# EXTRACTION OF MAGNESIUM FROM BURNING RESIDUES OF FUEL OIL AND STUDY THE IDEAL CONDITIONS TO EXTRACT IT

**2021**
**MASTER THESIS**
**METALLURGICAL AND MATERIALS ENGINEERING**

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# EXTRACTION OF MAGNESIUM FROM BURNING RESIDUES OF FUEL OIL AND STUDY THE IDEAL CONDITIONS TO EXTRACT IT

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**KARABUK**
**June 2021**

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*“I declare that all the information within this thesis has been gathered and presented in accordance with academic regulations and ethical principles and I have according to the requirements of these regulations and principles cited all those which do not originate in this work as well.”*

Raghdah Abdulridha Falih AL-RUBAYE

# ABSTRACT

## M. Sc. Thesis

## EXTRACTION OF MAGNESIUM FROM BURNING RESIDUES OF FUEL OIL AND STUDY THE IDEAL CONDITIONS TO EXTRACT IT

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**June 2021, 84 pages**

In this study it is studied that the ideal conditions for extracting magnesium metal from the ashes residues from burning fuel oil, as it is brought as ash from power plants in Al Durah Refinery in Baghdad and performed treatment operations for it such as grinding, screening and washing with water to get rid of the soluble impurities present in the ash to make it more useful. In order to increase the effectiveness of the magnesium metal extraction process and the wet magnetic separation process to separate the iron metal from the ash, then it is used that different conditions to dissolve the magnesium metal present in the ashes, where we used hydrochloric acid in different concentrations (3, 6 and 9) mol and different temperatures (room temperature, 60 and 80). We also used different granular sizes (53, 75 and 150) microns, and it is also used that three different times (30, 60 and 120) minutes, so it is conducted that 81 dissolving experiments to reach the ideal conditions for melting the magnesium metal, after which we designed a cell to perform the electrolysis process to separate the magnesium mineral. Lastly, it is extracted in a pure form. After that, it is carried out of the magnesium mineral examination by XRD and SEM.

**Key Words :** Fuel oil, fly ash, extraction, chemical leaching, and electrolysis
**Science Code :** 91530

# ÖZET

## Yüksek Lisans Tezi

## MAGNEZYUMUN YANAN AKARYAKIT KALINTILARINDAN ÇIKARILMASI İÇİN İDEAL KOŞULLARIN İNCELENMESİ

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**Haziran 2021, 84 sayfa**

Bu çalışmada, Bağdat'ta Al Durah Rafinerisi'ndeki santrallerden getirilen küle öğütme, eleme işlemleri uygulanmış ve külün içinde bulunan çözünür safsızlıklardan kurtulmak için suyla yıkayarak daha kullanışlı hale getirilmesi amaçlanmıştır. Magnezyum metal ekstraksiyon işleminin ve yaş manyetik ayırma işleminin etkinliğini artırmak amacıyla demir metali külden ayırmak için, daha sonra küllerde bulunan magnezyum metalini çözündürmek için farklı koşullarda test edilmiştir, burada hidroklorik asit kullanılmıştır. Farklı konsantrasyonlar (3, 6 ve 9) mol ve farklı sıcaklıklar (25, 60 ve 80). Ayrıca farklı granüler boyutlarda (53, 75 ve 150) mikron kullanılmıştır ve ayrıca üç farklı süre (30, 60 ve 120) dakika testler yapılmıştır, magnezyumun eritilmesi için ideal koşullara ulaşmak için 81 adet eritme deneyi yapılmıştır.

Sonrasında magnezyum mineralini ayırmak için elektroliz işlemini gerçekleştirmek üzere bir hücre tasarlanmıştır. Son olarak, saf halde Mg çıkarılmıştır. XRD ve SEM ile magnezyum mineral incelemesi yapılmıştır.

**Anahtar Kelimeler :** Akaryakıt, uçucu kül, ekstraksiyon, kimyasal liç ve elektroliz.
**Bilim Kodu :** 91530

# ACKNOWLEDGMENT

At first and before everyone I would like to thank God who helped me to complete this study. After that I would like to thank my father and mother who supported me, and I would like to give thanks to my advisor, Assist. Prof. Dr. İsmail Hakkı KARA, for his great interest and assistance in preparation of this thesis.

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## ABBREVITIONS

*Mg* : Magnesium
*POME* : percentage of Magnesium extraction
HPE : highest percentage extraction

# PART 1

# INTRODUCTION

Magnesium, which is a metallic element, its chemical symbol is mg. Its atomic number 19 is a series of elements that are available in nature. It is the eighth and makes up 3% of the Earth's crust. Magnesium compounds have been known for hundreds of years and its time was not known how to get to magnesium in its pure form.

## 1.1. HISTORY OF MAGNESIUM METAL EXTRACTION AND MODERN METHODS OF EXTRACTION IT

Extraction metallurgy is a science concerned with extracting metals from their natural ores or from various mineral sources such as waste, and they form a large part of heavy industries, including the iron industry [1].

The first step for extraction is the process of concentrating ores and is considered a science of metallurgical extraction science and is concerned with making the ore with a high concentration of the mineral to be extracted, and it is done by separating unwanted metallic and non-metallic impurities from it so that it raises the efficiency of the subsequent steps to extract the mineral from the ore and the engineers specializing in this use The field, Mechanical, physical and physiochemical methods to accomplish mineral extraction [2,3]. All extraction steps are carried out under conditions that differ according to the type of metal extracted, such as temperature, pressure and other conditions [4].

