results obtained are given in Table 4. Analysis results were evaluated using AquaChem.

Table 2. Major anion-cation chemical analysis results of water samples.

Elements	HK-1-1	HK-1-2	JK-1-1	JK-1-2	JK-2
Na (ppm)	268.67	256.38	271.59	254.77	254.68
K (ppm)	4.30	3.91	4.34	3.88	3.74
Ca (ppm)	16.48	16.6	16.1	16.2	15.72
Mg (ppm)	0.07	0.07	<0.05	0.06	0.07
Cl (ppm)	65	68	67	68	70
SO_4 (ppm)	280	290	280	280	270
HCO_3 (ppm)	232	182	232	190	197
CO_3 (ppm)	0.00	0.00	0.00	0.00	0.00
pH	8.45	8.30	8.38	8.10	7.97
T (℃)	58.2	48.3	58.0	58.5	58.2
EC (µS/cm)	1132	1195	1148	1196	1188

3.3. Geothermometry

One of the most important geochemical tools in the research and development of geothermal spring waters is chemical geothermometry. In observations during use and production, these geothermometers are calculated to see the response of the chamber to production. It is also used to estimate subsurface temperatures during exploitation. Chemical geothermometers are divided into 2 groups as silica and cation geothermometers and in this study was used silica geothermometer calculation [7].

3.3.1. Silica Geothermometer

Silica geothermometer, which is the most widely known among geothermometers, is used to estimate the aquifer temperature and the reservoir temperature of the geothermal source. The fact that many rocks on the earth contain silicate minerals within themselves is an indication of the widespread use of silica geothermometers.

Silica geothermometer calculation has been made for the geothermal spring water points in the study area and the formulas used are given in Table 3, and the calculation results with the formulas are given in Table 4.

The results of the silica geothermometer calculations of the hot water points in the study area are below 250 ℃, which is suitable for the reservoir fluid temperatures. Calculation results are not written in columns 5 and 6 of all samples and column 4 of JK-1-1, JK-2 samples since lower temperatures are obtained from the measured temperatures on the surface. Considering these calculations in general, the obtained reservoir temperatures are between 62 and 113 ℃ for HK-

1-1 welding, between 60 and 111 ℃ for HK-1-2 welding, between 60 and 110 ℃ when looking at JK-1-1 source, For JK-1-2 and JK-2 samples, it varies between 81 and 110 shows in Table 4.

Table 3. The formulas of the silica geothermometer used in the study.

Silica Geothermometer	Source	Meaning Range℃	Sequence number in the table
t℃=[1309/(5,19-logSiO_2)]-273 (SiO_2, no steam loss)	Fournier (1977) [8]	25-250	1
t℃=[1522/(5,75-logSiO_2)]-273 (SiO_2, Maximum steam loss at 100)	Fournier (1977)	25-250	2
t℃=[1032/(4,69-logSiO_2)]-273 (Chalcedony)	Fournier (1977)	0-250	3
t℃=[1000/(4,78-logSiO_2)]-273 (α-Cristobalite)	Fournier (1977)		4
t℃=[781/(4,51-logSiO_2)]-273 (Opal)	Fournier (1991)	25-250	5
t℃=[731/(4,52-logSiO_2)]-273 (Amorphous silica)	Fournier (1977)	25-250	6
(t<250℃ and SiO_2 concentration is mg / Kg			

Table 4. Reservoir fluid temperatures.

Sample No	Geothermometer equation (formulas are given in Table 3 according to the order number)						
	T (℃)	**1**	**2**	**3**	**4**	**5**	**6**
HK-1-1	58.5	113	112	85	62	*	*
HK-1-2	58.0	111	110	82	60	*	*
JK-1-1	57.1	110	110	81	60	*	*
JK-1-2	59.8	110	109	81	*	*	*
JK-2	59.7	110	110	81	*	*	*
*: The geothermometer value was not used because it is equal or lower than the surface temperature.							

4. RESULTS AND DISCUSSIONS

Groundwater data measured in the field were used to model the surface flow of groundwater exiting from the granite-granodiorite unit in the study area. There is no previous water budget calculation in the field. The field perimeter is divided into 400 cells with 20 x 20 units. Each cell is designed to be 67.85 m x 67.85 m. The area of the study field approximately 4.6 km^2. The height of each cell is limited by the topographic surface and the zone up to sea level (0 m) is defined as a single cell in the vertical area in Figure 3. Kx and Ky values were accepted as 1E-6 m/s, Kz value as $1E^{-7}$ m/s, porosity as 0.2. There are no flow and measurement data for groundwater and surface waters in the region. Therefore, theoretical values were used to calibrate. The hydraulic conductivity value of cracked granite was calibrated as 1×10^{-6} m / s.

Below is the 3D image of the study area mapped according to groundwater and digital topographic data modeled in Modflow Flex Pro 6.01 in Figure 4. Before creating Field Modeling, the Define Unstructured Q-Grid Method was chosen from 4 different celling methods in Modflow software.

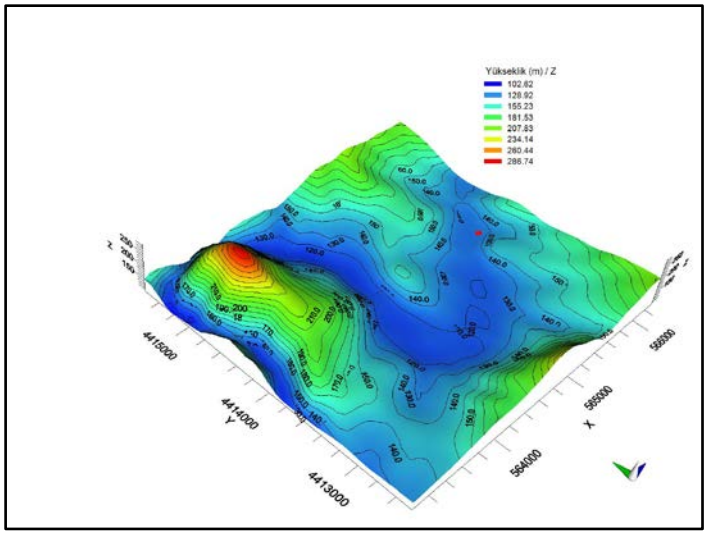

Figure 3. Topographic map of the study area created in Modflow program.

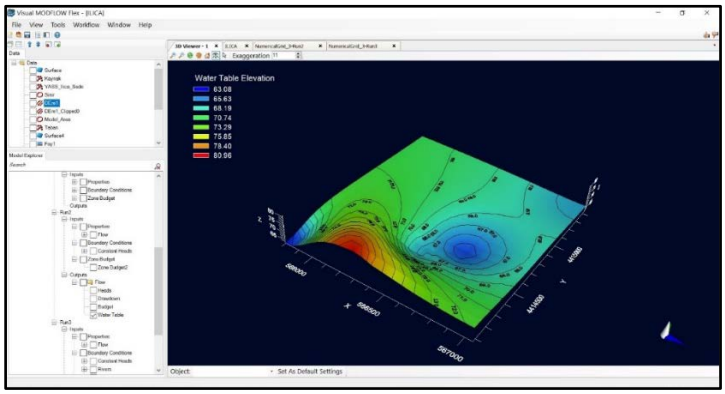

Figure 4. 3D view of groundwater level map of the study area prepared in Modflow program.

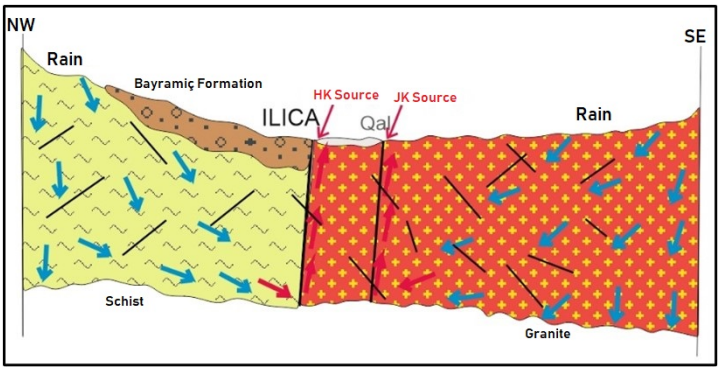

Figure 5. Schematic conceptual hydrogeological model of the Ilıca geothermal field.

The precipitation water entering underground from the dominant hills around the Ilıca hot water spring flows down through the cracks of the granites or granites, heats up along the flow path to the depths and rises upward from the Ilıca fault in Figure 5. Sediments belonging to the Neogene aged Bayramiç formation located in the west of the fault form the cover rock of the system. The reservoir rock of the system is Oligocene-Miocene Granitoids.

5. CONCLUSIONS

As a result of tectonic activity in the region, fracture-crack zones are formed in geological units. Geothermal spring waters reach the surface by seeping from hollow geological structures like this. It is believed that the source of the Ilıca Thermal spring is the granitoids of the Oligocene-Miocene age or the marble slates below it. The temperature of the water that comes to the surface of its own volition varies between 55 and 60 degrees.

The geological units in the study area from bottom to top consists of Fındıklı Formation, Altınoluk Marble Member, Oligocene-Miocene Granitoids, Bayramiç Formation, Hallaçlar Volcanite and Alluvial deposits. Alluvial deposits are the most productive aquifer among the geological units of the study area.

The temperatures of the fluid have been estimated using the geothermometer equations of the geothermal system in the Ilıca region. The results of the silica geothermometer calculations of the hot water points in the study area are found to be below 250 ℃, which is suitable for the reservoir fluid temperatures. Considering these calculations in general, the obtained chamber temperatures are between 62 and 113 ℃ for HK-1-1 welding, between 60 and 111 ℃ for HK-1-2 welding, between 60 and 110 ℃ when looking at JK-1-1 source, For the JK-1-2 and JK-2 samples, it changes between 81 and 110 ℃.

In addition, modeling studies of the geothermal system in Turkey has not been passed yet from a conceptual level, the measured-calculated size modeling studies (except areas in the direct production of electricity).

The information discovered by this study, has a high potential to contribute to the people living in the region Ilıca and to Turkey's economy. Because many properties of the water are determined by modeling the hot fluid, the possibilities of using the geothermal resource have also been determined.

The information obtained from this study shows that the geothermal potential of the site has a higher reservoir temperature than its current use and can therefore be used for geothermal applications at higher temperatures (if the resource is developed). For this reason, the trends of the faults should be determined with geophysical and structural geology-tectonic studies in the field, and it should be evaluated whether it is possible to increase the temperature and flow in order to benefit more from the field by conducting research drilling / drillings at appropriate locations. If high temperature and flow rate can be achieved; If high temperature and flow rate can be obtained; In this region, there is a suitable geography for activities such as house heating, geothermal greenhouse, fish farm.

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Research Article

Design and Construction of an Automated and Manual New-Fangled Fruit Juice Extractor

Authors: Dickson David OLODU, Patience Sherifat AKOKHIA

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Design and Construction of an Automated and Manual New-Fangled Fruit Juice Extractor

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ABSTRACT: The goal of this study was to design and build an automatic and manual new-fangled fruit juice extractor. People's growing desire for fruit juice, owing to its nutritional benefits, has resulted in the development of a machine that would make the extraction of huge quantities of fruit juice easier and more efficient. The ideal operating criteria for the new-fangled juice extraction machine, juice yield, extraction loss, and extraction efficiency, were assessed for performance throughout the design phase. The entire production capacity of new-fangled juice extraction machines, both automated and manual, was also assessed. The machine was built manually with the use of local materials and tools. The major materials used for the construction of the machine were mild steel, stainless steel, and plastic. During the construction of the machine, the component pieces were fabricated separately using mild steel sheet, stainless steel, and plastic before being finally assembled. It was built in such a way that when the handle is moved, the fruits are crushed and juice is produced. It was also built to run automatically thanks to the incorporation of a drive belt and an electric motor. The orange and citrus fruits were washed and weighed in this study, with fruit weights ranging from 1.4kg to 2.5kg. Maximum juice output, extraction efficiency, and extraction loss were all determined to be 77.6%, 85.3%, and 6.5 percent, respectively. The results demonstrate that the newly planned and manufactured juice extractor performed well in terms of juice extraction capacity.

Keywords: Extraction Efficiency, Extraction Loss, Juice Extractor, Juice Yield, New-fangled Design.

1. INTRODUCTION

Juice extraction industries have advanced fast in developed countries such as the United Kingdom and the United States. The development has enabled the use of juice extractors ranging from domestic models to fully automatic juice lines that can produce litres of juice per day. The majority of our houses, hotels, restaurants, and shopping centers employ juice extractors of various types and sizes. As a result, a juicer is a mechanical device that extracts juice from fruits, vegetables, and leafy greens. Depending on the type of fruit or

vegetable to be extracted, different types of juicers have been designed [1]. Most tropical countries, such as Nigeria, generate an excess of tropical fruits to the point where market supply surpasses demand, resulting in price drops during the fruiting season. As a result, most fruits expire in the market due to insufficient storage facilities, resulting in significant losses [2]. Due to its low production, manual juice extractors have been designed for household usage [3]. The transformation of locally produced fruit aids in the enhancement of a reliable farming system in many parts of Africa [4]. However, the processing facilities required for this conversion are insufficient, and when they do exist, they are uually burdened with maintenance and inadequate supply. Fruit processing should ensure that the fruit is safe for future eating and maintain its quality, which includes flavor, odor, appearance, and nutritional value. When the ugar content and flavor are at optmal peak, the fruit from which the juice is to be extracted must be fully ripe [5]. As a result, fruits should be processed as close to the collection point as possible to reduce fruit transportation over long distances before processing. This will result in fresher fruit and a higher quality of extracted juice. The juice extractor is being developed as a low-cost, environmentally friendly, energy-efficient, and adaptable machine for fruit processing. This effort will go a long way toward providing local alternatives to imported processed fruit juice brands. This will drastically reduce the amount of fruit that is thrown away due to rot Farmers' commercial demands will be satisfied, as will customer happiness. According to Ballinas et al. and Deck [6, 7], the storage life of fruits can be extended by removing the fluid content and turning them into juice, jam, and jelly. Depending on the method of preservation and packing, extracted juice might survive for months or even years before spoiling [7]. A small scale whole pineapple fruit juice extractor was devised and built by Badmus and Adeyemi [8]. Beater blades and a shaft, as well as a driven screw pressing mechanism, make up the machine. The machine roduced 8 liters of pineapple juice from 12 kg of ripe pineapple fruit. Ishiwu and Oluka [9] constructed and tested a juice extractor's extraction efficiency as a function of its performance. Screw jack, frame, connecting screw rod, pressing mechanism, interlock, feeding pot, reception pot, and discharge mechanism made up the extractor. Their research demonstrated that the created juice extractor performed admirably.

This research therefore focused on the design and construction of an automated and manual new-fangled fruit juice extractor

2. MATERIALS AND METHODS

Mild steel, stainless steel, polymers, and other materials were used in the design and construction of the juice extractor.

Construction Material: Plastic and stainless steel were chosen for the shaft, hopper, press cage housing, and gear to avoid contamination of citrus or orange fruit juice due to mild steel corrosion. The extractor stand was made of mild steel (steel with a carbon content of up to 0.25 percent) since it is easy to weld and fabricate [9]. They are not hardened by heat treatment due to their low carbon content, and as a result, weld and heat affected zone (HAZ) do not have hardened zones despite rapid cooling [10]. Mild steel is also recognized for its ductility and plasticity, which allows it to be rolled, bent, or pressed into a variety of shapes. It has strong malleability, allowing it to be hammered vigorously without losing too much energy [9].

Design concept: The goal of this project is to create an optimal and reliable design based on the following calculations: power calculation, shaft design, belt selection, and hopper volume calculation.

Frame: The fundamental criterion in the design of the machine's frame is that it maintains the right relative position of the units and parts installed on it during an extended term of operation in all working situations. The strength factor is the second aspect or need. The frame measures 840mm×300mm×551mm and was designed to withstand the various weights installed on it.

2.1 Fruit Juice Extraction

The process of crushing, squeezing, and pressing whole fruits in order to obtain juice and reduce the bulkiness of the fruit to liquid and pulp is known as fruit juice extraction. According to Badmus and Adeyemi [4], the several procedures involved in fruit processing include: sorting, ashing, pressing, lcing, cruhing, and extraction, addition of additives, homogenization, and pateurization. The processing tages entails cutting, cruhing, squeezing, pulping, and pressing (Figure 1). Extraction can be done manually or mechanically, depending on the volume of fruit to be processed. Fruit juice can be obtained from a variety of fruits, including pineapple, apple, citrus, orange, ginger, and cashew.

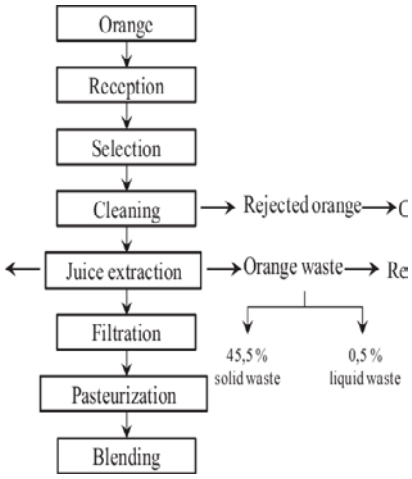


Figure 1: Flow chart for juice processing source: Abulude,2007

2.2 Efficiency of Extraction

The yield of juice obtained and the time taken to obtain it determine the efficiency of the extraction process. It is determined by the following factors: viscosity of the juice to be removed; persistence of the creation of the old pulp phase; pulp property; and pressure or force used. These factors are depending on the physical characteristics of the pulp to be extracted and are liable to change during the extraction process [11]. Separately, the extracted juice and the leftover waste were collected and weighed. The Tressler and Joslyn equation was used to calculate juice yield, extraction efficiency, and extraction loss based on the values obtained (Equation 1-3).

$$£y = \frac{W_1}{W_1+W_2} \times 100\% \quad (1)$$

$$£e = \frac{W2}{W_3} \times 100\% \quad (2)$$

$$E_L = \frac{W_{FE} - (W_{JE} + W_{RW})}{W_{FE}} \times 100\% \quad (3)$$

where $£y$ = Juice yield; $£e$= Extraction efficiency; E_L= Extraction loss; W_1= Weights of juice extracted, W_2= Residual waste; W_3= Feed sample; g and x=The juice content of orange in decimal.

2.3 Design Analysis / Specification

Following a compression test in which the fruits were pushed by a sliding parallel plate, we discovered that the highest fruit rupturing force was 220N [11] with an average mass of 272g per fruit (some fraction higher than experimental value). Solidworks was used to create the design. We may deduce that the machine is operational and that it is fully loaded with half the mass of each fruit in order to receive 272 grams[2].When you multiply this by four cups, you get 544 grams. The fruit recipient weighs 220 grams (for a size of 0.14m).

Total mass= 544+220=764g (fruit receiver with all four cups fully loaded)
About 0.764kg

And thus, the weight of the fruit receiver loaded is approximately 7.5N.

A rupture force of 220N was required to shear the fruit, as previously indicated. The resultant force applied on the shaft passing through the fruit recipient is shown in the free body diagram below. The force for compression of the fruit should be sufficient and able to cut(shear).

Radius of the crusher= 0.12m

Torque= $F.r(\text{Nm})$ (4)

Thus it has been chosen to use a force of 225N.

Torque required= $225\,\text{X}\,0.12 = 27Nm$

Thus any motor we select should be able to provide this minimum output torque requirement to impart on the fruit while at the same time causing rupture of the fruit.

Now using a motor of the following specification

Power=120W
Voltage=12V/24V
Speed =55rpm

$$\text{Power (P)} = \frac{2\text{NT}}{60} \quad (5)$$

The input torque T, from this motor is

$$\text{T} = \frac{60\text{P}}{2\text{N}} \quad (6)$$

$$T = \frac{60X20}{2X55} = 20.835Nm$$

This torque will be supplied by the motor shaft to the input gear which is to drive the output gears.

Now we know

$$\text{Velocity ratio } (V_r) = \frac{T_o}{T_i} \quad (7)$$

$$Velocity\ ratio\ (V_r) = \frac{27}{20.835} = 1.3$$

This is the marginal number for design purposes, thus a bigger value is chosen to account for unforeseen pressures that we may have neglected during the computation. As a result, the velocity ratio should be considered as 2.Where Z_2= number of teeth on output gear.

So, with a selection of input gear and knowledge of the velocity ratio as calculated above, we may select appropriate output gear on the market from any of the figures below.

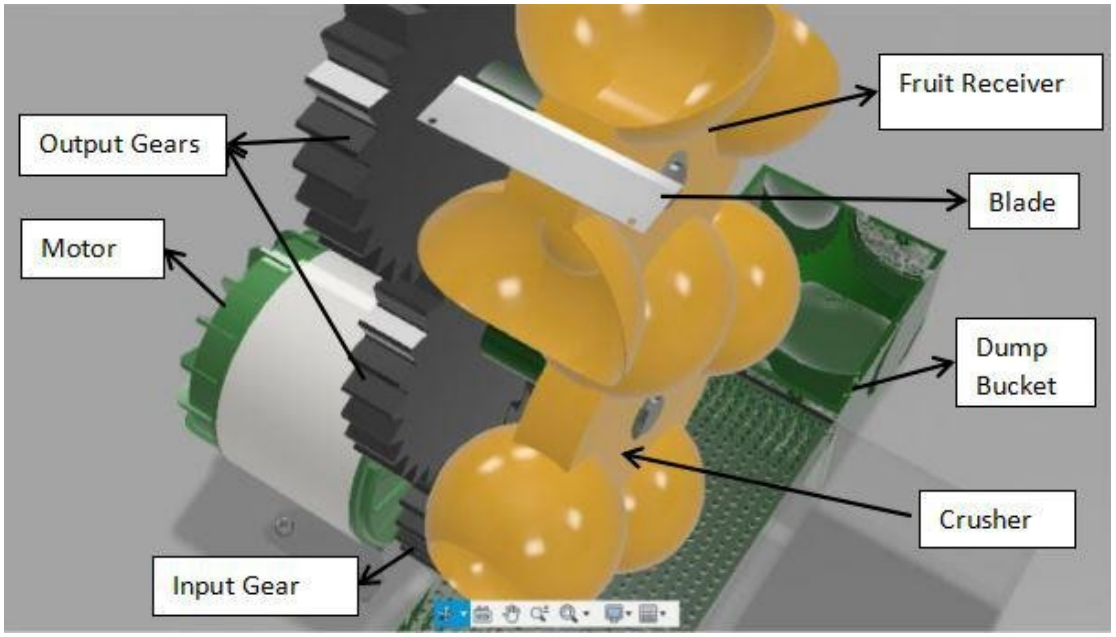


Figure 2. Internal Components of the proposed machine

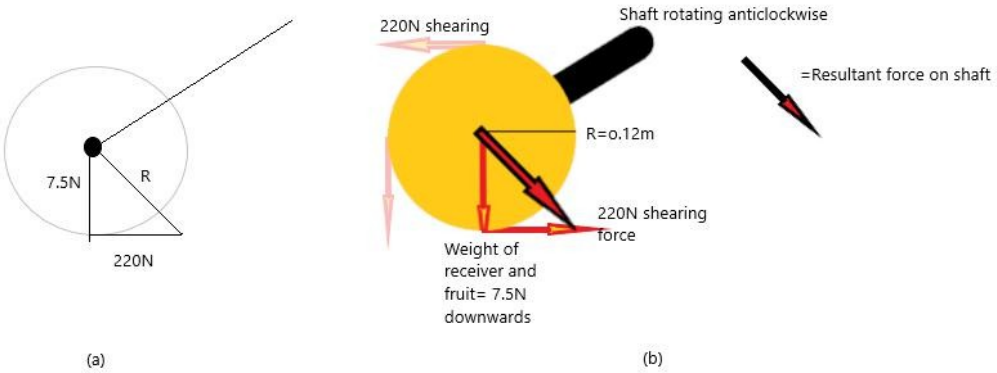
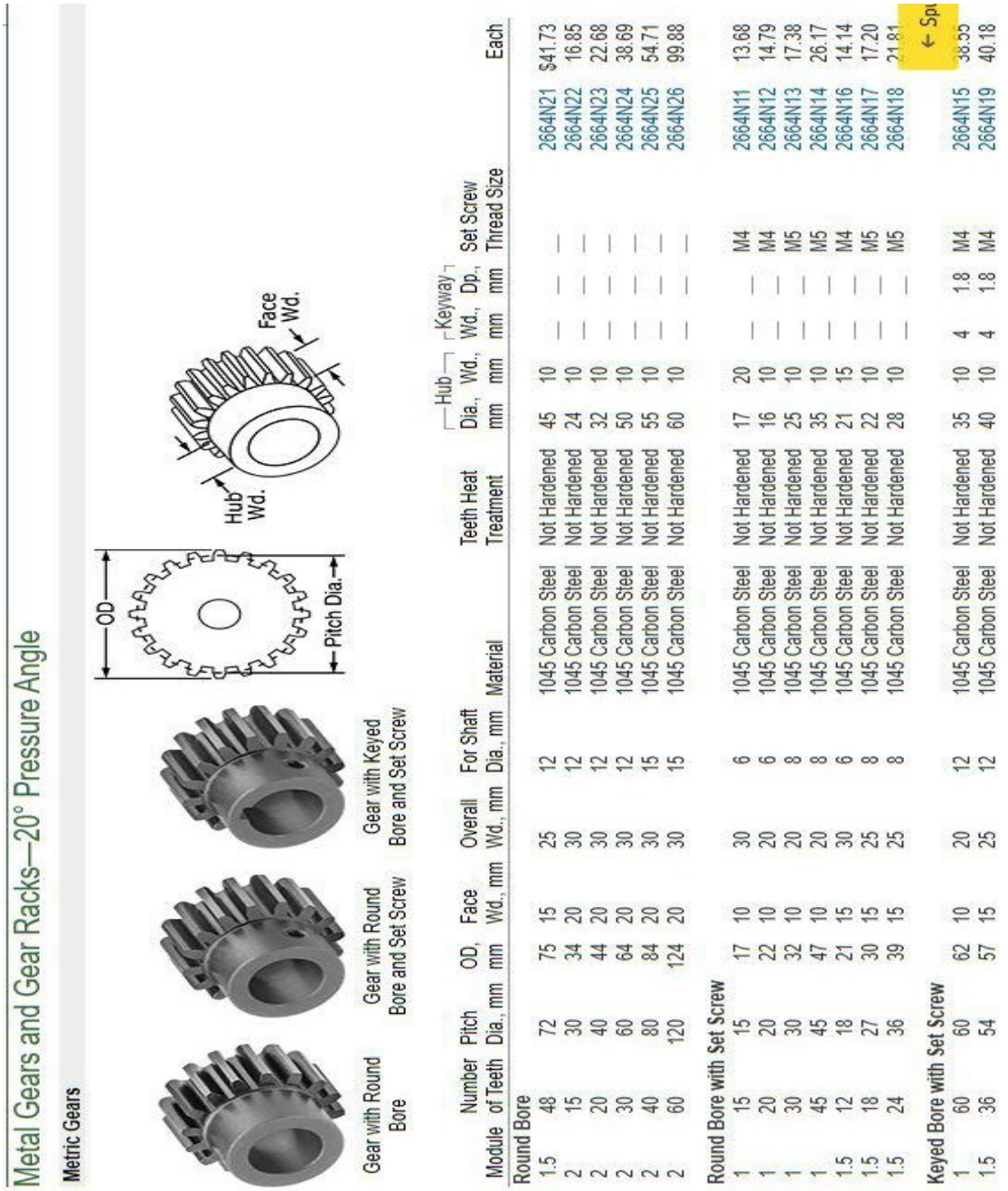


Figure 3. free body diagram and representation of forces on shaft carrying receiver.

This is the shaft's reference force, which we'll utilize in our computations. Any amount larger than this would be acceptable in calculations, but anything less would be incorrect. As a result, a force of 225N was chosen.

3. RESULTS AND DISCUSSION

The design analysis of the constructed automated and manual new-fangled fruit juice extractor is shown in Figure 4-10. The project is designed so that uncut fruit falls into a revolving receiving component, where it is sheared in half by shear force when it comes into touch with a blade permanently mounted to the machine's side wall.



Metal Gears and Gear Racks—20° Pressure Angle

Metric Gears

Gear with Round Bore

Gear with Round Bore and Set Screw

Gear with Keyed Bore and Set Screw

OD

Pitch Dia.

Hub Wd.

Face Wd.

Module	Number of Teeth	Pitch Dia., mm	OD, mm	Face Wd., mm	Overall Wd., mm	For Shaft Dia., mm	Material	Teeth Heat Treatment	Hub Dia., mm	Hub Wd., mm	Keyway Wd., mm	Keyway Dp., mm	Set Screw Thread Size		Each
Round Bore															
1.5	48	72	75	15	25	12	1045 Carbon Steel	Not Hardened	45	10	—	—		2664N21	$41.73
2	15	30	34	20	30	12	1045 Carbon Steel	Not Hardened	24	10	—	—		2664N22	16.85
2	20	40	44	20	30	12	1045 Carbon Steel	Not Hardened	32	10	—	—		2664N23	22.68
2	30	60	64	20	30	12	1045 Carbon Steel	Not Hardened	50	10	—	—		2664N24	38.69
2	40	80	84	20	30	15	1045 Carbon Steel	Not Hardened	55	10	—	—		2664N25	54.71
2	60	120	124	20	30	15	1045 Carbon Steel	Not Hardened	60	10	—	—		2664N26	99.88
Round Bore with Set Screw															
1	15	15	17	10	30	6	1045 Carbon Steel	Not Hardened	17	20	—	—	M4	2664N11	13.68
1	20	20	22	10	20	6	1045 Carbon Steel	Not Hardened	16	10	—	—	M4	2664N12	14.79
1	30	30	32	10	20	8	1045 Carbon Steel	Not Hardened	25	10	—	—	M5	2664N13	17.38
1	45	45	47	10	20	8	1045 Carbon Steel	Not Hardened	35	10	—	—	M5	2664N14	26.17
1.5	12	18	21	15	30	6	1045 Carbon Steel	Not Hardened	21	15	—	—	M4	2664N16	14.14
1.5	18	27	30	15	25	8	1045 Carbon Steel	Not Hardened	22	10	—	—	M5	2664N17	17.20
1.5	24	36	39	15	25	8	1045 Carbon Steel	Not Hardened	28	10	—	—	M5	2664N18	21.81
Keyed Bore with Set Screw															← Sp
1	60	60	62	10	20	12	1045 Carbon Steel	Not Hardened	35	10	4	1.8	M4	2664N15	38.55
1.5	36	54	57	15	25	12	1045 Carbon Steel	Not Hardened	40	10	4	1.8	M4	2664N19	40.18

Plastic Gears and Gear Racks—20° Pressure Angle

The current industry standard, these 20° pressure angle gears have thicker, stronger teeth than 14½° pressure angle gears. Made of plastic, they run quieter than metal gears and have good corrosion and chemical resistance. They're also known as spur gears.

Combine gears with different numbers of teeth to change speed and torque in your assembly. Combine a gear and rack to convert rotary motion into linear motion.

For components to mesh correctly, they must have the same pressure angle and pitch/module.

CAD For technical drawings and 3-D models, click on a part number.

Metric Gears

Module	Number of Teeth	Pitch Dia., mm	OD, mm	Face Wd., mm	Overall Wd., mm	For Shaft Dia., mm	Material	Fabrication	Color	Hub Dia., mm	Hub Wd., mm		Each
Round Bore													
0.5	12	6	7	3	7	2	Acetal Plastic	Molded	White	4.5	4	2662N27	$2.20
0.5	24	12	13	3	7	4	Acetal Plastic	Molded	White	8	4	2662N28	2.31
0.5	36	18	19	3	7	5	Acetal Plastic	Molded	White	10	4	2662N29	2.71
0.5	48	24	25	3	7	5	Acetal Plastic	Molded	White	12	4	2662N31	3.26
0.5	60	30	31	3	8	6	Acetal Plastic	Molded	White	14	5	2662N32	3.69
0.8	20	16	17.6	4	9	5	Acetal Plastic	Molded	White	10	5	2662N33	2.69
0.8	30	24	25.6	4	9	6	Acetal Plastic	Molded	White	12	5	2662N34	3.31
0.8	40	32	33.6	4	9	6	Acetal Plastic	Molded	White	12	5	2662N35	4.14
0.8	60	48	49.6	4	10	6	Acetal Plastic	Molded	White	14.5	6	2662N36	5.14
0.8	80	64	65.6	4	10	6	Acetal Plastic	Molded	White	15.5	6	2662N37	6.39
1	15	15	17	6	12	4	Acetal Plastic	Molded	White	8	6	2662N38	3.43
1	20	20	22	6	12	5	Acetal Plastic	Molded	White	11.7	6	2662N39	4.17
1	30	30	32	6	12	6	Acetal Plastic	Molded	White	14	6	2662N41	5.51
1	45	45	47	6	12	8	Acetal Plastic	Molded	White	16	6	2662N42	7.73
1	60	60	62	6	14	8	Acetal Plastic	Molded	White	18	8	2662N43	10.28