The ores contain valuable minerals and metallic and non-metallic impurities, and the process of concentrating the ores naturally before extraction for several reasons, including reducing the cost of transportation and making the size of the extraction reactors smaller, which leads to lowering the cost and because the process of separation and concentration by natural methods is cheaper than by chemical methods, and the concentration process takes place in two stages [4,5,6]. They are separated from each other and minerals are usually found in ores in different bodies, where they are either adherent, separate, trapped or scattered, and each of these bodies has a suitable separation method for them, and these processes are divided into two stages [3,6].

The first we mentioned that it is the liberation of minerals and at this stage the rocks are broken by mechanical means so that the components of the rock are disintegrated and the minerals inside are separated from each other, meaning that each of them is separated and liberated [4,5]. The second is the separation of the valuable minerals from the rest by physical and physiochemical means, depending on the difference in the specific weight, magnetic properties, etc [1,5].

There are three techniques for the process of separating and extracting minerals. The first is thermal metallurgy, which is the oldest technique for extracting metals. It includes dry extraction methods. It is carried out at high temperatures and includes processes of chlorination, smelting [6,7], oxidation, reduction, slag formation, and others. For the metals desired in the liquid state, and among the ores for which this method is used are iron, copper and lead ores [2,8].

The second method is hydrometallurgy, which is an almost modern field in the extraction of minerals and includes water methods [9]. This method takes place at room temperature or near the boiling point of water and includes the process of separating minerals or depositing metals or their compounds from aqueous solutions loaded with important minerals and also includes Purification methods for minerals such as ion exchange and solvent extraction that are loaded with minerals. Examples of minerals are aluminum, gold and uranium minerals [10,11].

The third method is electrical metallurgy, and this method is considered the latest in the field of mineral extraction and includes all electrophilic methods that use electric current to extract or purify metals in aqueous solutions or in molten salts, and from the metals produced in this way are copper, aluminum and zinc [5,12].

## 1.2. THE HISTORY OF MAGNESIUM EXTRACTION FROM ITS SOURCES

Magnesium compounds are known previously and used for centuries before the production of magnesium and were called magnesia, and magnesia is magnesium oxide, and they used magnesium carbonate and it was known as Alba [1,5].

The Scottish scientist Joseph Black, a specialist in physics and chemistry, was the first to discover magnesium compounds in the eighteenth century. He realized and in 1755 he realized the difference between lime, which is calcium carbonate, and magnesium Alba, which is magnesium carbonate. For this reason, the scientist called Black the name of the discoverer of magnesium, although he did not It represents pure magnesium but its compounds [3,7].

In the year 1808, Mr. Humphrey Davy extracted magnesium from magnesium hydride by electrolysis process, where he used the ash column in its electric voltages, but it was also not in its pure form because it was used as a cathode of mercury, so he extracted magnesium oxide and considered it the oxide of a new metal [5,9].

The process of extracting pure magnesium in small quantities was successful in 1828 by heating magnesium chloride with potassium. The French scientist Antoine Bossi, a specialist in chemistry, was considered the first to extract pure magnesium by the method of electrolysis of magnesium chloride, and that was in 1833 [1,3].

Also, the German scientist Robert Wilhelm Bunsen, a specialist in chemistry, also worked in the years 1840 and 1850 to extract pure magnesium by electrolysis of molten mineral salts. And this chemist worked on developing the electrolysis cell in 1852 to extract larger quantities of pure magnesium using anhydrous magnesium chloride, and these methods are still used today [9,10].

French scholars Henri Etienne Sainte-Claire Deville and H. Caron. By extracting pure magnesium in good quantities by a process called Deville-Caron in 1857 through the reaction of a mixture of anhydrous magnesium chloride with sodium.

And calcium fluoride. In England, the scientist Johnson Matthey extracted pure magnesium in a currency representing the previous process, and that was in 1860, but their methods were considered uneconomic [1,5].

The Scottish physicist and chemist Joseph Black was the first to work on magnesium compounds scientifically and that was in the eighteenth century where Joseph Black discovered in 1775 the difference between the limestone that is calcium carbonate and Magnesium carbonate, therefore Black is the discoverer of magnesium, but he did not find a way to extract it in its pure form [2,8].

In the year 1808, the Englishman Humphry Davy was able to extract magnesium through electrolysis of wet magnesium hydroxide. This experiment is the first in which magnesium is extracted, but it was not pure, but it got mixed with mercury because it used a mercury landing pad [6,7].

In 1828, the methods of the French chemist Antoine Bossi succeeded in extracting pure magnesium, but its quantity was small and the extraction method he used depends on heating the magnesium chloride in the presence of calcium as a reducing agent. As for the scientist Faraday was the first to be able to extract pure magnesium through the electrolysis of magnesium chloride and that was in the year 1833 [3,4].

## 1.3. EXTRACTION OF MAGNESIUM BY MODERN METHODS

The magnesium metal is extracted in two basic ways, the first is by the electric flow of molten magnesium chloride in the Downs cells, the Downs cells are large iron basins that are heated from the bottom and the anodes are made of graphite rods as in the figure () that surrounds the annular cathode [15,16].

The magnesium metal collects on the molten salt, while the resulting chlorine gas collects at the top of the cell and is reused again to produce magnesium chloride from magnesium oxide. The melting point of magnesium chloride is high, it is reduced. Sodium chloride and calcium chloride are added to the molten salt [17,18].

The second major method is called the thermal reduction method of magnesium oxide or the Pidgeon process. The method involves burning dolomite and barite ores with the addition of a reducing agent such as ferroalloys in a stainless steel container. Then it is heated to 1160 ° C, then the magnesium metal is evaporated, then the vaporized magnesium condenses on the water-cooled tube outside the furnace [20,21].

The recovered magnesium metal is then purified by a vacuum distillation process. The second method, which is the Pidgeon process at the present time, is the most important magnesium mineral extraction process and is used in China. Market share in Russia and Kazakhstan [22,23].

The mineral magnesium is present in more than 60 ores, but the ores of dolomite, talc, olivine, magnesite, bruceite and karnalite are the most used and have great economic importance in addition to sea water, as well as waste, which is also an important source of many minerals [24,25].

Sea water is one of the important sources of the mineral magnesium, as it contains Mg2 + canton and is considered the second most canton in sea water, and this makes sea water and sea salt important economic sources of magnesium. This is a precipitate of magnesium hydroxide, as shown [26,27].

$$MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2 \quad (1.1)$$

As a result to the equation the magnesium hydroxide (bruceite) that is insoluble in water, so the filtration process takes place after which it is reacted with hydrochloric acid to produce a liquid magnesium chloride as in this chemical reaction.

$$Mg(OH)_2+2HCl \rightarrow MgCl_2+2H_2O \quad (1.2)$$

Then pure magnesium is produced from the electrolysis of magnesium chloride. This is done in the electrolysis cell for that [28,29].

## 1.4. MAGNESIUM AND ITS NATURAL AND ABNORMAL SOURCES

Considering that magnesium is a light metal, it has a silver color as shown in figure 1 and a fast reaction that burns easily in the air with a bright flame that has many natural and non-natural sources such as waste. Because of its rapid reaction, magnesium metal is present in the form of compounds and magnesium has many characteristics that make it widely used in modern industries [5,9].

Figure 1.1. Image showing pure magnesium mineral and its crystal structure under microscopes [12].

Magnesium metal is present in more than 60 ores, which are bruceite, kernalite, talc, dolomite, magnesite, or olivine, and these ores have a very large commercial significance, where the magnesium mineral is extracted from them and several other minerals. The earth's crust contains magnesium by 2.5%, so it is the eighth most abundant on Earth, and the sixth element is among the most common minerals. The most important ores of magnesium are (for magnesium MgCO3, Dolomite

MgCO3.CaCO3, Epsom salts (Epsom) MgSO4.7H2O, Kecerite MgSO4.H2O, Carnalite KCl.MgCl2.6H2O, Olivine (Olivine) Mg2SiO4, Einstite Mg2SiO4) [6,10]. The second very important source of the mineral magnesium is sea water, as sea water is a major and very important source of the mineral magnesium. The positive ion Mg2 + is in the second place in terms of positive ions most abundant in sea water, which is 12% of the mass of the sodium mineral in it, and this thing makes sea water and sea salt a very important commercial source for the mineral magnesium. To extract is extracted in ways that we will mention later [28,29].

The third source of magnesium is the waste, there are many wastes that contain large quantities of important minerals, including the mineral magnesium. This will be our study on how to extract magnesium metal from the ashes resulting from burning heavy fuels used in the operation of power stations [32,33].

Likewise, magnesium and its alloys are used in the manufacture of aircraft and engine parts for their strength and light weight, so the parts manufactured will be made of less weight, thus reducing fuel consumption [30,34].

Among the important uses also for magnesium is in the manufacture of electronic devices that the light weight of magnesium and its good electrical and mechanical properties make it of high importance in electronic industries where it is used in the manufacture of mobile phones, laptop computers, cameras and electronic parts [55,56].

As for the previous periods, magnesium was one of the main elements of the space industries and war planes that were produced in the first and second world wars where the Germans named the magnesium alloy (electron), which is still used today [62,63]. Given the risk of ignition of magnesium, its use in aircraft structures and space vehicles has receded for a certain period, but then Magnesium alloy has been developed to become safer as I am of the high importance of magnesium for its desired equilibrium and most important of its light weight has made it necessary to develop these alloys to make aircraft and spacecraft less weight and thus the fuel used is less and also becomes environmentally friendly [65,66].

The European Union has worked to develop these alloys and the most important developed magnesium alloy is (Electron 21), which has passed extensive and comprehensive tests for use in the aerospace and aircraft industries where it was used in the manufacture of engines and external structures [3,6].

There are also inflammatory uses of magnesium because of its ability to ignite and many other uses. These important and many uses of magnesium explain to us the importance of industrial magnesium and the importance of its extraction. Magnesium in its free form can ignite easily so it can be beneficial from its compounds that the magnesium has a single oxidation degree of +2 that is, it makes a valence electronic loss in it [4,5].

$$Mg^{+2} + 2\ e^{-} \rightarrow Mg$$

When interacting that magnesium is affected by water at normal temperatures unlike other light elements the magnesium is easily decomposed and oxidized by its interaction with high elements the electronegativity of the most prominent compounds of magnesium is magnesium oxide ($MgO$) and magnesium salts and magnesium hydroxide as well as magnesium carbonate that these compounds are very important and have many uses [9, 12].

## 1.5. THE PROBLEM WITH EXTRACTING MAGNESIUM FROM FLY ASH AND REACHING IDEAL METHODS

Power plants annually consume very large quantities of fuel oil, and the burning of petroleum fuels produces large quantities of how much fly ash. Fly ash contains large quantities of minerals such as vanadium, nickel, iron, magnesium and other minerals. These minerals are extracted and utilized by multiple extraction methods [66, 67].

This large amount of ash can be considered as an important source of many minerals, especially in countries that produce large quantities of oil. The main source of magnesium in the world is sea water, but for countries that do not have borders with the seas, it is considered that they do not have a source for the mineral magnesium, so this ash is considered a very important source for this mineral because the percentage of magnesium in the ash resulting from burning the fuel oil is higher than the percentage of magnesium in sea water [45,47].