Figure 4. Plastic Gear sizes and cost in the market

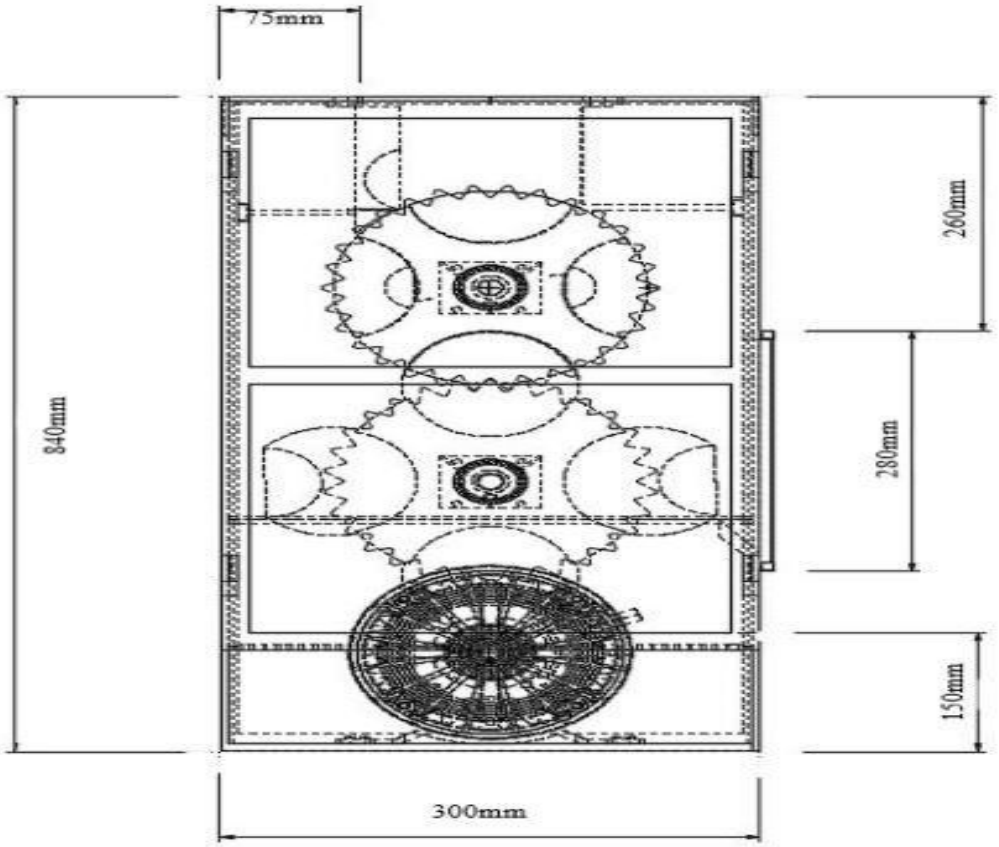


Figure 5. Front View of the model

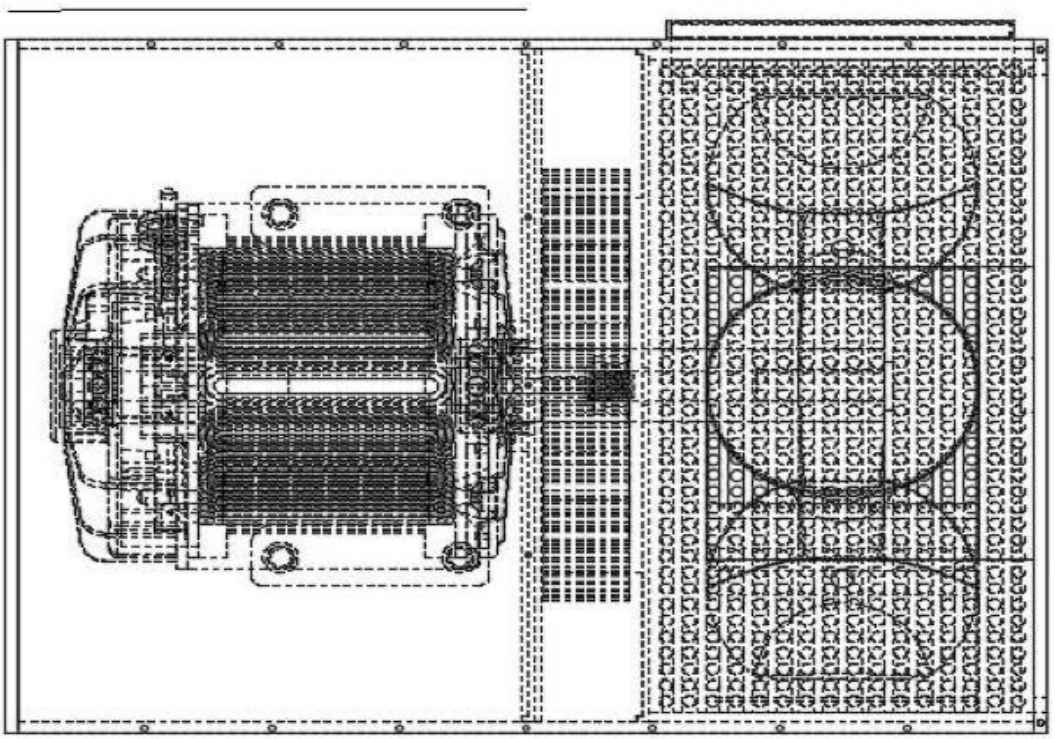


Figure 6. Top View of the model

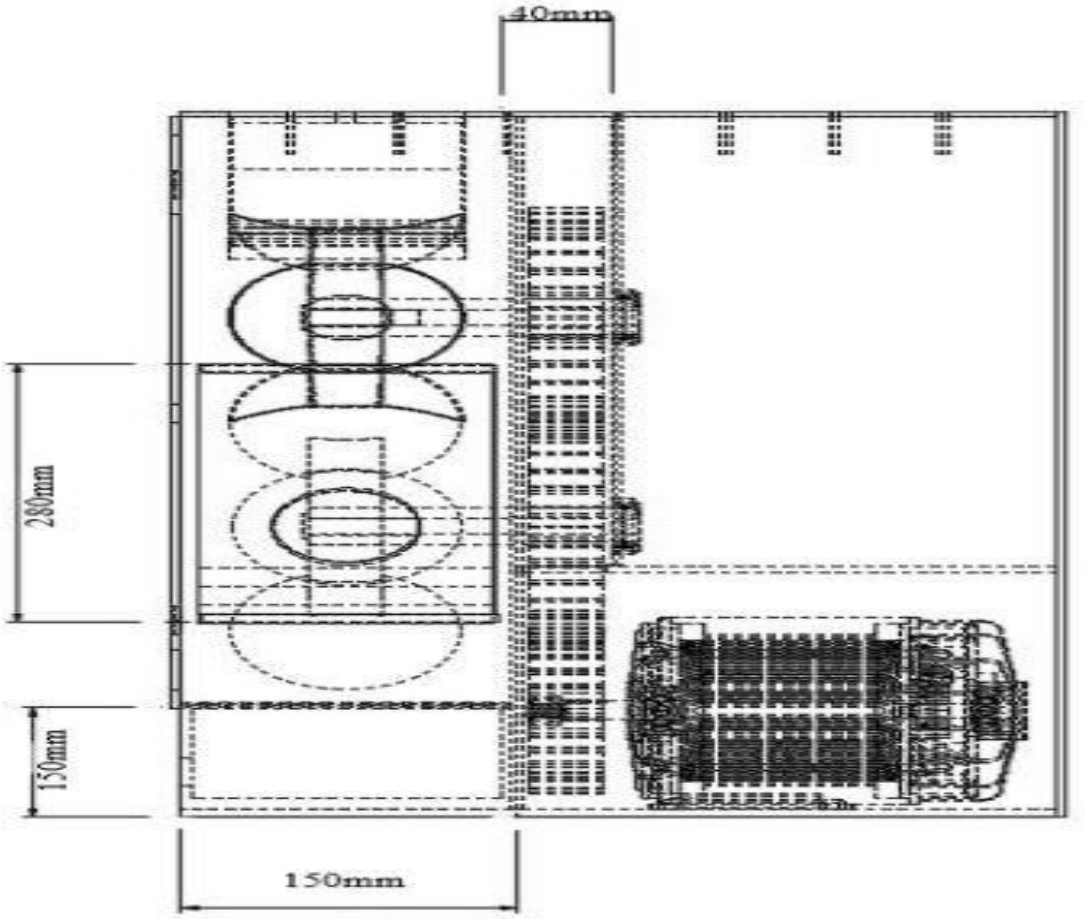


Figure 7. Side view of model

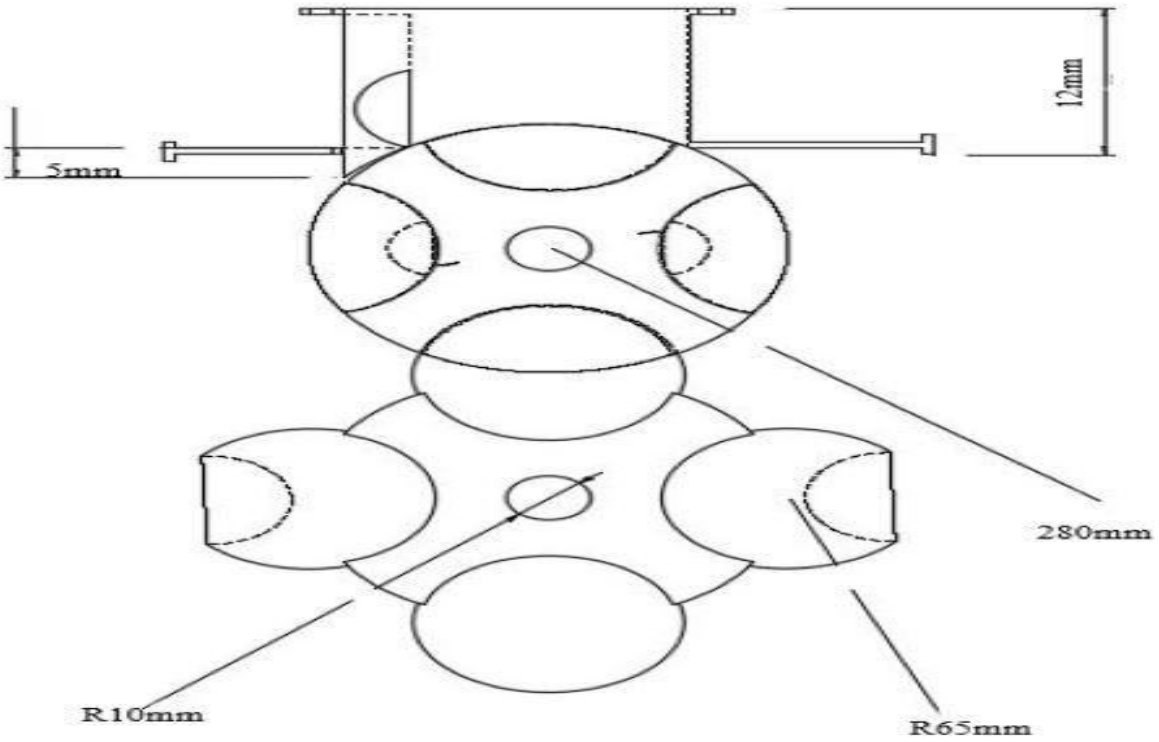


Figure 8. The inlet, fruit receiver and crusher(top-bottom)

Parts List		
Item	Part Name	Material
1	Fruit Inlet	Plastic
2	Fruit Receiver	
3	Crusher	
4	Sieve	Plastic
5	Juice container	Plastic
6	Juicer Body	
7	Electric Power Drive	
8	Shaft	Plastic
9	Mating Gears	Iron, Gray Cast ASTM A48 Grade 20
10	Key	Iron, Gray Cast ASTM A48 Grade 20
11	Power Gear	Iron, Gray Cast ASTM A48 Grade 20
12	Horizontal Closing	Plastic
13	Front closing	Plastic
14	Midway Closing	Plastic
15	Top Cover	Plastic
16	Rear Covering	
17	Blade	Stainless Steel
18	Key	Iron, Gray Cast ASTM A48 Grade 20
19	Glass Door	
20	Screw	Iron, Gray Cast ASTM A48 Grade 20
21	Side exit Cover	
22	Bearing	

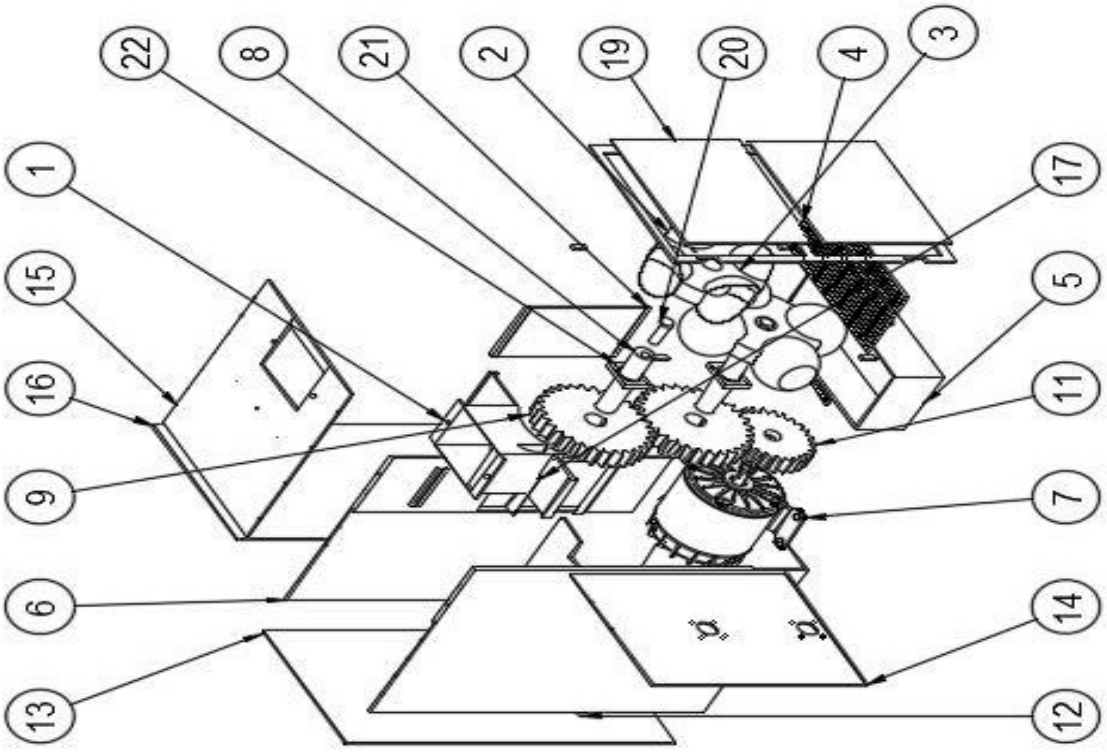


Figure 9. An Exploded View Showing the Component Parts and the Materials used for the Design.

Figure 10. The Design Model (Assembled Parts)

3.1. Discussion

It was important to anticipate the machine's average juicing time for a finite amount of fruits. With the acquisition of 24 citrus or orange fruits, a stopwatch, and a way to record the data from the test run, this goal was set. The goal was to perform three trials of eight fruits each, determining the average time it took to juice each batch.

Table 1: Individual Trial of 8 Citrus Fruits versus the Time Take to Juice in Machine

Trial	Number of Fruits	Juicing Time (s) for Manually Operated	Juicing Time (s) for Automated Operated
1	8	60	25
2	8	56	26
3	8	66	27
Average Juicing Time (s)		**60.33**	**26**

From the table in the previous section, the question arose as to why there were some time difference between set runs made. To explain this, some reasonable assumptions have been made below;

1. Timing: The machine did not have an automated timer or a setting for the number of fruits to juice; instead, it was done manually with a stopwatch/clock. As a result, the time difference could be the result of less-than-accurate timing based on eye observation of the eighth fruit being juiced.

2. Time between feedings in each set: For each set of eight fruits, the feed was done by hand to aid the blade's cutting activity at the machine's receiving portion. As a result, it's not unreasonable to consider the tiny time difference between each feed activity.

3. The state of each fruit: The fruits in each trial set of eight may have included, for example, much succulent softer skin fruits in set 1 with a run time of 60 seconds, compared to set 3 with a run time of 66 seconds and fewer fruits as soft and succulent as set 2 with a much

higher percentage of ideal soft and succulent fruits being fed into the machine. Using the data previously created, the average yield time for juicing was anticipated to be around a minute and a third. We have calculated that the yield time for this juicing machine will be one minute for every eight citrus fruits that pass through it.

The maximum juice output, extraction efficiency, and extraction loss were all determined to be 77.6%, 85.3 percent, and 6.5 percent, respectively. For village-level uses, a device of this sort can be made at a small machine plant in an orange-producing developing country. This study's findings were similar to those of Ishiwu and Oluka [7], who reported a juice yield of 76 percent, extraction efficiency of 83 percent, and extraction loss of 3%, respectively. The results show that the newly designed and built juice extractor has a high capacity for extracting juice.

3.2. Cost Evaluation

Table 2. Bill of Engineering Materials and Evaluation

S/N	Materials	Cost(Naira)
1	Alcoboard	3800
2	2 x 1 Angle bar	2200
3	Acrilic	4000
4	A and B Gum	300
5	Silicone Gum	1000
6	Pattern design	6000
7	Gears	3000
8	DC motor with mechanism and driver	10000
9	Bearings	1200
10	Ply board	800
11	8mm bolts	500
12	10mm bolts	10mm bolts
13	1/2'' Square pipe	600
14	Welding electrodes	1000
TOTAL		34900

The cost incurred in the fabrication of the juicing machine have been broken down and outlined as in the table above

4. CONCLUSION

The design and construction of an automated and manual new-fangled fruit juice extractor had been achieved, the newfangled juice extractor operates automatically and manually, it is motorized and also be operated manually. The design of this device was done using solid works version. This device have a high juice production capacity of 42 liters per minute for the motorized powered juice extractor while 20 liters per minute for the manually operated. The machine had a production efficiency of 85.3%. It was possible to design a juicing machine that could both shear the fruit and juice at the same time with minimum contact between the fruit

juice and the unwanted peels from the fruit surface. As such, a juicing machine was designed and fabricated with an average predicted run time of 60.3 seconds and 26 seconds for every 8 citrus or orange fruit specie.

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Research Article

PROBLEMS FACED IN COTTON EXPORT BY THE GINNER ROLE, COST ANALYSIS AND ASSESSMENTS IN TERMS OF OCCUPATIONAL SAFETY

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PROBLEMS FACED IN COTTON EXPORT BY THE GINNER ROLE, COST ANALYSIS AND ASSESSMENTS IN TERMS OF OCCUPATIONAL SAFETY

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ABSTRACT: Due to the fact that cotton is an industrial product, the production amounts of the countries that control the world cotton production (such as China, India, USA) and the raw product taken by the main mechanisms reach the industrialist after pre-treatment. increasing day by day. Yalvaç District Leather arts and leatherwork; The leather, which is processed and made ready for use in the shops in the region called the tannery, is generally marketed abroad. In the past, although the masters used to tan leather for use in different fields in the tannery region, it is now known that many masters produce cotton ginning rolls due to the market problem. In this study; The aim is to examine the problems faced by the producers of Yalvaç ginning rolls in foreign trade, to investigate the effects of these problems on the economy of Yalvaç, and to gain a scientific perspective on the problems they encounter in foreign trade. In addition, leather processing workshops were evaluated in terms of occupational safety.

Keywords: Ginner role, Export, Cost analysis, Safety.

1. INTRODUCTION

The historical development of leather processing in Yalvaç dates back to the Leather Factory established in 1929. Factory; It operated until 1949 under the Beykoz Leather Factory [1]. Today, production continues in the tannery where there are more than 20 workplaces. Bovine and ovine hides are processed in Yalvaç. Approximately 1,500 tons of cattle and 500 tons of small cattle hides are processed in Yalvaç. The leather industry, which makes a significant contribution to Yalvaç's economy, is one of the important centers in this field in Turkey. One of the most important manufactured products is the ginner role made from bovine hides. Yalvaç Turkey stands out in the production of ginner roles. Approximately 30,000 ginner rolesare produced annually.

Cotton is the most produced fiber worldwide. The increase in world cotton production and consumption has increased the demand of the textile industry for cotton fiber. In addition, the

fact that raw materials constitute 45-80% of the cost in textile factories has increased the importance of clean cotton, known as cotton yarn feasibility, in the yarn-weaving sector [8].

The expectations of the developing textile industry from cotton fiber are increasing. In our country, foreign matter and ginning are important in grading cotton in terms of cleanliness. The importance of cotton ginner role, which is important in the pre-treatment phase of cotton, is increasing day by day. It is known that although the masters in the tannery used to process leather to be used in the manufacture of different products in the past, it is now known to produce cotton ginner roles because there is no market problem. In this study; The problems faced by the manufacturers of Yalvaç ginning rolls in export were examined and a scientific perspective was gained on the effects of Yalvaç economy.

2. GINNER ROLE MANUFACTURING

The purpose of the ginning process is to separate the bean from the fibers and also to bale the fibers. The gin industry is a source of raw materials for some industries, these are the textile oil and feed industry.

The seed cotton in the warehouse is transported to the ginning machine with the help of an aspirator. Firstly, the seed cotton is passed through the pre-cleaner, the seed cotton is divided into two parts as fiber and core in the ginning machine, the fibers are cleaned in the fiber cleaner and sent to the baling department.

The skins are cut in thicknesses of at least 3.5 mm and maximum 10 mm and pressed into thin strips by performing the preliminary preparation process to be used in the role in the desired length.It is seen in the Figure 1.

Figure 1. Preparation of wood covered skins

The square-shaped iron in the middle, whose two ends will be connected to the machine, forms the backbone of the ginner role. This piece of iron is covered with a cylindrical poplar tree consisting of two or four parts. The cylindrical tree, which is covered on iron, gains complete integrity with the iron, which is in the position of the main shaft, thanks to the clamping wire and clamping screw wrapped around it, and it is prevented from getting rid of the iron and loosening. The leathers, which are cut to the desired length and prepared from cowhide, are glued to the wooden cylindrical role with gelatin glue and the leather ends are stretched one on top of the other and dried. It is seen in the Figure 2.

Figure 2. Application of adhesives to the skin

Figure 3. The stage of covering the skin to the wood

After all the leathers are dry and firm, the nailing process is carried out. pressed against the chassis. Row iron is used to wrap the skins. In the manufacture of ginner role; 160 mm role (35 square iron), 180 mm relay (40 square iron) and 220 mm relay (50 square iron) are covered with dry poplar wood.

Figure 4. Wrapping process

After the poplar wood is turned in the form of a cylinder on a lathe, the coating process is carried out by wrapping it with a leather belt for 1.5 cycles.

Figure 5. Drying process of the ginner role

After the process, it is kept in areas with suitable ventilation for one day to dry the ginner role. Iron nails are removed from the dry and hardened skin

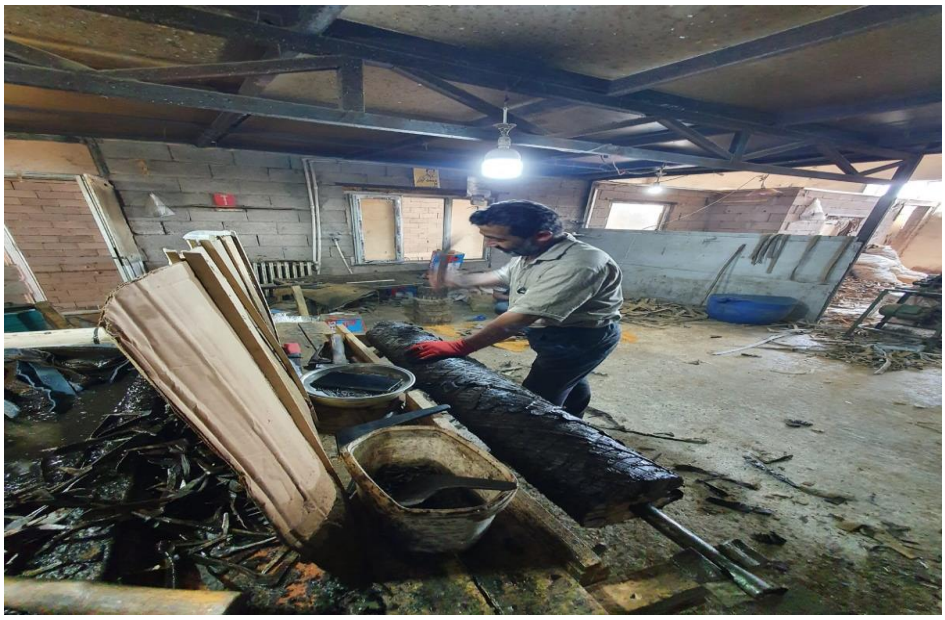

Figure 6. Shaving

With specially produced blades for shaving, the excess skin protrusions on the sides of the skin bundle are cut and cleaned by shaving.

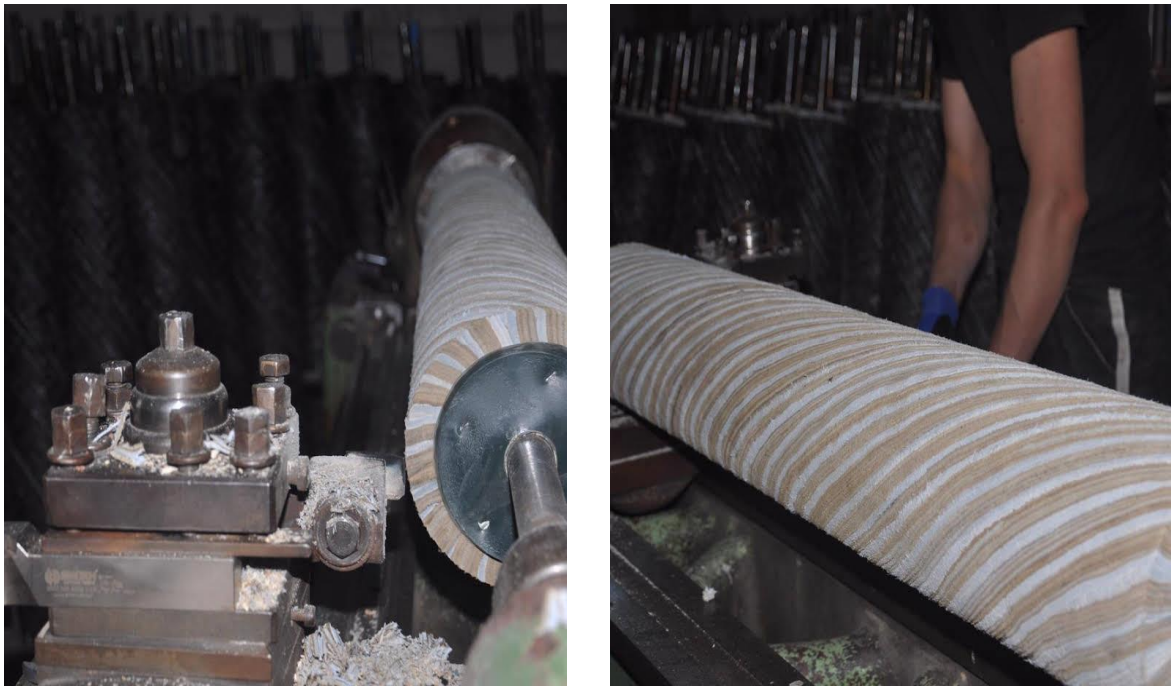

Figure 7. Turning and cleaning process

In the final stage, after the ginner role is passed through the turning process, it is subjected to a cleaning process and becomes a product. A ginner role is manufactured in seven days. It meets the demands of customers in the world market with relay manufacturing, which is a labor-intensive business.

Figure 8. Final product

The cotton ginner roles, which are turned into the final product, are prepared in line with the demands of the customers and transported as a result of the customs clearance process to be exported.

Figure 9. Ready-to-ship ginner roles

3. EXPORT PROBLEMS AND COST ANALYSIS OF LEATHERS

Ginning role manufacturers are leather makers established with a low capital and trying to survive. With the number of workers around 250 employed in Yalvac, they have a great contribution to production and exports. Of course, manufacturers that contribute to Yalvaç's economy also have problems. In manufacturing enterprises, important problems are encountered in subjects such as education, personnel, planning, institutionalization, decision making.

The most common point encountered in supply problems is that the raw material cannot be found and its quality is insufficient due to the increase in gelatin factories. Since leather manufacturers are small businesses, they are limited in taking orders for economic reasons[2].

Problems faced by businesses

✓ Manufacturers do not have an export market plan

✓ Sales level for international markets

✓ Pricing issues

✓ Insufficiencies of production amount

✓ Uncertainty in the national economy

✓ Amount of tax incentive support

✓ Transport and port distance

✓ Exchange rates

✓ Inadequate product standards

✓ Storage and stock costs

✓ Price imbalance in foreign markets

✓ Supply-demand fluctuations in foreign markets

✓ Language and communication difficulties

Table 1. Cost analysis

N	Substance, Materials and Activities	Previous Period	Current Period
1	wood raw material	13	20
2	bleaching process	6	8
3	crimping operation	4	5
4	Turning Process	3	3
5	Repair Process	4	5
6	Wire, Nails, Bolts	2	4
7	Workmanship	35	40
8	shaving process	15	20
9	Strap On	25	25

10	Strap Bonding	25	25
11	Glue	50	50
12	Leather Turning process	8	8
13	Head-Line Drawing	3	3
14	Paint	1	1
15	Lid	2	2
16	Derby	5	5
17	Hook Straightening	5	5
18	Transport	25	30
19	Finance, Accounting	7	9
20	Electricity Water	8	10
21	Workplace and Facility expense	8	10
22	Skin	150	200
	Total	**337**	**488**

When the current period cost analysis is made, a cost increase of 151 TL emerges compared to the previous period.

4.SAFETY IN LEATHER PROCESSING INDUSTRY

4.1. Accidents

Various accidents are encountered during tanning works. Fractures, dislocations, sprains and crushes caused by falls due to wet and oily floors are common. The sharp knives used while trimming the leather cause cuts. Along with these, the machines used to process the leather cause cuts, jams and ruptures[3].

4.2. Diseases

4.2.1. Infectious Diseases

In the tanning process, the upper skins of the animal hides are removed and the rest is converted into leather as is known. There is always the possibility of infection during this job; because there are many micro-organisms in animal hide. Fungal colonies such as Aspergillus niger and Penicillus glaucum may have settled on the skins. Chlorinated phenols, especially pentachlorophenol, have been used frequently to prevent their formation. However, they are extremely dangerous for workers' health because they can be poisonous[4,5].

4.2.2. Diseases Caused by Chemical Hazards

Eczema and contact dermatitis are seen in crockery workers due to chemicals that protect their skin. It has been statistically proven that the highest rate of dermatosis among different sectors in the USA is in the leather tanning business. Inflammation of the mucous membranes may occur in the throat and nose.

Those who work in tanning businesses, suspected of causing cancer; They are exposed to chromium salts, benzidine-based azo dyes, organic solvents (benzene and formaldehyde), pentachlorophenol, arsenic, dimethylformamide and leather powders. Various studies conducted in England and Italy have revealed that the risk of the disease known as soft tissue sarcoma is higher in crockery workers and the leading cause of this may be chlorophenols[6, 7].

5.CONCLUSION AND RECOMMENDATIONS

Leatherworks has been operating in Yalvaç District of Isparta province in the Western Mediterranean Region from past to present, and it provides the formation of knowledge in this field and the training of a qualified workforce. From the point of view of the leather ginners, the production of ginner role is an opportunity. It is exported to Azerbaijan, Uzbekistan, Sudan, Egypt, Turkmenistan and all countries where cotton is grown. Yalvaç contributes approximately 30 million dollars annually to its economy. The correct use of this potential is of great importance for manufacturers. In this study, the problems faced by leather makers in manufacturing and marketing in Yalvaç are discussed. Problems that may occur in marketing may prevent manufacturers from exporting. In this case, determining the main problems and taking effective and constructive measures will be beneficial for the producers. Economy is one of the most important problems of leather traders. In addition, providing tax relief to leather producers, ease of payment in loans, incentive policy will provide economic relief. If the economic support to leather makers is increased, production will increase, so the unemployed will decrease, and the country's economy will revive.

Another problem for the manufacturers is the exports made in the world market without the necessary examination. Research and development studies should be developed to increase competition. With institutionalization, production efficiency will increase. Innovations in technology should be followed closely.

Recommendations for ginner role manufacturers:

✓ Incentive studies should be carried out by supporting the export of the products produced.
✓ Marketing policies should be implemented by conducting market research.
✓ Incentive measures should be taken to increase the amount of domestic input.
✓ Leather companies that want to export should be organized and export should be realized within the framework of cooperation.
✓ Advertising activities should be increased
✓ Exchange rates should be followed.

Taking these measures will reduce the problem of ginner role manufacturers and thus their contribution to Yalvaç economy will increase.

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Research Article

A FACTORIAL ANALYSIS OF INDUSTRIAL SAFETY

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A FACTORIAL ANALYSIS OF INDUSTRIAL SAFETY

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ABSTRACT: In spite of all the efforts in different industries to reduce the number of undesirable accidents, a lot of events always threaten industrial societies. These events often cause huge damages to the environment, facilities, fatalities and disabilities for people. Therefore, it is important to analyse the numerous variables associated with industrial accident considerations and the inter play among these variables. This paper adopts a novel combination of two statistical methods to analyse the various hazards factors in the most important sector of the economy. In this analysis, critical hazards variables were identified and classified based on HSE (Health Safety and Environment) standards. Kendall's Coefficient of Concordance (KCC) and Principal Component Analysis (PCA) were employed to analyse the set of data generated from respondents and were summarized into a number of factors that promotes occupational safety and health in industries. KCC was used to analyze data matrix generated by thirteen Judges who were requested to rank the thirty two identified hazards variables in merit order of sequentiality scaled with 5-point Rensis Likert's attitudinal scale and administered to 22 respondents where only 13 were retrieved. The PCA aided by StatistiXL software package was proficient to achieving parsimony in factor reduction from thirty-two variables to mere five factors. The results obtained by KCC suggested that the judges ranking of the thirty two variables were consistent with index of concordance computed as W = 0.958. The result by PCA indicates that five factors creatively labelled: Work World Culture, Ground Rule Matters, Safety Considerations, Work Condition and Perception of Safety represent the principal factors that influence the industrial safety. This study unwrapped the deeper meanings associated with multi-dimensional factors in industrial safety.

Keywords: Principal Component Analysis, Parsimony, Hazards, Industrial accident, Concordance

1. INTRODUCTION

The health and safety environment within Oil and Gas Exploration operations is a growing concern as oil and gas production increases to keep up with demand and technology advances creating new hazards. Recent high-profile events have brought safety and environment concerns to the forefront demanded by regulators, general public and within operating companies themselves. Health and safety issues affect oil and gas producing companies, and industrial sectors in general to the extent where the potential risks cannot be ignored. In spite of all the efforts in different industries to reduce the number of undesirable accidents, a lot of events always threaten industrial societies. These events often cause huge damages to the environment, facilities and even in some cases, fatalities and disabilities for people. Therefore, it is important to analyse the numerous variables associated with industrial accident considerations and the inter play among these variables. A lot of factors are associated with industrial accidents considerations; unfortunately, the major problem is that we do not understand the character and the inter-play among these factors.

Industrial accidents studies have been carried out using several models. Such work on the use of Markov model to study industrial accidents has been reported. Typical studies include: [1-4] among others who also employed other models to safety. These studies go to underscore the importance of industrial safety. Also, a gargantuan of literature on general management of industrial safety exists. See, for example, [5-8]. Others are [9-11]. Specifically, victims show inherent tendencies to make causality attributions of industrial accidents. Research interest on safety is on constant increase, there is yet to be a research analysing the correlation among all levels of accident variables. Okwu et al. [4] used Markov theoretical approach to forecast the severity and exposure levels of workers in the oil and gas sector. The perils were classified into four states which include: catastrophic, critical, marginal and negligible. The result showed 41.45% of workers would likely transit from negligible state to catastrophic state. Monday [12] researched on occupational health and safety in the oil and gas industry by investigating the various hazard workers are exposed to, the effect of these hazards to the health of the workers, the effectiveness of the existing means of mitigating these hazards and the adequacy of the legislation that impacts on the provision of occupational health and safety in the oil and gas industry. Statistical package for social sciences (SPSS) software was used for the analysis. Achojakimoni [13] studied hazards control measurement by evaluating the effective use of personal protective equipment, good housekeeping, adequate maintenance, good maintenance of machinery, emergency procedures to follow when there is accident in confined space. Confined space include but are not limited to storage tanks, compartments of ships, process vessels, pits, silos, vats, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines. Amol [14] carried out hazard identification and risk analysis in iron ore and coal mining operations. The study revealed that the number of high risks hazards in the coal mining operations was more than the one of the iron ore mining operations. Jeong et al. [15] used Hazard and Operability Method (HAZOP) to identify the potential hazards and operability problems of decommissioning operations and concluded that the decommissioning of a nuclear research reactor must be accomplished according to its structural conditions and radiological characteristics. Jelemenesky et al. [16] applied the probabilistic safety assessment in chemical industry. The method was applied to a pressurized spherical tank for ammonia storage in order to estimate reliable risk of its casual rupture with different magnitude of the tank damage. Dziubinski et al. [17] studied basic reasons for pipeline failure and its probable consequences taking individual and societal risk into consideration and proposed methodology of risk assessment for hazards associated with hazardous substance transport in long pipelines. Ramin [18] examined the application of semi-Markov models to the phenomenon of earthquakes in Tehran province. In his research, the province of Tehran was divided into six regions and grouped the earthquakes using their magnitude into three classes. Semi-Markov model was used to predict the likelihood of the time and place of occurrence of earthquakes in the province under stochastic environment. Peng et al. [19] in the study on "prediction of Ship Traffic Flow Based on BP Neural Network and Markov Model'' concluded from their work that the prediction accuracy of short-term ship traffic flow is of great significance to ensure the safety of navigation, efficient use of resources and reduce maritime accidents. A prediction model based on BP neural network and Markov Chain to improve the prediction accuracy of short-term ship traffic flow was set up. The empirical study indicated that using this method can achieve forecasting accuracy improvement feasible. This work only forecast the ship traffic flow from the macro and did not consider the impact of other factors, such as weather, sea conditions, and policies and so on as well as the correlation among them. Oluoch et al. [20] determined the effects of occupational safety and health awareness on work environment in the Kenyan Kisumu County Water Service industry. The study utilized a descriptive research design with simple random sampling employed to draw the respondents from each site. Self-administered semi-structured questionnaire was used

to acquire the data used. The data was analyzed using Statistical Package for Social Sciences version 21. Frequencies and percentages were obtained and correlations carried out using Spearman's correlation coefficients. The study analyzed the relationship between staff awareness of occupational safety and health and work environment using Spearman's coefficient at Confidence Level (CL) of 95%. The result showed that there is a significant moderate positive relationship between staff awareness of occupational safety and health and work environment in the water service industry in Kisumu County. Katsuro et al. [21] assessed the impact of occupational health and safety (OHS) on workers' productivity in the commercial food industry. The study explored OHS problems of different work areas and their impact on productivity. The study found out that OHS related problems negatively affect workers' productive capacity in the food industry resulting in reduced worker output. It was also observed that the workers develop a negative attitude and low morale towards work and that high incidents of accidents at work also occur. According to Manduku and Munjiri [22], a closer scrutiny of the OSHA, 2007 revealed that many of the dangerous occurrences and prescribed occupational diseases in the 1st and 2nd schedules may exist. The author noted that there are several instances of unsafe working conditions and work behaviour that both employees and employer should place emphasis on. Malek et al., [23] explored the possible benefits of focusing on the occupational health and wellness of construction and industrial workers as a separate category from safety. According to the authors, the occupational health of workers has an impact on the workers' wellbeing, state of mind, overall attitude and morale; therefore the safety, quality of work and inevitably the profitability of the company is affected. Bibay and Agapito [24] carried out a study to determine the commonly encountered occupational hazard of laboratory animal workers in Singapore and the Philippines. The study determined the percentage of hazard exposure according to the workers' personal profile, work profile, and frequency of exposure. The result showed no significant difference between the three hazards studied when compared to one another. These hazards were consistent regardless of age, gender, education, job, biosafety level of the facility, years of work experience and type of animal exposures. Otitolaiye et al., [25] investigated the indirect effect of safety management system in the relationship between organizational safety culture and safety performance. The study employed the use of a 5-point Likert questionnaire to collect data from 134 respondents who are head of safety officers in F&B industries located in Lagos, Nigeria. The results from the path analysis revealed that safety culture and safety management system positively relate to safety performance. The mediation analysis carried out indicated an indirect effect of safety management system in the relationship between safety culture and safety performance. A more efficient model on variables associated with industrial accident analysis with considerations on the inter-play among the variables is considered in this research.