### 1.5.1. Chemical Leaching to The Fly Ash to Extract Mg

Annually, very large quantities of solid fuel are burned in all countries that use fuel to operate power stations. Burning fuel leads to the formation of tons of fly ash annually, which is reprocessed in most countries to take advantage of it instead of the ash dumps that occupy large areas within urban lands and consume For water (from 10 to 100 m3 / ton) and this leads to pollution, which makes Recycling and utilization of ashes is much better than disposal. Construction and operation of landfills requires a high cost, which leads to increases in the cost of power generation [69].

Fly ash contains many minerals such as vanadium, nickel, magnesium and iron, which makes this type of ash important and is used as a substitute for many ores for the production and extraction of many minerals that are high in ash. The effect of temperature, micro and nanoparticle size, as well as the time required to extract magnesium from fly ash resulting from burning fuel oil will be studied. These conditions and variables in the case of chemical dissolution and microorganism dissolution will be studied [50].

Hydrochloric acid has been used in the treatment of fly ash, because the use of sulfuric acid leads to the formation of calcium sulfate on the surface of the ash particles, and this prevents the interaction between ions and sulfates. The use of the fluoride method leads to toxic emissions of ammonia and fluorine [37,38].

The use of hydrochloric acid to dissolve minerals in fly ash has a number of advantages over the use of other acids, as the low solubility of silicon dioxide in hydrochloric acid as well as the possibility of selective crystallization is considered an artificially sophisticated technique for collecting hydrochloric acid, i.e. collecting hydrochloric acid for reuse in leaching processes to extract minerals from Ash from burning fuel oil [53,54].

The ashes resulting from burning the fuel contains a percentage of iron oxide, which can be removed by using a wet magnetic separation. The presence of iron in the ash is not only in the form of magnetite but also like hematite, which does not have magnetic properties. Leaching with acid to carry out extraction [40].

There are many techniques that have been researched and applied to extract metal from fly ash, and biological methods in which bacteria or fungi are used are among the most successful methods used to extract minerals, as well as the methods in which leaching is carried out with organic acids. And inorganic and alkaline compounds, and after that electrolysis processes are performed in which alternating current and direct current are used, and thermal processes are used for drying and techniques that incorporate several variables to conduct the extraction process [42,43].

# PART 2

# LITERATURE REVIEW

Magnesium metal has great economic and industrial importance, as magnesium is one of the minerals that are widely used in industries recently because of its good properties, the most important of which is light weight and a very good casting element that improves the properties of many alloys. In this part of our study, we will explain about the magnesium metal in a detailed way. We clarify the previous studies related to its extraction and how it was extracted, from what was extracted, and what scientists and researchers have come up with in developing methods of extracting it. In our study, we will extract magnesium metal from the ashes resulting from burning heavy fuels used in operating power plants. In this part we will show the previous study that was conducted on how to extract magnesium from the ashes resulting from burning fuel oil.

## 2.1. MAGNESIUM MINERAL AND ITS QUALITIES

Magnesium metal has a white, silver color that disappears when magnesium is exposed to air due to its oxidation, and from its properties that it is well conductive to heat and electricity and has a very important property that made it very important in industrial processes is that it is light in weight This characteristic made it very important in the manufacturing processes as it was introduced into the industry Interior and exterior parts for cars, airplanes and spacecraft.

The magnesium metal in pure form can be compared to aluminum metal it is characterized by being very strong and light in weight so it is used in many industrial fields to manufacture certain procedures in large quantities for cars, trucks, airplanes, and spacecraft such as wheels so the super-strong wheels for cars made of magnesium metal alloy called (mag wheels). In other year the Corvette SS was designed to racing and its body was built from magnesium metal plates to reduce the weight of the racing car now he keeps the mileage record.

And the car model (917/30 Can-Am) which was also distinguished by its structure of magnesium which helped it to use the advantages of its engine which had a capacity of (1100-1500) horsepower the Volkswagen company for the manufacture of cars used magnesium in the manufacture of its engines for several years and in October (2007) Volkswagen has told the world the news of a car made entirely of magnesium metal.

This car is characterized as an economical and environmentally friendly car in which carbon dioxide emissions are reduced as well as low in fuel consumption. The reason for this is due to the magnesium metal which is lightweight and in addition to this the car’s light weight makes its speed high. But when starting to implement the idea the main obstacle was the high price of the car which was approximately 35 thousand euros due to the high cost of the magnesium metal used in its manufacture which is used to make the engines and the entire body of the car. The car has good features a prototype of the car was executed from magnesium and the car was launched for the first test in 2002.

For a long time magnesium alloy was used to manufacture the engine block due to its light weight advantages. Interest in the manufacture of engines from magnesium metal for cars as we see in the models for the year 2006 has renewed and other companies used aluminum alloy filler for the walls of the cylinders and cooling shirts surrounded by a heat-resistant magnesium alloy that is AJ62A and AE44 magnesium alloy was used in the engines in 2006. The use is to demonstrate the technology of designing power-demanding auto parts using magnesium metal. The alloy is a modern addition to the family of magnesium alloys that are resistant to high temperature and low creep.

The second use of it in electronics devices because of its good electrical and mechanical properties and its light weight magnesium metal is used in the manufacture of cell phones, cameras, laptops, and many electronics parts.