2. MATERIALS AND METHODS

A massive literature survey was carried out in the subject area to identify various industrial safety variables for the study and thirty-two industrial safety variables were identified. These identified variables were utilized to make a well-structured questionnaire with the aid of Rensis Likert's 5-point attitudinal scale whose dimensions include strongly agree, agree, undecided, disagree, and strongly disagree as shown in Table 1.

Table 1. Rensis Likert's 5-Point Response Option

S/NO	RESPONSE OPTION	WEIGHT ASSIGNED
1	Completely-Agree	5
2	Agree	4
3	Undecided	3
4	Disagree	2
5	Completely-Disagree	1

The descriptive sample size of the small and medium sized enterprises population employed for this study was obtained by using Eq. (1) to validate an adequate population size for the study.

$$Sample\ \text{Size} = \frac{p(100-p)z^2}{E^2} \tag{1}$$

where, p is the percentage occurrence of a state or condition

E is the percentage maximum error required

z is the value corresponding to level of confidence required (Taherdoost, 2017).

The questionnaires were then administered to the respondents in the oil and gas industry; those with enormous knowledge on the subject matter.

2.1 Data collection

The data used for this study was obtained through the well-structured questionnaire administered to the knowledgeable respondents in the oil and gas industry after carefully defining the sample size. The 95% confidence level was chosen to ensure an adequate representative population size and to validate the data used for the study. The respondents' scores were collated into m x n data matrix.

2.2 Data analysis

The m x n data matrix obtained served as an input variable that were analyzed in two different ways: first through the use of Kendall's coefficient of concordance (KCC) in which the knowledgeable respondents (thirteen selected judges) in the oil and gas industry were requested to rank the first set of questionnaire in descending order of importance. The respondents' scores were collated into data matrix having a dimension of 13 by 32. The measure of agreement among the judges who ranked the variables was computed. A test statistic called chi square ($\chi 2$) was used to appraise how consistent the judges were in ranking the variables. The Chi-square test, moored on a null hypothesis (H_0) proposes that the ranking by the 13 judges are discordant while the alternate hypothesis (H_1) proposes that the 13 judges were consistent.

Decision Rule: if $\chi^2_{cal} > \chi^2_{tab}$, we reject the null hypothesis, H_0.

if $\chi^2_{cal} < \chi^2_{tab}$, we accept the null hypothesis, H_0.

Kendall coefficient of concordance is given by

$$W = \frac{S}{\frac{1}{12}K^2\left(N^3 - N\right)} \tag{2}$$

where,

$$S = \sum\left(R_j - \frac{\sum R_j}{N}\right)^2$$

R_j = Column sum of ranks
N = Total number of Variables
S = Variance
K = Number of Judges

The second analysis was carried out through the use of Principal Component Analysis (PCA) where the respondent's scores were collated as data matrix and fed into StatistiXL software that provided the following output namely: descriptive Statistic, correlation matrix, eigenvalues, eigenvector, unrotated factor loading, case-wise factor scores, varimax rotated factor loadings, explained variance and factor plot, among others. On the basis of this statistiXL output, 5 factors with eigenvalues ($\lambda > 1$) were extracted and labeled for significant interpretations. The fundamental reason of using the principal component analysis (PCA) is to reduce the dimensionality of the data set containing large number of interrelated variables while retaining as much as possible of the variation present in the data set.

3. RESULTS AND DISCUSSION

3.1 Result of Kendall Coefficient of concordance (KCC)

The Kendall coefficient of concordance (*W*) was obtained as 0.96 using equation 2, and substituting that into chi square (χ^2) equation 3, we have $\chi^2_{cal} = 356.4$

$\chi^2_{cal} = K\,(N - 1)\,W$ (3)

where, K = 13, N = 32, W = 0.96

Since $\chi^2_{cal} = 356.376 > \chi^2_{tab} = 52.1914$, we fail to accept the null hypothesis (H_0) and therefore conclude that the judges ranking of the 32 scaled items were consistent.
The judges ranking were shown as a data matrix in the column which was arranged in ascending order. The Rj connote the ranking coefficients.

Table 2. Merit order of sequentiality of the 32 industrial safety variables

S/N	Rj	Variables	S/N	Rj	Variables
1	13	Work environment	17	251	Complexity of work-zone
2	39	Nature of existing workplace	18	251	Work-zone speed limit
3	86	Workspace design	19	257	Traffic volume
4	98	Nature of task	20	263	Disabled vehicles
5	133	Human error	21	264	Adverse weather condition
6	137	Drowsiness and distraction	22	268	Spilled load
7	153	Personal organization	23	286	Hazardous material
8	155	Logistic pattern	24	291	Driver impairment
9	155	Maintenance on demand	25	298	Mentally challenged faculty
10	164	Response to warning	26	301	Ignoring headlamp usage
11	167	Sub-system failure	27	306	Driver's error
12	182	Catastrophic accident	28	316	Poor lateral control
13	182	Compound failure	29	324	Poor longitudinal control
14	198	Power flow overload	30	344	Poor manoeuvring
15	209	Voltage instability	31	344	Tool type
16	247	Aging of parts	32	686	Poor performance

3.2 Result of Principal Component Analysis (PCA)

The five factors extracted by the principal component analysis loaded clusters of industrial safety variables with several factor loadings. Figure 1 depicts the scree plot of the factorial analysis carried out showing the number of factors extracted by the analysis. It explains how much variation each principal component exerted in the data examined. This shows that there is significant parsimony in factor reduction from 32 to mere 5.

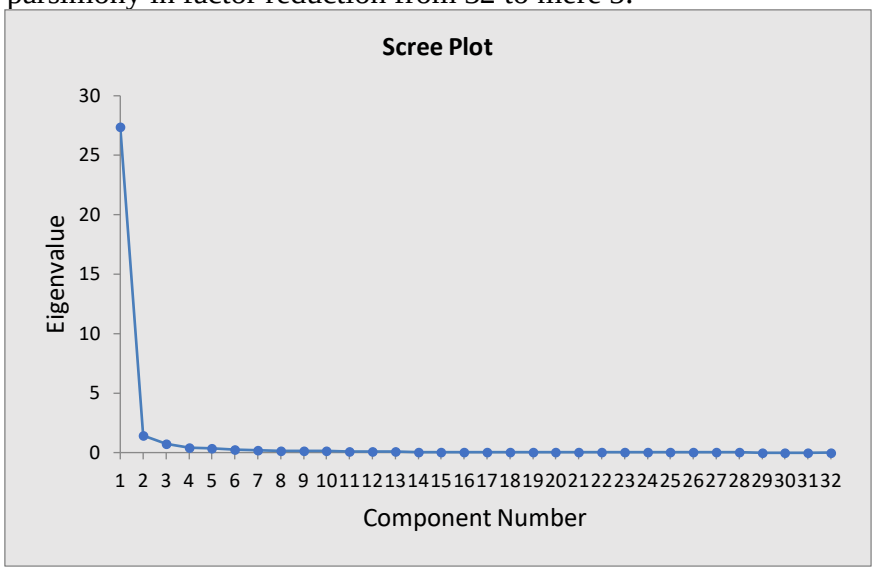

Figure 1: Scree Plot

The result of the varimax rotated factor matrix is depicted in Table 3

Table 3. Varimax Rotated Factor Loadings matrix of 32 variables of industrial accidents

Varimax Rotated Factor Loadings matrix of 32 variables of industrial accidents						
S/N	**Variable**	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**
1.	Work environment	0.516	0.385	0.316	**0.684**	0.097
2.	Nature of existing workplace	**0.815**	0.463	0.228	0.057	0.103
3.	Workspace design	0.452	**0.776**	0.255	0.236	0.134
4.	Nature of task	**0.594**	0.437	0.380	0.266	0.333
5.	Human error	0.530	**0.742**	0.207	0.137	0.126
6.	Drowsiness and distraction	0.540	**0.724**	0.300	0.142	0.067
7.	Personal organization	**0.811**	0.465	0.208	0.150	0.144
8.	Logistic pattern	0.543	**0.737**	0.222	0.185	0.081
9.	Maintenance on demand	**0.739**	0.376	0.245	0.359	0.033
10.	Response to warning	**0.527**	**0.555**	0.458	0.193	0.181
11.	Sub-system failure	**0.830**	0.425	0.211	0.165	0.144
12.	Catastrophic accident	**0.723**	0.344	0.355	0.268	0.113
13.	Compound failure	0.405	**0.597**	**0.619**	0.223	0.114
14.	Power flow overload	0.382	**0.793**	0.312	0.246	0.146
15.	Voltage instability	0.411	**0.826**	0.260	0.107	0.121
16.	Aging of parts	**0.819**	0.433	0.214	0.192	0.109
17.	Complexity of work-zone	**0.624**	**0.500**	0.361	0.093	**0.426**
18.	Work-zone speed limit	0.426	**0.667**	0.238	0.115	0.149

19.	Traffic volume	**0.787**	0.480	0.270	0.100	0.134
20.	Disabled vehicles	**0.790**	0.498	0.233	0.101	0.078
21.	Adverse weather condition	**0.771**	0.384	0.264	0.263	0.244
22.	Spilled load	0.506	**0.776**	0.212	0.157	0.089
23.	Hazardous material	0.461	**0.584**	**0.561**	0.233	0.123
24.	Driver's impairment	**0.592**	**0.469**	0.383	0.176	**0.468**
25.	Mentally challenged faculty	0.470	**0.786**	0.234	0.124	0.106
26.	Ignoring headlamp usage	**0.783**	0.380	0.267	0.254	0.031
27.	Driver's error	0.312	**0.599**	**0.694**	0.176	0.105
28.	Poor lateral control	0.395	**0.721**	0.334	0.165	0.174
29.	Poor longitudinal control	**0.667**	0.344	0.374	0.320	0.126
30.	Poor manoeuvring	0.398	**0.710**	0.419	0.204	0.124
31.	Tool type	0.418	**0.789**	0.297	0.232	0.133
32.	Poor performance	**0.725**	**0.567**	0.182	0.168	0.022

3.2.1 Creative labeling of the three factors:

Table 4. Factor 1: Work World Culture

Clusters 1 (Factor 1): Work World Culture.		
S/N	Variable description	Factor loading
2	Nature of existing workplace	0.815
4	Nature of task	0.594
7	Personal organization	0.811
9	Maintenance on demand	0.739
10	Response to warning	0.527
11	Sub-system failure	0.830
12	Catastrophic accident	0.723
16	Aging of parts	0.819
17	Complexity of work-zone	0.624
19	Traffic volume	0.787
20	Disabled vehicles	0.790
21	Adverse weather condition	0.771
24	Driver's impairment	0.592
26	Ignoring headlamp usage	0.783
29	Poor longitudinal control	0.667
32	Poor performance	0.725

A principal factor embodying sixteen (16) variables which we creatively labelled, work world culture emerged. The variables all bear positive factor loadings suggesting that it is a sturdy or stocky factor. Seven (7) variables emerged top in the list on the basis of their high factor loadings. We shall discuss these (7) and then give a general review of the rest nine (9). First on the list is Subsystem failure wielding a factor loading of **0.830.** Under this work world culture, a sub- system can be figuratively compared to the heart or kidney as a sub- system (organ) of the human system. If any of this sub- system fails in a human system, the important role they perform collapses and the human dies. Aging of parts with factor loading **0.819** deals with fatigue failure. Again, metaphorically, when the organs and body parts of human system are

ageing, it will eventually lead to human death. So it is in all mechanical systems. Next in other of importance is nature of existing workplace, with factor loading of **0.815.** Workplace, work environment or work conditions skulk in stillness as surprise awaits in ambush. So it is in a work place. Work environment is full of potential hazards which can only be avoided by good safety culture rules. Next is personal organization with a factor loading of **0.811** which implies the way a worker organizes themselves. In safety parlance it is referred to as personal trouble. And, if you permit, in African parlance it is called home trouble. Therefore, the way an individual organizes his world goes to a large extent to determine how they react to hazard in work environment. That presupposes that nervousness, slowness in learning and suchlike are indicators of lack of personal organization. Disabled vehicles **0.790** imply vehicles in bad repair state. It could lead to system or sub system failure thereby causing injuries and even fatalities. Traffic volume with a factor loading of **0.789**, in this context, could refer to vehicle traffic, human traffic, or entities traffic. When such movements are beyond certain limit they pose great hazard to industrial safety. Again, adverse weather condition may constitute an act of God and that is why flights and even vehicular movements are suspended. But where flight is already on course it might constitute great hazard to human and equipment. The rest variables under this factor in themselves are potential hazard that could be avoided through appropriate safety culture.

Table 5. Factor 2: Ground Rule Matters

Clusters 2 (Factor 2): Ground Rule Matters.		
S/N	Variable description	Factor loading
3	Workspace design	0.776
5	Human error	0.742
6	Drowsiness and distraction	0.724
10	Response to warning	0.555
13	Compound failure	0.597
14	Power flow overload	0.793
15	Voltage instability	0.826
17	Complexity of work zone	0.500
18	Work zone speed limit	0.607
22	Spilled load	0.776
23	Hazardous material	0.584
24	Driver’s impairment	0.469
25	Mentally challenged faculty	0.786
27	Driver’s error	0.599
28	Poor lateral control	0.721
30	Poor manoeuvring	0710
31	Tool type	0.789
32	Poor performance	0.567

Cluster 2 is creatively labelled Ground Rule matters. The factor loadings are all positive. The variables therein are majorly ergonomic/work conditions and they constitute veritable matters for forging safety ground rules.

Table 6. Factor 3: Safety Considerations

Clusters 3 (Factor 3): Safety Considerations		
S/N	**Variable description**	**Factor loading**
13	Compound failure	0.619

23	Hazardous material	0.561
27	Driver's error	0.694

The third factor is a trio comprising compound failure, hazardous materials and driver's error. They have middling factor loadings suggesting that their influence in safety is moderate

Table 7. Factor 4: Work Condition

Clusters 4 (Factor 4): Work Condition.		
S/N	**Variable description**	**Factor loading**
1	Work environment	0.694

There is also a lone factor in this cluster creatively labelled work condition. It is a lone factor that is almost a work world of its own in that variables under work conditions are multifarious and it is a major factor that causes accident in the work world. Its factor loading is almost substantial.

Table 8. Factor 5: Perception of Safety

Clusters 5(Factor 5): Perception of Safety.		
S/N	**Variable description**	**Factor loading**
17	Complexity of work- zone	0.426
24	Driver's impairment	0.468

Finally, we encounter a dual factor creatively labelled perception of safety under this cluster. It comprises complexity of work zone and driver's impairment. As the saying goes, beauty is in the eyes of the beholder; and so is safety perception depend upon how an individual perceives safety condition. A worker with one impairment or another may not be able to have the right or correct perspective of the work world. The work zone may appear too complex for them to analyse, comprehend and appreciate.

4. CONCLUSION

Arising from the foregoing results and discussions, it is evident that safety in an organisation depends on the prevailing safety culture, the ground rule guiding safety practices, safety considerations observed by management and workers alike. The nature of hazards (work conditions) existing in the organisation as well as the way workers and managements perceive safety. Hence the PCA and KCC statistical models adopted appear to provide enlightenment on the complexion of multi- factor work world. This study focused on the panoramic view of the work world containing multifarious variables that characterize multi -factor world of work and the PCA models adopted was quite successful in achieving parsimony by reducing the 32 identified variables of work world to mere 5. This is indeed a significant parsimony in factor reduction. The study is therefore successful in explaining the dynamism of multi-factor culture of work world. This study therefore unwrapped the deeper meanings associated with multi-dimensional factors in industrial safety.

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Research Article

Multi-Objective Optimization of Distributed Generation Despite Energy Storage Systems for Optimal Management

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Multi-Objective Optimization of Distributed Generation Despite Energy Storage Systems for Optimal Management

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Abstract: The influence of distributed generation resources and energy storage units in distribution networks is increasing. Therefore, it is essential to examine their effect on network reliability. In this study, in order to present the optimal energy management strategy in the smart distribution network, the problem of multi-objective optimization of rearrangement of distribution feeders with the presence of distributed generation sources and energy storage units has been solved in a dynamic framework. Objective functions in this study include minimization of energy losses, redistributed energy and operating costs. In order to simultaneously optimize the reliability index and other objective functions, another optimal design for the production of distributed generation units, charging and discharging of energy storage systems as well as the topology of distribution network feeders is presented. In order to solve the multi-objective optimization problem in this study, a combination of particle social algorithms and frog mutation has been used. In order to show the ability of the method in providing an optimal energy management plan in a 95-bus network has been tested. In this paper, it is shown that the effect of distributed generation resources and energy storage units in solving the optimization problem leads to a reduction in losses, undistributed energy, and operating costs.

Keywords: rearrangement of distribution feeders, distributed generation sources, energy storage systems, multi-objective optimization.

1. INTRODUCTION

Distribution network operation strategies have changed significantly in the last decade due to the high penetration of renewable energy sources and energy storage along with automation systems [1-3]. The random nature of energy storage units poses a serious challenge to the power supply with high reliability. Accordingly, many studies have been conducted to provide a model for the optimal management of charge and discharge of energy storage units, because these units play a crucial role in the management of renewable energy sources in distribution networks. One of the most common energy management techniques in intelligent distribution networks is the rearrangement of distribution network feeders in the presence of energy storage units and distributed generation sources. The process of rearranging distribution feeders to change the topology of distribution feeders is done by switching management and due to operational limitations in distribution systems. The rearrangement problem of distribution feeders can be formulated as a nonlinear and convex problem. Therefore, mathematical methods are not suitable due to the limitations of objective functions and constraints of this problem such as discontinuity and derivation [4]. Accordingly, researchers have proposed optimization methods based on heuristic algorithms to solve this optimization problem, which is discussed below:

In [5], an improved gravitational search algorithm is proposed to solve the rearrangement problem of distribution feeders in the presence of distributed generation sources with the aim of improving transient stability, reducing losses, and operating costs. In [6], a combined algorithm of particle clustering and frog mutation is proposed to solve the problem of rearrangement of distribution feeders in the presence of distributed generation sources with the aim of improving voltage stability and reducing losses. An improved genetic algorithm with variable population has been proposed to solve the rearrangement problem in the distribution network with the aim of reducing losses [7]. In [8], the particle community coding optimization algorithm is presented in order to solve the rearrangement problem of distribution feeders by considering different models of distributed generation sources. The expansion of electrical energy storage units along with distributed generation sources in the distribution network has led to further studies on the optimal management of these resources. Many studies have been performed to obtain an optimal energy management plan for integrating electrical energy storage units with distributed generation sources in fixed topology distribution networks.

In [9-11], the optimal energy management strategy is proposed by integrating a large scale of distributed generation resources in the distribution network in order to reduce operating costs. In [1], the colonial competition algorithm is proposed to provide optimal energy management in the distribution network in the presence of distributed generation sources and energy storage units with the aim of reducing operating costs. The combined particle and gray wolf community algorithm has been introduced in order to present the optimal energy management strategy in the distribution network with the presence of distributed generation sources and energy storage units [12]. Considering the previous work in the previous paragraphs related to the problem of rearrangement of distribution feeders, it is clear that the electric charge is considered in the fixed problem-solving interval. As a result, we have an optimal arrangement for the study interval, but in real distribution networks, due to the change in the electrical load of the network per hour, solving the optimization problem by considering a constant load is not acceptable. In [13], an improved hybrid particle and wolf community algorithm is proposed to solve the problem of dynamic rearrangement of distribution feeders in the presence of distributed generation sources with the aim of improving reliability and reducing energy losses. An improved hybrid particle assembly and frog mutation algorithm are proposed to solve the problem of dynamic rearrangement of distribution feeders and capacitive switching in the presence of distributed generation sources and energy storage units [14]. In [15], the ant colony algorithm is proposed to solve the problem of dynamic rearrangement of distribution feeders and switching of capacitor banks in the presence of distributed generation sources. In a high-penetration distribution system, distributed generation resources using a random program to model the intermittent behavior of resources have the uncertainty of a common and practical solution for the operation of the distribution network. In addition, solving the problem of dynamic rearrangement of distribution feeders with the integrated presence of distributed generation sources and energy storage units has also not been considered considering the uncertainty of distributed generation sources in previous studies related to energy management. Accordingly, the model presented in this study includes the following aspects:

- Dynamic rearrangement of distribution feeders,
- Provide an optimal plan for energy management in the presence of integrated distributed generation resources with energy storage units,
- Respond to demand at an appropriate level of network reliability due to the uncertainty in the output power of distributed generation sources and the purchase price of energy.

Solving the problem of multi-objective optimization of dynamic rearrangement of distribution feeders in the presence of distributed generation sources requires an accurate and powerful

solution method. For this purpose, a combined optimization algorithm of particle assembly and frog mutation to deal with the complexity of the optimization problem is presented in this study. Particle clustering [16] and frog mutation [17-25] algorithms have minor drawbacks such as premature convergence or entrapment in local optimizations. For this purpose, a combination of two algorithms has been used in order to use the advantages of these methods to reduce their disadvantages.

2. DEFINING THE PROPOSED PROBLEM AND ITS FRAMEWORK

In this section, it is assumed that a company owns all the equipment and facilities of the distribution network, as well as the operation of the distribution network is the responsibility of this company. The operator of this company solves the problem of random optimization due to the uncertainties related to the output power of solar units and the purchase price of electricity from the market. Problem variables, objective functions, problem constraints, and uncertainty modeling are described below.

2.1. Problem variables

The variables of the multi-objective optimization problem are as follows:

$$X = \left[X_{SW}, X_{Tie}, X_{DG}, X_{ES} \right] \quad (1)$$

$$X_{SW} = \left[SW_1^t, SW_2^t, ..., SW_{Ntie}^t \right] \quad (2)$$

$$X_{Tie} = \left[Tie_1^t, Tie_2^t, ..., Tie_{Ntie}^t \right] \quad (3)$$

$$X_{P_{DG}} = \left[P_{Dg1}^t, P_{Dg2}^t, ..., P_{DgN_{Dg}}^t \right] \quad (4)$$

$$X_{P_{ES}} = \left[P_{ES1}^t, P_{ES2}^t, ..., P_{ESN_{ES}}^t \right] \quad (5)$$

X is the vector of the control variables of the problem. N_{dg} and N_{ES} the number of distributed generation sources and energy storage units, respectively. Tie_i Indicates the status of the i-th switch and its value is zero or one. SW_i and N_{tie} indicate the number of closed switches and the number of closed switches. $P_{Dg,i}^t$ and $P_{ES,j}^t$ the amount of active power is the i-th scattered production unit and the j-th energy storage unit at t-th time, respectively.

2.2. Objective functions

In this study, the objective functions include minimization of energy losses, redistributed energy and network operation costs.

Energy losses are calculated from Equation (6) [8]:

$$f_1(x) = \sum_{t=1}^{24} \sum_{i=1}^{N_{brch}} R_i \times \left| I_i^t \right|^2 \quad (6)$$

I_i^t and R_i are the impedance and the actual current of the line i-th at time t-th, respectively. N_{brch} Indicates the number of network lines.

The redistributed energy is calculated from Equation (8):

$$ENS_i = P_i \sum_{i,j \in V, i \neq j} \left(U_{i,j} + U'_{i,j} \right) \quad (7)$$

In the above relation, V is the set of buses that are fed from a feeder. $U'_{i,j}$ and $U_{i,j}$ indicate the repair time (hours per year) and the time related to compensation (hours per year) of the branches related to bus i, respectively. $d_{i,j}$ and $\lambda_{i,j}$ failure rates and line lengths, respectively. $t'_{i,j}$ and $t_{i,j}$ the average repair time and the average recovery time of the line are between the i-th and j-th bus axes [9]. The final relation of the redistributed energy of the whole network is calculated by considering the reference node of Equation (8):

$$f_2(x) = \sum_{i=2}^{N_{Bus}} ENS_i \quad (8)$$

The operating cost in this study is calculated from the following equation:

$$f_3(x) = \sum_{t=1}^{24} \left(\sum_{j=1}^{N_{DG}} Price^t_{DG,j} P^t_{DG,j} + \sum_{s=1}^{N_{Sub}} Price^t_{Sub,s} P^t_{Sub,s} + \sum_{k=1}^{N_{SW}} Price^t_{Sw,k} \left| S^t_k - S^{t0}_k \right| \right) \quad (9)$$

$P^t_{Sub,s}$ and $P^t_{DG,j}$ the active power of scattered production is j-th and post-th at time t-th, respectively. $Price^t_{DG,j}$ and $Price^t_{Sub,s}$ the purchase price of electricity is from the scattered generation and the third post at the time of t, respectively.The cost of switching is $Price^t_{Sw,k}$ at the time of t-th. N_{sub} and N_{sw} represent the number of switches and posts, respectively. S^{t0}_k and S^t_k represent the primary and secondary status of the km switch at t-th time, respectively.

2.3. Problem constraints

The constraint on the radius of the network is calculated from Equation (10):

$$N^t_{branch} = N_{Bus} - N_{Source} \quad (10)$$

N_{Bus} ands in the network, respectively.represent the number of buses and substation N_{Source}

The constraint of load distribution equations is calculated from the relations (11) and (12):

$$P^t_j = \sum_{i=1}^{N_{Bus}} V^t_i V^t_j Y_{ij} \cos\left(\theta_{ij} - \delta^t_i + \delta^t_j \right) \quad (11)$$

$$(12)\ Q^t_j = \sum_{i=1}^{N_{Bus}} V^t_i V^t_j Y_{ij} \sin\left(\theta_{ij} - \delta^t_i + \delta^t_j \right)$$

P^t_j And Q^t_j the active and reactive capacities of the network are injected into the i-th bus at t-th time, respectively. δ^t_i And V^t_i the amplitude and angle of the voltage are i-th at time t-th, respectively. They represent the size and angle of branch admittance between the i and j axes, respectively.

Bus voltage range:

$$V_{min} \le V_i^t \le V_{max} \quad (13)$$

$$\left|I_{f,i}^t\right| \le I_{f,i}^{Max} i = 1,2,...,N_{feeder} \quad (14)$$

Transformer limitations:

$$\left|I_{trns,i}^t\right| \le I_{trns,i}^{Max} \quad (15)$$

$$i = 1,2,...,N_{transformer}$$

In fact, distributed generation sources in distribution systems are modeled as PV and PQ. In PV modeling, distributed generation sources must generate reactive power to maintain voltage in their range. In this study, PQ has been used to model dispersed production units [3-2].

In addition to the use of distributed generation sources in this study, the effect of energy storage units in solving the problem of dynamic rearrangement of distribution feeders has been considered. Simultaneous use of energy storage systems along with distributed generation sources improves reliability, improves voltage profiles, etc. in distribution systems. Proper operation management does not compromise network stability or reduce equipment efficiency [7, 1]. The following are the restrictions on energy storage units.

$$E_x^h = E_x^{h-1} + \sigma_{ch,x} P_{ch,x}^h \times \Delta h - \frac{1}{\sigma_{dis,x}} P_{dis,x}^h \times \Delta h \quad (16)$$

$$\Delta h = 1hour, \quad x = 1,2,...,N_{ES}$$

$$(17)\ E_x^{min} \le E_x^h \le E_x^{max}$$

$$P_{ch,x}^h \le P_{ch,x}^{max} \quad (18)$$

$$P_{dis,x}^h \le P_{dis,x}^{max} \quad (19)$$

E_x^h is the energy value of x-th units at h time. $P_{ch,x}^h$ and $P_{dis,x}^h$ are the charge and discharge rates of the x-th unit at hm, respectively. E_x^{min} and E_x^{max} are the maximum and minimum energies of the x-th unit at time h, respectively. $P_{ch,x}^{max}$ and $P_{dis,x}^{max}$, respectively, represent the maximum charge and discharge of the x-th unit at h-th.

2.4. Uncertainty modeling

In this section, modeling sources of uncertainty, including the power of solar units and the purchase price of electricity is examined:

The beta distribution function in Equation (20) has been used to model solar radiation according to previous data.

$$f_b(s) = \begin{cases} \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha).\Gamma(\beta)}.s^{\alpha-1}.(1-s)^{\beta-1} & 0 \le s \le 1, \alpha, \beta \ge 0 \\ 0 & \text{Otherwise} \end{cases} \quad (20)$$

$f_b(s)$ is a function of the beta distribution, α and β are determined based on past solar radiation data.

The log-normal distribution function in relation (21) has been used to model the purchase price of electricity according to previous data.

$$f_p\left(E^{pr},\mu,\sigma\right)=\frac{1}{E^{pr}\sigma\sqrt{2\pi}}\exp\left(-\frac{\left(\ln E^{pr}-\mu\right)^2}{2\sigma^2}\right) \quad (21)$$

E^{pr} The parameter is a function of the probabilistic distribution, σ and μ are the standard deviation and the mean, respectively. The scenario generation method has been used to model the uncertainty related to the parameters in this study [13]. In this method, like Monte Carlo, we generate random numbers according to the number of uncertainty parameters, then we calculate the amount of error and probability related to each of the sources of uncertainty using the roulette wheel corresponding to each of the generated random numbers. After generating the scenario, the high number of scenarios reduces the speed of problem-solving and increases the calculations. For this reason, it is necessary to reduce the set of main scenarios in such a way that the characteristics of the problem do not change drastically.

2.5. Multi-objective problem strategy and a proposed algorithm

In this section, the proposed multi-objective problem strategy and algorithm are presented. In a multi-objective problem where the goals are in conflict with each other, the problem is formulated as follows [8, 3]:

$$Minf\left(x\right)=\left[f_1\left(x\right),f_2\left(x\right),...,f_n\left(x\right)^T\right],G_i\left(x\right)\le 0,H_i\left(x\right)=0 \quad (22)$$

$G_i\left(x\right)$ and $H_j\left(x\right)$ are equal and unequal constraints, respectively. n and x are the numbers of objective functions and the vector of the optimization variables, respectively. The pareto optimization method works for multi-objective problems based on mastery. The x_1 and x_2 vectors prevail when the following conditions are met [8, 3]:

$$\forall i\in\left\{1,2,...,N_{obj}\right\},\quad f_i\left(x_1\right)\le f_i\left(x_2\right) \quad (23)$$

$$\exists i\in\left\{1,2,...,N_{obj}\right\},\quad f_i\left(x_1\right)< f_i\left(x_2\right) \quad (24)$$

Since the objective functions are not in the same range, fuzzy sets are executed to replace each objective function with a value between (0 and 1). f_i^{min} and f_i^{max} represent the upper and lower bounds of the objective function. These values are calculated separately using the optimization of each objective function. The value of the normalized membership function for each member in the set of answers is obtained from Equation (25) [9]:

$$N_{\mu j}=\frac{\sum_{k=1}^{n}\beta_k\times\mu_{jk}\left(x\right)}{\sum_{j=1}^{m}\sum_{k=1}^{n}\beta_k\times\mu_{jk}\left(x\right)} \quad (25)$$

m and n are non-dominant solution numbers and objective functions, respectively. Expresses the weight k-th of the objective function and the value is selected by the operator based on the degree of importance of each objective function. The particle clustering algorithm is used in many optimization problems due to its simple execution and high speed. The main problem of this algorithm is early convergence and it may be solved quickly in solving a problem, but the answer is a local optimal problem. One of the advantages of the frog jump algorithm compared to other algorithms is the simplicity and minimal storage space of this algorithm. The reason

for using a combination of particle clustering algorithms and frog mutations is to use the advantages of both algorithms to reduce their disadvantages. The following is a step-by-step hybrid algorithm for solving the multi-objective optimization problem:

1. Production of the initial population as follows:

$$\text{Initial} - \text{population} = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_N \end{bmatrix} \quad (26)$$

2- Calculation of objective functions for all particles based on relations (6, 8, and 9).
3- Calculate the membership function for each objective function based on the relation (24).
4. The normalized value for all particles is calculated from (25).
5. Using the Pareto optimization method in order to obtain the normalized objective functions from the previous step and store the non-dominant answers in the set of considered answers.
6. Dividing particles in K sets based on decreasing fit.
7. Specify and in the set of particles.
8. At this stage, information is exchanged between all collections. To do this, all sets are combined and reclassified, all non-dominant solutions are extracted from existing particles, and stored in the set of answers.
9. Calculation of objective functions for particles based on relations (6, 8, and 9).
10. Calculate the membership function for each objective function based on the relation (25).
11. Calculate the normalized value for all particles in Equation (26).
12- Convergence condition study, in this study, the maximum number of repetitions has been used.

3. SIMULATION RESULTS

To solve the problem of optimizing the rearrangement of distribution feeders in a dynamic framework, the 95-bus test network [9] has been used. The study period for solving the proposed problem is 24 hours. In this section, the combined algorithm of particle clustering and frog mutation is used for single and multi-objective optimization and its results are compared with the algorithms of colonial competition [14] and grenade launcher [15]. In the 95-bus test system, 4 distributed generation units (diesel generators) with a capacity of 1000 kW are used in 6, 10, 25, 34, and 45 buses. 3 solar units with a capacity of 3000 kW along with 300 kW energy storage units have been installed in Buses 41, 85, and 88. The cost of purchasing electricity from distributed generation units and the cost of switching is 0.042 $ per kilowatt and $ 0.041 per switch, respectively. 30 scenarios have been used to model the considered uncertainties. Figures (1) and (2) show the load profile and electricity price in 24 hours. The number of energy losses, operating costs, and undistributed energy before the make-up are 315969.55 kW, 1401651.91$, and 315.56 kWh per year, respectively.