Magnesium metal one of the main metallic minerals used in space industries and it has been used by German warplanes since World War I and this usage increased dramatically in World War II. The Germans developed a magnesium alloy and called it (electron) which is still used today and because of the risks for parts made of magnesium In the event of a fire due to its rapid ignition the use of magnesium metal in the manufacture of the exterior parts of aircraft and spacecraft has been generally reduced and it was used only in the manufacture For AMMA engines the use of magnesium alloys is currently increasing in the aerospace industries.

The reason behind this is the increasing importance of reducing the fuel used as fuel consumption decreases with less weight a new magnesium alloy has been developed and tested the most important of which is the electron 21 alloy which has passed full and lengthy tests in the aerospace and aviation industries and has been confirmed for its suitability in both aerial structure and engines. The European Union now has three related development research projects with the mineral magnesium and its alloys and its use in the aerospace industry. So the use of the magnesium has increased since its discovery, but its use has decreased for a certain period due to the speed of its ignition, but scientific research has addressed this and the rate of its use has increased again, as shown in Figure 3.

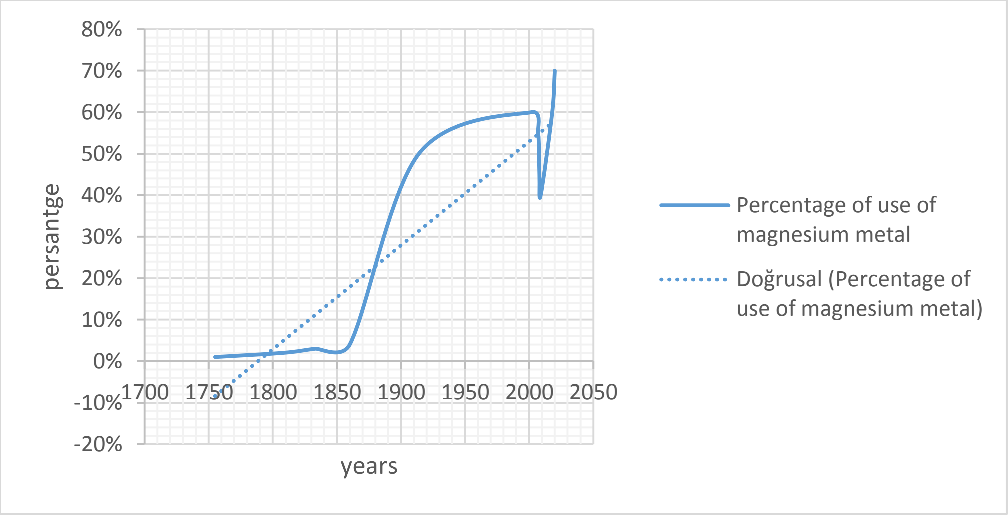


Figure 1.2. Chart showing the percentage of magnesium metal use increasing and decreasing over the years.

Magnesium metal is flammable and burns at a temperature of about 2200 ° C and the degree of self-ignition of the magnesium metal is about 473 ° C the extremely temperature at which magnesium metal ignites make it to start the ignition of nuclear installations other uses include photography with flash light torches, fireworks and incendiary bombs.

There are uses for the magnesium metal and other uses are desulfurization of iron and steel and the production of titanium and in the printing industry it is also used as an alloyed alloy in metal alloys because this metal is very important for the manufacture of aircraft and missiles.

Magnesium has very many other uses, so we conclude from this the importance of its extraction, the multiplicity of its sources, the importance of developing methods for its extraction and creating ideal conditions for that.

Magnesium metal has a single oxidation degree of +2 meaning that it loses its electrons valence when it enters into any reaction. It is similar to several minerals such as beryllium as it is less sensitive to water at room temperature unlike heavy metals.

Magnesium metal burns with a luminous flame in the air or oxygen forming magnesium oxide MgO as it forms $Mg_3N_2$ nitride when magnesium burns in the air. It burns instantly due to its high electronegativity in an atmosphere of carbon dioxide and metal oxide and carbon are formed. When it is burned at low temperatures a thin oxide film forms on the surface of the magnesium protecting it from oxidation at high speed. The mineral magnesium liberates hydrogen very slowly when interacting with water. Magnesium dissolves easily with acids and is a strong reference that oxidizes when interacting with highly electronegative elements.

The mineral magnesium has several compounds. The first is Magnesium oxide MgO which is difficult to melt and is very stable does not decompose at temperatures below 3000 ° C. It is a poor conductor of electricity. There are uses for magnesium oxide and it is called magnesia as it is used for lining furnaces and large quantities of magnesium oxide and calcium mixture are used as an alternative to pure magnesia by calcining dolomite ore.

The magnesium hydroxide precipitate consists of a magnesium salt solution with the addition of a primer and is slightly hydrolyzed. As for the magnesium carbonate MgCO3 it is in the form of magnesite and the precipitated salt is used in medicine under the name of magnesia Alba and large quantities of it are used in the preparation of silver polishes and it is also used in the preparation of tooth powder.

Magnesium borate, and magnesium salicylate as well as magnesium sulfate are used as disinfectants. Magnesium bromide is a good sedative, Calcined magnesite to be used for refractory purposes such as making bricks, making transformers and furnace lining. One of the properties of magnesium carbonate MgCO3 is that it is weakly dissolved by water, but it also decomposes by heat and carbon dioxide is formed.

$$MgCo_3\ (sold) \rightarrow MgO\ (sold) + CO_2\ (gas) \qquad (2.1)$$

The magnesium stearate compound is flammable at low temperature and is a white powder in form with lubricating properties. It is used in the pharmaceutical industries and in the manufacture of tablet. As for the magnesium sulfate compound MgSO4 it has the shape of MgSO4.7H2O crystals and is characterized by dissolution with water and is called Epsom salt. It has recently spread its use in medicine. It is also used in the paper production process.