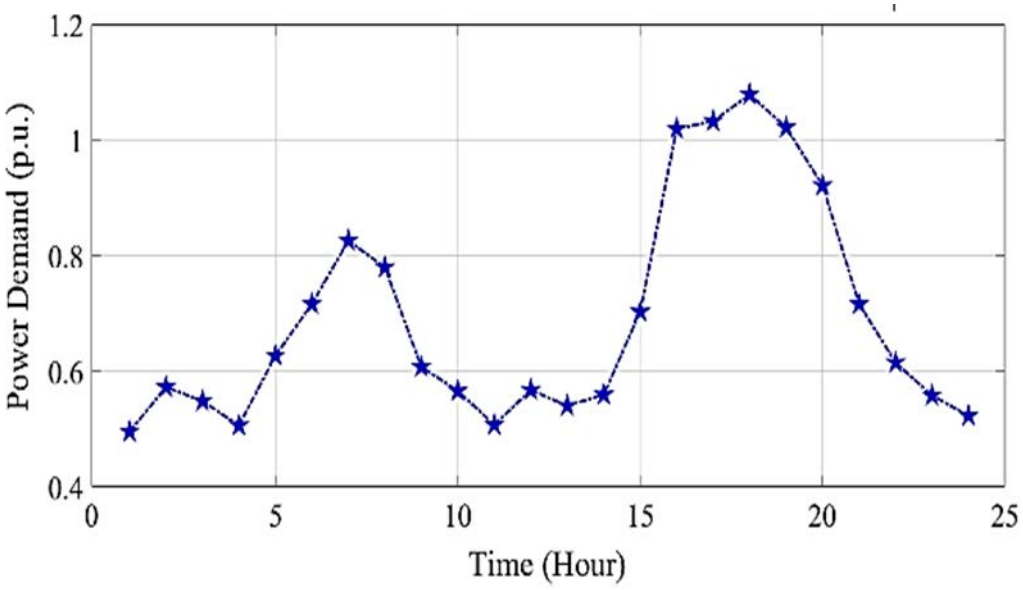

Figure 1.Load profile in twenty-four hours

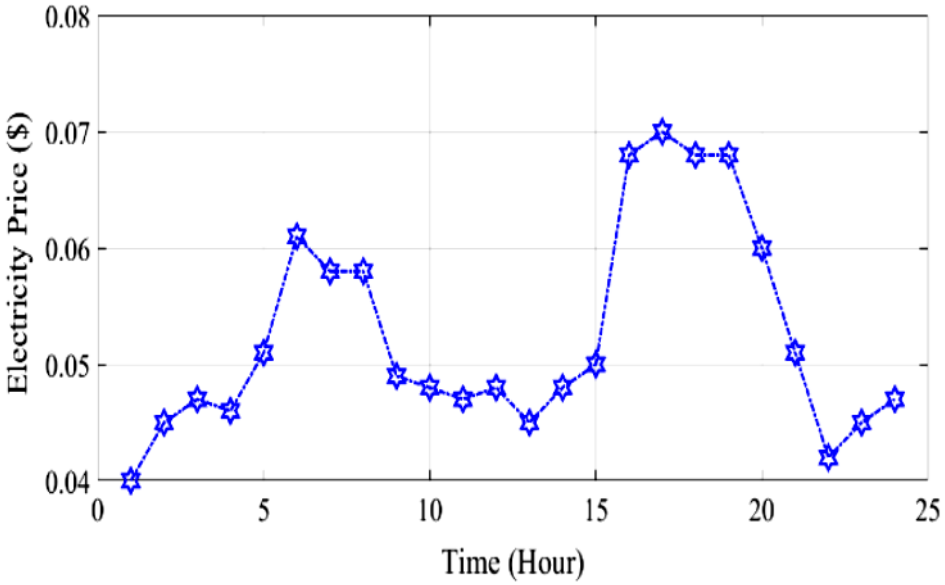

Figure 2. Electricity prices in twenty-four hours

3.1. Solving the problem of one-purpose optimization in the absence of distributed generation and energy storage units

The purpose of solving this section is to emphasize the ability of the proposed algorithm to solve the one-objective optimization problem. Tables (1) and (2) compare the results of different algorithms to optimize operating costs and undistributed energy. The results for all three algorithms are shown in 30 experiments.

Table 1. Optimization of operating costs in the absence of distributed generation and energy storage units

Algorithms	**Operating cost (dollars)**			
	The best	**Average**	**the worst**	**Standard deviation**
GEM	133683.23	133738.68	133801.48	45.23
ICA	133667.15	133727.52	133722.23	44.34
suggested method	133611.16	133644.35	133705.15	42.65

Table 2. Optimization of redistributed energy in the absence of distributed generation and energy storage units

Algorithms	**Redistributed energy (kWh per year)**			
	The best	**Average**	**the worst**	**Standard deviation**
GEM	308.65	315.84	324.85	6.95
ICA	299.45	305.55	314.52	5.65
suggested method	294.31	295.85	298.24	4.15

Comparing the results of Tables (1) and (2), it is clear that the proposed algorithm has achieved better results than other algorithms. According to the results of these tables, it is clear that the amount of energy is not distributed and the operating cost of the proposed algorithm is reduced by about 17% and 6% compared to the initial values. Figure (3) shows the convergence curve of operating costs. Given this figure, it is clear that the proposed algorithm converges to the optimal answer sooner than other algorithms.

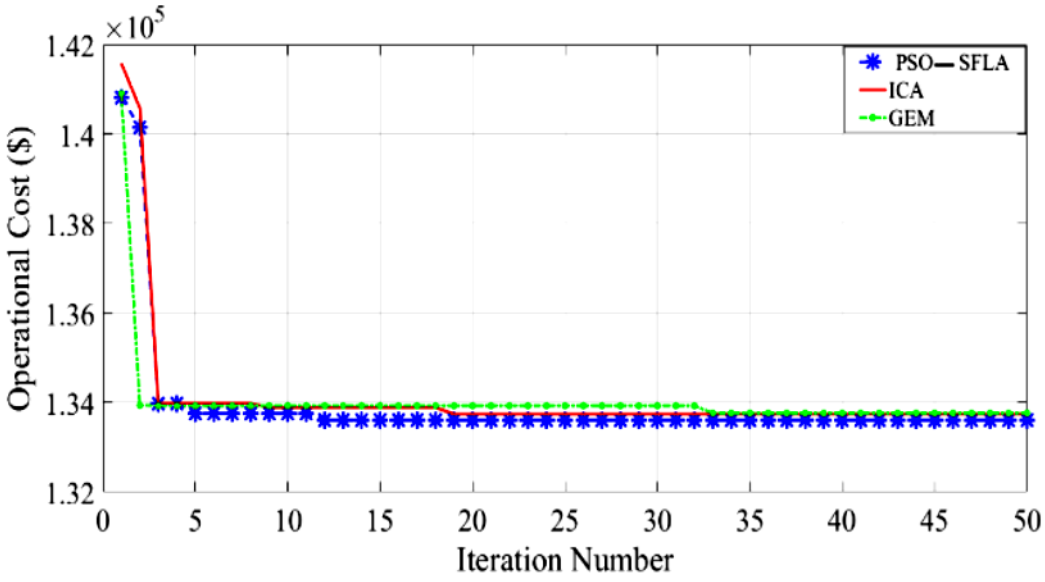

Figure 3. Convergence curve to optimize operating costs

3.2. Solving the problem of multi-objective optimization in the presence of distributed generation and energy storage units

In this section, the proposed algorithm is used to solve the problem of optimizing single and multiple objectives of dynamic rearrangement of distribution feeders in the presence of distributed generation sources and energy storage units. Table (3) shows the results of one-objective optimization for undistributed energy with all three algorithms. The optimal amount of redistributed energy from the hybrid algorithm is reduced by about 25% compared to the initial amount before the rearrangement.

Table 3. Optimization of redistributed energy in the presence of distributed generation and energy storage units

Algorithms	**Redistributed energy (kWh per year)**			
	The best	**Average**	**the worst**	**Standard deviation**
GEM	281.64	286.15	290.35	3.85
ICA	285.64	282.86	286.54	3.35
suggested method	276.15	279.68	282.15	3.24

Also, the optimal amount of energy losses and operating costs resulting from the combined algorithm are 28563.21 kW and 133664.14 $, respectively. Comparing the simulation results in this section with the preliminary results before the rearrangement and the results in the previous section, it is clear that the effect of distributed generation sources and energy storage units has not reduced distributed energy and energy losses.

In order to solve the two- and three-objective optimization problem, the Pareto optimal fronts obtained from the hybrid algorithm are shown in Figures (4) and (5). The optimal arrangement of switches, the output power of distributed generation units, and energy storage units obtained from the proposed algorithm for three-objective optimization are shown in Tables (4), Figures (6), and 7, respectively. According to Figure (7), the discharge and charging of energy storage units with negative and positive values are shown.

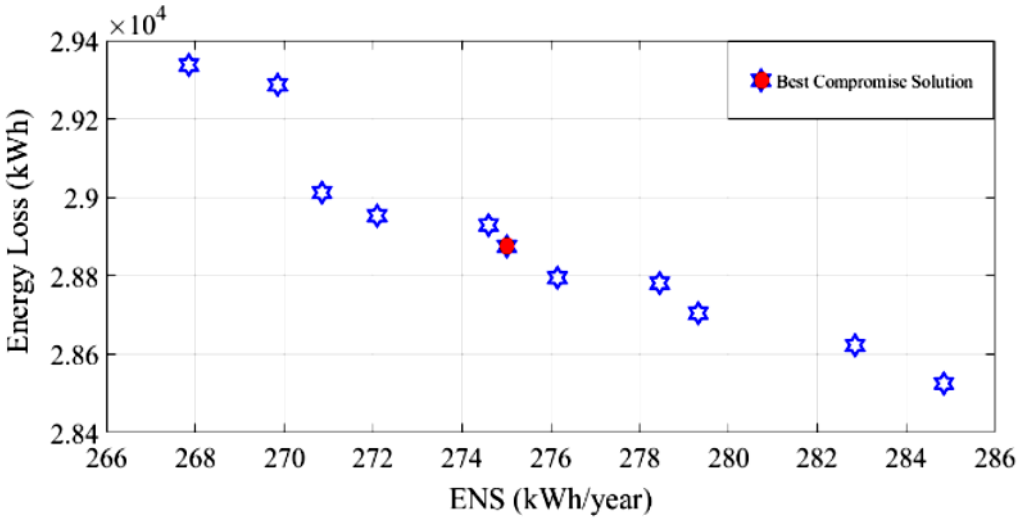

Figure 4. Pareto Optimal Front for the two-objective optimization problem

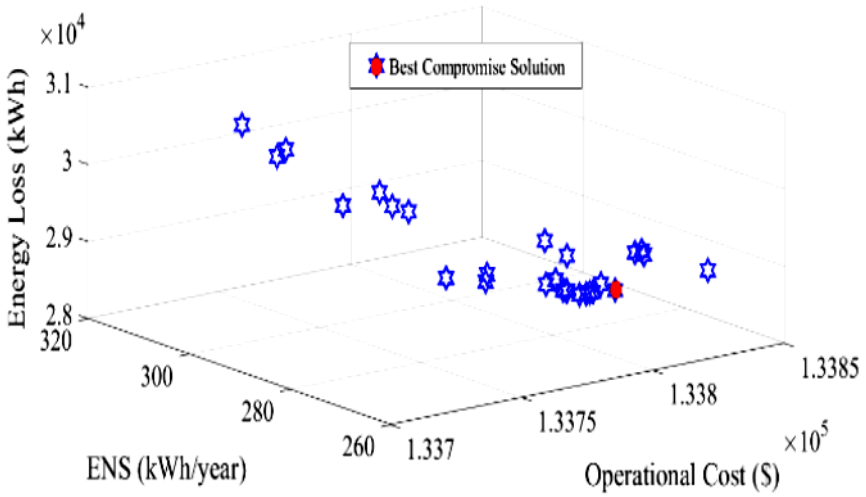

Figure 5. Pareto optimal front for the three-objective optimization problem

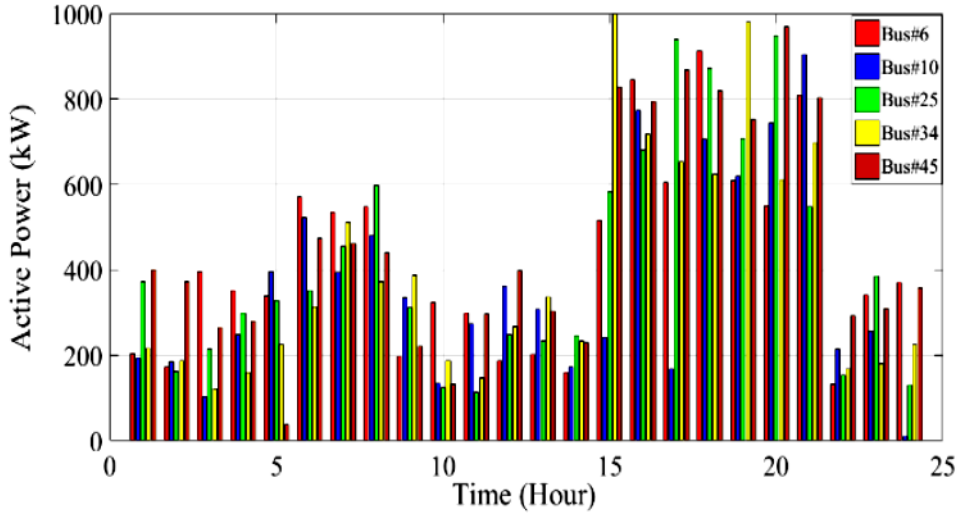

Figure 6. Production capacity of distributed generation units in twenty-four hours

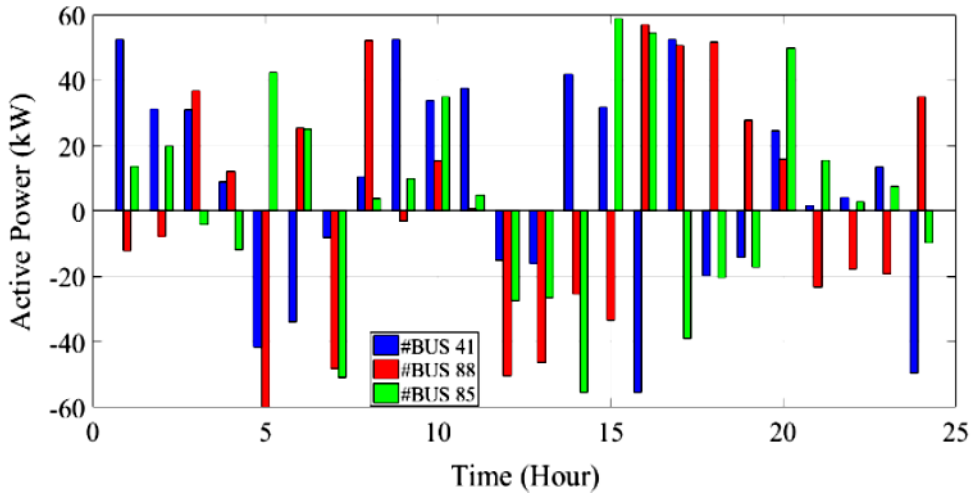

Figure 7. Production capacity of energy storage units in twenty-four hours

According to Figures (6) and (7), it is clear that the best value obtained for each objective function in response to the compromise (indicated in red) is very close to the optimal value of that function. The Pareto front is indicative of the ability of the proposed algorithm to solve the multi-objective problem. According to Figure (4), the optimal amount of undistributed energy and energy losses are 267.85 kW and 28586.356 kWh per year, respectively. The value of the two indicators mentioned in the compromise response is 274.35 kW and 28868.65 kWh per year, respectively. The difference between the optimal value of these indicators in the compromise response and their optimal values in the Pareto front is less than 2%.

Table 4. Optimal switching obtained from the proposed algorithm in twenty-four hours in order to optimize the three objectives

Load levels	Switches open										
	Sw1	Sw2	Sw3	Sw4	Sw5	Sw6	Sw7	Sw8	Sw9	Sw10	Sw11
1	70	43	15	39	26	35	80	86	85	32	30
2	4	43	15	22	82	84	18	86	85	31	30
3	4	40	15	22	49	35	66	86	85	71	30
4	77	43	79	22	82	35	80	86	85	32	30
5	68	43	15	81	82	52	19	86	54	87	30
6	4	43	15	81	82	84	80	65	55	32	30
7	4	78	13	81	49	84	80	57	55	32	30
8	4	78	15	39	26	52	67	86	85	32	30
9	70	78	79	81	82	84	19	86	85	32	83
10	70	7	15	81	26	84	19	86	55	71	30
11	4	43	15	22	26	35	19	86	85	32	27
12	4	78	79	81	26	35	19	86	72	87	30
13	77	78	79	81	26	84	19	86	55	71	30
14	68	7	15	22	49	84	19	86	72	32	30
15	70	43	15	39	26	33	19	86	85	87	29
16	77	7	79	39	49	84	19	86	85	32	83
17	77	43	15	39	82	35	80	86	55	71	30
18	77	43	15	81	82	35	19	65	55	87	30
19	77	43	15	39	26	35	19	86	85	32	83
20	77	43	79	39	82	84	19	86	74	87	30
21	4	7	15	21	49	52	67	60	85	87	30
22	77	43	15	22	82	84	19	86	72	32	83
23	4	43	79	39	82	35	80	60	85	32	29
24	77	78	15	22	26	84	19	86	85	32	29

4. CONCLUSION

The purpose of this study is to present the optimal energy management strategy in the distribution network. For this purpose, the issue of dynamic rearrangement of distribution feeders in the presence of distributed generation sources and energy storage units has been investigated. A combined algorithm of particle clustering and frog mutation is proposed to solve the optimization problem. Target functions include minimization of redistributed energy, energy losses, and operating costs. The important results of this study are as follows:

- The proposed algorithm is able to solve one- and multi-objective problems without considering their complexities.
- The effect of distributed generation resources and energy storage units in solving the optimization problem has led to a reduction in losses, undistributed energy, and operating costs.
- Considering undistributed energy as an indicator of reliability creates a safe and acceptable situation for the operation of the network.

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Review Article

INTERACTION BETWEEN AQUATIC BIVALVE SPECIES AND GLOBAL CLIMATE CHANGE

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INTERACTION BETWEEN AQUATIC BIVALVE SPECIES AND GLOBAL CLIMATE CHANGE

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ABSTRACT: Climate changes affect the bio-ecological characteristics of living things in aquatic ecosystems. It is the main factor in accelerating the geographical distribution of species, especially by triggering species invasions. Also, climate change is important as it increases the risk of infection between species. Bivalve species are among the important fishery species due to their high nutrient content, widespread distribution in aquatic ecosystems, rapid growth, and ecological and commercial values. Climate change and its effects have caused some invasive bivalve species, which can spread rapidly in aquatic environments, to be included in the list of biological pollutants due to their ecological and economic effects. In this review, the role of climate change in the growth performance, economic and ecological effects of bivalve organisms and the sustainable alternatives that can be applied at the solution point were evaluated.

Keywords: Global Warming, Mussel, Biological Invasion, Aquatic ecosystem.