Magnesium Phosphate is used to protect wood from fires and magnesium hexafluorosilicate, which is used to protect tissues. As for the magnesium halides or magnesium fluoride MgF2 it does not dissolve in water as it passes ultraviolet rays up to 0.1 microns and magnesium chloride in table salt and due to its fluidizing property leads to salt clumping in a humid atmosphere and this condition can be prevented by adding the acidic sodium carbonate compound to form basic magnesium carbonate. As for magnesium chloride, it hydrates and forms the water salt MgCl2.6H2O.

Magnesium metal and its alloys are highly flammable in their pure state if molten, powder, or magnesium strip. The molten molten magnesium reacts strongly with water, either the magnesium powder poses an explosion risk, and those dealing with the magnesium metal must wear glasses, but if it is on fire, the glasses must have a UV filter similar to those used in welding operations. The bright white light resulting from the ignition of magnesium can catch Damage to the retina of the eye.

When magnesium ignites, water should not be used to extinguish the fire because it will produce hydrogen, which increases ignition according to the reaction.

$$2H_2O_{(gas)} + Mg_{(sold)} \rightarrow Mg(OH)_{2\,(sold)} + H_{2\,(gas)} \quad (2.2)$$

Used fire extinguishers that contain carbon dioxide should not be used in magnesium fires because magnesium can ignite in carbon dioxide, such as magnesium oxide, MgO and carbon, but dry chemical fire extinguishers of type D are used if available or cover the fire with sand.

Magnesium metal is included in many different alloys. It enhances the base metal's strength and properties without increasing the weight of the alloy. Magnesium metal forms alloys with aluminum, silicon, zirconium, zinc, manganese, the rare-earth metals and atrium.

The important alloys of magnesium metal in the industry are zinc, aluminum and magnesium alloys. The properties of this alloy can be modified by heat treatments. These alloys have a bad characteristic, which is that their strength decreases rapidly when temperatures rise, especially above 941 ° C, and for this reason researchers have been interested in developing alloys that contain rare earth metals or thorium or both.

These alloys are used in high temperature conditions between 371 ° C and 482 ° C or higher according to the time that The alloy is exposed to it at high temperatures and the best rare earth metal, neodymium and for magnesium, alloys with silver that can be used at high temperatures of up to 316 ° C and the use of rare earths and thorium to make the field of applications of magnesium alloys in the manufacture of missiles and spacecraft's.

There is another popular type of magnesium alloys (magnesium, aluminum, silicon) that are used in temperatures of 135 ° C - 190 ° C. The alloy is characterized by its improved fluidity and mold ability, and this is why it is suitable in mechanical machinery and magnesium is important in the manufacture of building materials because it has a safe ability to absorb mechanical vibrations. Adding various elements to the alloy reduces this property. All magnesium metal alloys have casting properties, especially in high temperature conditions, and corrosion resistance.

There are many sources of magnesium from which they are extracted and because magnesium is highly reactive, it is not found in nature in its pure form, but it is in the form of compounds such as magnesium chloride ($MgCl_2$), which contains 21% magnesium and also the carnalite complex ($KMgCl_3$-$6H_2O$), which contains 9% magnesium.

The most popular source of magnesium is sea water, as seawater contains magnesium chloride compound that is interacted with calcium carbonate, producing calcium chloride and magnesium carbonate, and after that, several steps are taken to extract pure magnesium from it.

$$MgCl_2+CaCo_3 \rightarrow MgCo_3+CaCl_2 \qquad (2.3)$$

Likewise there is magnesium in the earth's crust in the form of compounds and ores such as the ore of brucite ($MgO.H_2O$), in which the proportion of magnesium is about 42% and the Margaret ore ($MgCo_3$) has a magnesium content of 29%.

There is a final source of magnesium is waste. There are many types of wastes that contain an abundance of minerals. These wastes are ash resulting from the burning of heavy fuel used in power plants, where this ash contains many minerals, including vanadium, nickel and magnesium in good proportions, where it has a ratio ( % Of magnesium metal, and this percentage of magnesium metal in these wastes. In this study, we will search for the ideal conditions for extracting it from these wastes and considering these wastes as another source of magnesium metal.

Magnesium metal is of great industrial importance as there are too many uses for its compounds such as magnesium oxide which is used in the manufacture of transformers as well as furnace lining and also uses magnesium oxide and other compounds for magnesium oxide in the agricultural, chemical and construction industries.

Magnesium is an important addition to many alloys, such as aluminum alloys, due to its multiple advantages, it is characterized by strength and light weight, therefore it is used in several applications and for the manufacture of structural and mechanical parts such as car and truck parts where alloys containing magnesium have been used at a high rate in the manufacture of racing cars since 1957 that Magnesium reduces the weight of the car and becomes more rapid.

## 2.2. FUEL OIL QUALITIES AND METALS IT CONTAINS

Fuel oil (also known as heavy oil, marine fuel, or furnace oil) is one of the types of fuel that is obtained from petroleum refining. Fuel oil gives this name to any liquid fuel that is burned in a furnace or heat-generating station or used in operating engines to generate Energy, the chemical composition of fuel oil is from long hydrocarbon chains such as alkanes, cycloalkanes and aromatics. The term fuel oil is also used in another sense to refer only to heavy commercial fuels that can be obtained from crude oil and are heavier than gasoline and lighter white oil.

There are particles in petroleum fuels such as small particles that are present in propane, naphtha, gasoline used as fuel for cars, some engines and jet fuel called kerosene. These particles have low boiling points and are removed in the distillation processes of crude oil to produce petroleum products such as diesel fuel and lubricant oil, which are less volatile. It is distilled again more slowly and there is also a type called basement oil, which is located at the bottom of the barrel in the process of distillation of oil. The only things that are denser than fuel in the warehouses are black carbon ore and bituminous residues, which is called asphalt, which is used for paving roads and covering roofs.

Fuel contains a large amount of minerals and when combusted, these minerals are present in the ashes that result from burning it.

## 2.3. ASH FROM BURNING FUEL OIL HAS ITS CHARACTERISTICS AND USES

Fuel oil is burned to generate energy in power plants, such as electric power plants and oil refineries. All of these stations use fuel oil to generate energy and operate it by burning fuel oil. When fuel oil is burned, the burning output is ashes, and these ashes are loaded with many minerals such as vanadium, nickel, iron, magnesium and others. Important minerals and the frequent use of this fuel oil, the resulting ash is in large quantities, so this ash can be considered an important source for many minerals that are extracted from it, such as vanadium, nickel, iron and magnesium. This ash is treated and purified, and several methods are used to extract the important minerals from it.

## 2.4. EXTRACTION PROCESSES AND THEIR TYPES THAT ARE USED TO EXTRACT MINERALS FROM THEIR SOURCES

Extraction is one of the methods of chemical separation. The process of chemical separation is one of the most important processes of chemical engineering, which is one of the foundations of mining and mineral extraction processes, which is mainly based on converting a mixture of materials into useful and distinctive products. And in its crystalline formation, as the materials are usually found in its impure form, and we need the separation process to obtain the raw material, to facilitate the work on it later and use it in manufacturing.

There are several types of methods and processes of chemical separation, including, Distillation, It is a chemical process that depends on the separation of fluids, which differ in their boiling points. Examples include the way to separate alcohol from water, as well as the extraction of oil and its conversion into dependent oil industries. Also on this principle. Filtration, It is also an important chemical process that relies on the principle of separation of materials that differ in their particles and sizes, whether they are small granules, or solids, and others. Chromatography, or what is also called chromatography, and they depend in the way of its separation on the separation of fluids that differ in their polar physical properties for example, and the difference in the size of the components, and on the harmony between the compounds themselves, and they have different methods, including TLC chromatography, and gas chromatography, And others.

Extraction, this process mainly depends on the separation of different substances in the manner of their dissolution and dissolution in organic solutions that are difficult to mix, as well as on pH levels, which greatly affect the displacement of the substances, which affects their dissolution and transfer.

Centrifugation, it is a chemical process that relies on the principle of “centrifugal force” that arises as a result of accelerated rotation, with the aim of separating a mixture of substances either liquid or gaseous, which differ in their density, and in the way they separate particles, droplets, or their solid suspended elements in the liquid. These were the most important methods of chemical separation, but there are many other methods. Such as centrifugation and vorticity, crystallization, clarification, drying, electrophoresis, evaporation, buoyancy, sedimentation, screenings and sublimation.

In this study we will extract magnesium metal from the ashes of burning heavy fuels, ash burning heavy fuel that is produced in power plants as large as electrical power plants and crude oil refineries, as well as water desalination plants. Heavy fuel is one of the sources of energy used in abundance, especially in oil-producing countries is used to generate the energy needed to run the shatter.

Heavy fuel residues are fumes and ash present inside and outside the combustion chambers The heavy fuel burning ash is a micro-size atom that contains a good amount of minerals such as vanadium, nickel, magnesium, iron and other minerals so it is a good source for extracting minerals from it.

This ash contains good proportions of these minerals, which makes it an important source of these minerals. Instead of burying this ash and not benefiting from it, it must be made a source of these minerals and extracting these minerals from it is considered to be of good economic importance.

In this study, we will extract the magnesium metal from the ashes of burning heavy fuels, as it is well preserved in ash, which is estimated at 2.3% of the magnesium mineral.

We brought samples from the power generation plants that run the oil refining stations to do this study on, where we will study the optimal way and ideal conditions to extract the magnesium metal from the ashes of burning heavy fuel.

We brought ash samples from power plants and performed a chemical analysis of them to clarify the proportion of minerals in it. It was found that the proportion of magnesium metal is 2.3%. After that, we conducted several practical steps for ash to extract magnesium metal from it, and these steps are to grind the ash to reach the required granular sizes after that procedure. Magnetic separation to separate the iron metal and make several subsequent steps to reach the pure magnesium metal, and we performed microscopic examinations and XRD and XRF for samples and the resulting solutions and the extracted metal.

## 2.5. LEACHING PROCESSES USED TO LEACH MATERIALS TO EXTRACT METALS FROM THEM AND METHODS OF LEACHING

The leaching process occurs naturally, so scientists have applied it for a variety of scientific applications with different methods of application methods. The methods of extraction depend on the characteristics of work in order to dissolve it. Is it a soluble substance with respect to the solvent and also depend on other factors such as concentration, distribution and volume of the substance to be dissolved and leaching can occur Naturally from inorganic plant materials and also organic leaching dissolved in the soil and it occurs in the decomposition of organic matter. Leaching is used to improve water quality and remove pollutants and is used to get rid of hazardous wastes such as fly ash and convert it to an important source of some minerals, Understanding the characteristics of the leaching process is important in preventing or encouraging and developing this process.