1. INTRODUCTION

It is a fact that there are changes in climate systems as global average temperatures increase which is a result of increasing greenhouse gas emissions in the atmosphere. These changes have become one of the most important issues of our time and it requires urgent actions. Among the main causes of global climate change are reportedly people's destructive activities on nature [1]. Emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbon (CFC), ozone (O_3) released because of human activities are increasing excessively [2]. As a result of the increasing use of fossil fuels, the destruction of forests and misapplication in some sectors, some changes in the atmosphere have started to negatively affect our world and human life as a whole [3,4]. These impacts cause short-term and long-term effects not only on the environment, but also on the economy. Therefore, it is necessary to pay attention to how societies will be affected [5]. Many sectors that are critically important for societies to continue their economic activities are directly or indirectly affected by global warming [6]. The most important reason for global warming can be expressed as the greenhouse gases emitted from the industrial sector, whose importance is constantly increasing due to economic requirements and today's conditions, is the use of carbon dioxide fossil fuels [7]. This situation requires energy-oriented businesses to improve their environmental performance with environmentally friendly technologies [8]. Because some sectoral applications cause increased

pressure on the environment. Every year, millions of people are affected by urban air pollution and water problems due to environmental pressures.

Climate change affects biodiversity on earth. The most important factor causing biodiversity erosion is biological invasions. In recent years, the movements of living organisms have gained speed and it has become easier to move them from one place to another. Depending on the changing ecological conditions, species settle in different areas from their habitats, and they provide the formation of new conditions by changing the ecological balance in their new habitat. This situation has led to ecological problems among the species. These species, known as invasive, are creatures that migrate from their places of residence to other places for various reasons or spread by expanding their habitat and establishing habitat in new locations where they migrate. Invasive species in aquatic ecosystems can be transported from one region to another in different ways as it occurs in other ecosystems [9]. Oceans, seas, mountains, and deserts, form geographical barriers on earth. Thanks to the existence of these barriers that do not interact with each other, species emerge which is specific to each region. If one of these geographical barriers is to be broken, the species will pass through the corridors to the other side and adversely affect the biodiversity where they pass. With the opening of the Suez Canal, more than 250 species, 34 new genera and 13 new families of Red Sea origin fish and at least as many invertebrate species have passed and continuously entered the Mediterranean [9,10,11]. Due to the opening of the Suez Canal, some creatures of Atlantic origin passed to the Red Sea, while marine creatures of Indo-Pacific origin began to change their habitats by migrating to the Mediterranean. Balloon fish, whose numbers of individuals have increased rapidly in the Mediterranean in recent years, cause serious harm to human health since they contain a neurotoxin called tetrodotoxin (TTX) in their tissues, in addition to the economic damage they cause especially to fishermen [12,13].

Species transitions increase not only with the opening of the channel, but also with the realization of ocean currents along with the changes in the climate. Another way of spreading these invasive species is the usage of ships. As a result of increasing ship traffic in the seas and oceans, the eggs and larvae of many creatures can travel long distances in the ballast waters of the ships or by adhering to the surface of the ship under the waterline. Eggs and larvae entering a new environment in this way, if they have survived and adapted to the new environment, begin to spread rapidly. Similar transport systems for invasive species in freshwater ecosystems are also known. For example, *Dreissena polymorpha*, a bivalve aquatic organism, is one of the species that can be transported via fishing gears and traps by the activities of fishermen who can easily cross the geographical barriers and then the species can spread very quickly. When an invasive species comes to a new habitat, it competes with the native species in the environment and over time they begin to replace the native species. In fact, by creating new hybrid species, they pose a threat to the natural balance and biodiversity by changing the genetic structure of some species.

While the struggle for the existence of every living thing continues in nature, some creatures are more successful than others in this regard. Oceans and seas, which form a large part of the world, contain many living things which are struggling to exist, and therefore these aquatic ecosystems have a rich biodiversity. However, aquatic ecosystems are most affected ecosystems by the climate change process created by global warming [14]. The effects of global climate change cause changes in aquatic ecosystems such as oceans, seas and lakes [15]. In aquatic ecosystems, it has caused a noticeable water level decrease in lake waters, melting of glaciers, rise in sea level, changes in currents and precipitation patterns. In other words, it has begun to show its negative effects on all aquatic organisms, from plankton which are the

primary producers' to mammals [16]. New communities shaped by climate warming and biological invasions are reportedly spawning a 'new ecosystem' that cannot be returned to historical bases [17]. Again, in the same article, it is reported that 60% of native species do not reach the breeding length and 12% of species diversity falls on shallow subtidal soft surfaces.

Almost all natural resources in the aquatic environment can meet many demands. Although fish constitute an important part of aquatic organisms, mollusks can also meet a significant part of this need. Especially bivalve species are one of the foods that have been loved and consumed by people who are living on the seashore since ancient times. Mussels, which are bivalve organisms, are invertebrates that are an important part of the food chain in nature. It is a quite valuable and delicious food source for humans as well as being the food source of many aquatic organisms. Nutritionally, they meet the need for high polyunsaturated fatty acids and high-quality protein. In addition, they have their place among the other important street tastes [18]. It is also known that bivalve organisms are used for decoration and accessory purposes [19,20]. Especially the use of mother-of-pearl as a raw material in the production of buttons makes these organisms indispensable.

Bivalves are filter-feeding organisms and provide ecosystem services by filtering the water at a rapid rate of 3-5 l/hour in the water column [21]. During their feeding activities, they take in phytoplankton, organic detritus, bacteria and dissolved organic materials which are suitable for filtration size as their food source. In addition, they are very effective in improving water quality, as they filter and retain the pollutants such as heavy metals and dissolved substances in the water during their feeding activities. For this reason, it is important to evaluate them as bioindicator species in the investigation of water quality and ecological parameters [22,23]. The focus of this review is how aquatic bivalve species, which have ecological and economic importance, are affected by climate change damage and how strategies should be adjusted to protect these species.

2. DESTRUCTIONS OF CLIMATE CHANGE ON BIVALVES

Bivalves are invertebrates that are an important part of the food chain in nature. The labial palps surrounding the mouth of these creatures that feed by filtering water are responsible for the selection of food particles. Digestion of food occurs by secreting enzymes with the crystal-looking gelatin rod contained in the stomach of bivalves. Indigestible particles move from the posterior region of the stomach to the lower part of the descending intestine and are expelled from the rectum [47]. During their feeding activities, they consume some zooplankton species and organic detritus as well as phytoplanktonic organisms, which are the most important food sources [48]. They also filter out contaminants such as heavy metals from the water [49]. In the aquatic ecosystem, bivalves might be affected by climate change in various ways. (Figure 1). Climate change has a chain effect on the marine ecosystem by affecting both the phytoplankton takes a part in primary production in aquatic environments and bivalves which are the food source of many other aquatic organisms. According to studies, when the bivalves are fed on toxic phytoplankton, toxins enter the digestive tract through the gills and accumulate in tissue [24, 25]. Paralytic shellfish toxin (PST), potentially known as a water-soluble neurotoxin, blocks sodium channels in nerve cells in mammals, preventing signal transmission between neurons and causing muscle paralysis. As a result of this situation, deaths occur due to respiratory failure [26]. Bivalves are the organisms affected by anthropogenic activities. Thus, there are some situations that are not suitable for human consumption and have a negative effect on human health [27]. Human poisonings and deaths due to consumption of marine mussels fed with toxic dinoflagellates have also been reported [25]. However, there are no studies on

PST poisoning caused by bivalve organisms in freshwater environments. The reason for this can be explained as the low consumption of freshwater bivalves as a food source by humans. However, the presence of toxins in the ecosystem should be determined so that the aquatic organisms, fish, and birds feeding on these organisms are not exposed to toxins [25]. It is reported that shellfish are important in the spread of foodborne diseases in developed and developing countries. It has been reported that the amount of virus in bivalve organisms can be 100-1000 times higher than the water they are in, and people can be exposed to the virus cocktail during their consumption [28]. Neurotoxic Shellfish Poisoning occurs because of the consumption of contaminated shellfish [29].

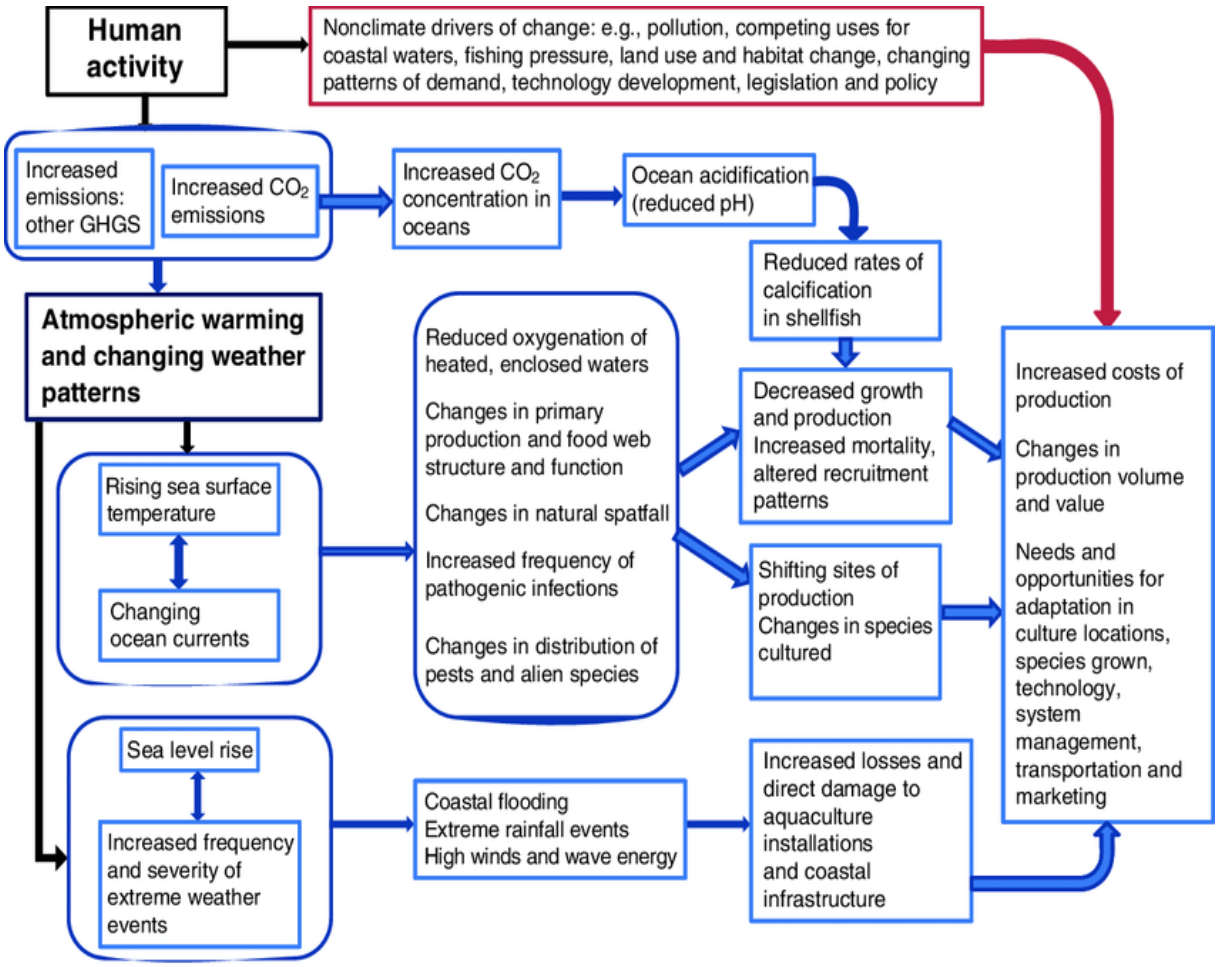

Figure 1. Various effects on bivalves of climate change [30]

One of the most important factors affecting the growth of mussels is seawater temperature. Studies have shown that optimum growth in mussels can be observed at a water temperature of 16-18 °C [31]. Seawater temperature varies according to the seasons. Seasonal changes affect many factors such as water depth, tide, water circulation rate, current speed, and direction [32]. Temperature plays an important role in bivalve physiology, gene expression, distribution, and fitness [33]. Changes in environmental temperatures can make individual stress factors synergistic [34]. At the individual level, it is reported that the physiological stress caused by a factor can reduce the resistance of the organism to other stress factors or the synergistic effect of multiple stress factors can lead to irreversible and negative consequences [35]. During periods of heavy rainfall, a large amount of freshwater enters the marine environment. Since

saltwater is heavier than freshwater, the probability of presence of freshwater increases on the sea surface and in the water column. As a result of this situation, it is thought that the filtration rate, growth performance and yield of bivalve organisms will be negatively affected while they exposed to environmental stress. Changes in temperature and salinity parameters due to global warming may endanger the welfare of bivalve organisms, which have an important place in aquatic ecosystems, by increasing the stress factors. The formation, which is frequently seen in marine environments and defined as mucilage, is related to different physical, chemical and biological factors caused by phytoplankton increase due to nutrient salts [36]. Mucilage is polysaccharide structure that emerge because of the death of certain over-proliferated phytoplankton and bacterial species. These structures trap living and non-living carbon sources and cover large areas on the sea surface, water column and seafloor. It causes the death of bivalve species that live by burrowing under the seafloor, by not being able to breathe adequately. Thus, it causes both visual, ecological, and economic damages.

Freshwater bivalve species are found in a variety of permanent freshwater habitats, including streams, rivers, lakes, canals, and reservoirs. They also occasionally inhabit permanent ponds and marshes with good water circulation, usually those that are connected to a nearby lake or river system [37]. In the natural reproductive physiology of bivalve species in freshwater environments, females release their larvae in free-flowing waters during each reproductive activity in spring and summer [38]. These larvae passively detect the biochemical signs in the water, along with the water current, and reach the host creature, namely the fish, and preferably cling to the gills of the host creature and ensure its development up to the juvenile mussel stage. After metamorphosis, juvenile mussels separate from the host and survive by burying themselves in the stream floor for a while. After this period, the mussels rise above the sediment and continue their life by passing to the "filter feeding" phase. During this complicated life cycle, some of the host creatures, namely fish species, where they spend a part of their life cycles, prefer areas with dense ground vegetation to reproduce, hide or feed. Therefore, local fish populations may also decrease with the decrease of floor plants in the environment. The extinction of native ichthyofauna poses a serious threat to biodiversity reduction, as well as the introduction of diseases and parasites into habitats, along with invasive species.

Studies conducted in recent years indicate that populations of some marine mussel species caught are decreasing due to their high nutritional value, delicious meat and their shells provide raw materials for indispensable decoration materials, while some freshwater mussel species have come to the point of extinction and even some of them are extinct [39]. Warming oceans are changing the existing natural habitats of many marine species [40]. Some of the creatures that cause ecological and economic problems in aquatic ecosystems are species in the Dreissenidae family such as *Dreissena polymorpha* species. It is known that *D. polymorpha* lived in the seas until the end of 1700, then moved to freshwaters and continued to spread in Europe. It is reported that this species was detected in England in 1824 and later spread to Denmark, Sweden, Finland, Ireland, Italy and other countries of Europe [41]. Studies on this species have intensified when it infects freshwaters in Europe from its natural range and entered North America in 1988 [42]. Especially in marine transportation, aquatic plants, water currents, migratory water birds and crayfish transported in the ballast waters of ships are counted among the natural or human-induced factors that ensure the spread of these species. These species cause many economic problems when they enter a different habitat because they can reproduce very quickly and in large numbers, have a high tolerance to environmental conditions and have small freely swimming larvae. It also has serious effects on other mussel populations native to the environment. They begin to compete with native species for physical space and food. Most importantly, they survive by clinging to other mussels. This gives the zebra mussel (*D.*

polymorpha) a significant advantage in the race for space, oxygen, and food, while causing slow extinction of other species. For example, it is reported that zebra mussels will invade breeding areas of pearl mullet in Lake Van (Turkey) and cause great damage to the fisheries of the region [43]. In addition, pollutants accumulated in their bodies due to their diet are higher than other bivalve organisms and cause teratogenic formation in birds feeding on these species. Determining the places where problematic mussel species are detected is of great importance in terms of taking preventive measures against invasive mussel species.
The increase in temperature in water bodies with the effect of global warming causes changes in the physical and chemical properties of water [16]. Bivalve organisms are important in the calcium cycle in lakes and streams and mix the sediment top layer through bioturbation. Among the greenhouse gases, the solubility of carbon dioxide in seawater, which has the largest share in terms of contributing to climate change, is considerably higher than other gases in the atmosphere. The drastic increase in carbon dioxide emissions in aquatic environments causes pH reduction, increased acidification. Bivalve organisms that use calcium to form shells become more fragile and sensitive under pressure, inhibiting their ability to form shells due to the increased acidification [44].

Global climate change originated from anthropogenic activities is likely to have a major impact on marine ecosystems, affecting both biodiversity and productivity. These changes will have a major impact on humanity's interactions with the sea [45]. It is predicted that the effects of climate change will increase even more in the future. Climate change affects socio-economic sectors and ecological systems due to reasons such as rising sea level, displacement of climate zones, more frequent and effective occurrence of severe weather events, drought, epidemic diseases, agricultural pests, damage to wildlife species because of deterioration of natural balance and deterioration of human health. It is predicted that it will cause significant consequences by affecting directly or indirectly [46]. Although the consequences of global warming seem to be quite complex, according to a general view, it is estimated that many ecosystems will change with the living populations they contain, and the habitats of both animal and plant populations will change due to temperature [1].

3. CONCLUSIONS

The negative effects of global climate change and greenhouse gases are felt in different parts of the world. Awareness of this situation is becoming increasingly important. The worldwide increase in greenhouse gas emissions is associated with the growth of both human population and economy. It is predicted that the world population will continue to grow in the future. Accordingly, carbon dioxide emission rates will increase worldwide in the coming years. Therefore, it is essential to accelerate the process of moving away from fossil fuels. Finding ways to organize our society more efficiently is one of the important ways to reduce the carbon dioxide dependence of the modern world. Bivalve production is a food production method that does not have any external feed costs and has low greenhouse gas emissions in aquaculture activities. However, uncertainties about future production areas and production levels come to the fore. It is clearly seen from the literature that climate change is effective on bivalves. Consequences such as temperature increases in aquatic ecosystems due to global climate change, changes in ocean currents, sea level rise, increase in the amount of carbon dioxide, acidification, pathogenic infections, harmful and alien species will affect the growth and yield of bivalve species. The increase in mortality rates in these creatures, it will cause a decreased production volume and increased cost of the aquaculture facilities. It is beneficial to develop and support climate modeling strategies to adapt future management policies on shellfish. Sustainable production activities with a low carbon footprint should be supported and increased.

The information in this review is useful for raising awareness in ensuring the sustainability of bivalve species, which form the important link of the food chain.

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