There is a stage in the leaching stages called the equilibrium stage, and this stage is the ideal stage in which all the solute is dissolved by the liquid solvent, so the solvent is a carrier of the solute substance without change, but the leaching process is not always perfect and it can be very complicated to understand and return it again often leads to the conditions and accompanying variables Different leaching process leads to different results.

### 2.5.1. Conditions Affecting the Leaching Process

There are several variables that greatly affect the leaching process, which are particle size, type of solvent, and temperature during the dissolution process, surface area of solute grains, homogeneity of the carrier and solute. In the case of using microorganisms, the efficiency of the dissolution process depends on the activity of the microorganism, as well as the intermediate products have an effect. On the efficiency of the dissolution process, the crystal structure has a very large effect on the dissolution process and its efficiency.

### 2.5.2. Fly Ash Leaching Processes

Fly ash resulting from the combustion of most fuels is exposed to large quantities of leaching during use or disposal of it and the reuse of fly ash is now being encouraged in other industries such as concrete and brick industries, but much of it is still disposed of in many countries in ponds, rivers and lakes. Landfills for waste, as well as piles of slag, and these wastes contain many main elements, and washing and leaching processes can cause the extraction of many different main elements. The type of material extracted depends on the type of fly ash that is being treated and the location from which it was taken.

## 2.6. ELECTROLYSIS PROCESS

The electrolysis process can be defined as the passage of a direct electric current through the electrolytic fluid, which results in chemical reactions at the electrodes and the decomposition of the materials in the electrolytic fluid. The main components that must be present to achieve electrolysis are an electrolyte, electrodes and an external electrical power source. Partitioning is optional to prevent propagation to the vicinity of the opposite electrode.

An electrolytic liquid is a conductive ionic chemical substance that contains free ions and carries an electric current if the ions are not moving, and this condition occurs in the presence of solid salts, in this case the electrolysis will not occur.

Electrolytic liquid can be produced by dissolving an ionic compound with a solvent liquid such as water to produce, the electrolytic fluid that contains the moving ions is then immersed in the electrodes at a specific distance so that the current flows between them through the electrolytic liquid and the electrodes are connected to the electric power source. Opposite charge.

Metal and graphite electrodes are used in the electrolysis cells, and semiconductors can also be used. The choice of the electrode in the appropriate electrolysis cell depends on the chemical interaction between the electrode and the electrolytic liquid and the manufacturing cost. Previously, non-reactive anodes were required for electrolysis, so graphite electrodes were used and the name of the made electrode was From graphite and it’s called plumbago in Faraday's time and they used platinum electrodes because it was one of the least reactive materials, so it was used as anodes because a metal that corrosion occurs in platinum slowly with respect to other materials because its corrosion is fast compared to the element platinum and graphite is disadvantage because it breaks down and produces carbon dioxide in Electrolytic solutions, but graphite electrodes have a good side because they do not participate in the reaction. As for the cathodes, they are made of the same material and may be made of a more reactive material because the corrosion of the anode is greater due to the oxidation that occurs at the anode electrode.

The basis of the work of electrolytic cells is the atomic and ion exchange by removing or adding electrons and this occurs due to the electrical current that passes from the electrodes through the electrolytic liquid. The electrolysis products that are to be separated from the electrolyte are in a different physical state from that of the electrolyte and are collected by physical processes such as assembly And sedimentation.

The amount of materials to be separated is proportional to the current passing through the electrolytic fluid and a series of electrolysis cells are made by connecting two or more electrolytic cells and they are linked to the same electrical energy source. The separated materials in the electrolysis cells are proportional to their equivalent weight. And this ratio is calculated by means of Faraday's laws of electrolysis.

Each electrode present in the electrolysis cell attracts ions with opposite charge. The positively charged ions move towards the cathode, while the negatively charged ions are towards the anode, where electrons are effectively inserted into the cathode electrode as a reactant and removed at the anode electrode as a material separated from the electrolyte liquid and the loss of electrons is called oxidation. Electron gain is called reduction.

When neutral atoms or atoms, such as those on the surface of an electrode, gain or lose electrons, they will become ions and dissolve in the electrolyte liquid and interact with other ions. In the event that ions gain or lose electrons, they become neutral, and they form separate compounds from the electrolyte liquid. After the electric current passes in the electrolytic liquid, positive metal ions deposit on the cathode and form a layer on the cathode surface. The scientific applications for this process are electroplating and electrophoresis. When an ion acquires electrons or losing it without becoming neutral its electronic charge changes in the process.

## 2.7. PREVIOUS STUDIES REPORTING ON EXTRACTING MAGNESIUM FROM FLY ASH

In 2010, scientists (Sanjay Baliram Attarde, Dhananjay Bhaskar Sarode, Ramanand NiwrattiJadhav, Sopan Tukaram Ingle, Vasimshaikh Ayubshaikh Khatik) at the (North Maharashtra University) conducted a study on Extraction and Leaching of Heavy Metals from Thermal Power Plant Fly Ash. Where they studied the solubility of the fossil minerals present in fly ash in the area of the thermal power plant, where they extracted many heavy metals such as Pb, Mn, Mg, Cd, Zn, Ni, Cu, and Fe.

But we will focus on their extraction of the mineral magnesium in their study, as they extracted the minerals Mg, Mn, and Fe with a greater amount of zinc, Cu and Pb. And they studied the presence of these minerals in the groundwater, but it was in a lower form, as the concentrations of zinc, iron, manganese, magnesium and cadmium were in the groundwater samples.

In their study the process of extracting heavy metals in three ways, the first method is Batch Leaching Tests In their study, a series of batch dissolution tests were performed Laboratory in order to better parallel the natural conditions Where 5 grams of fly ash was mixed With 25 ml of deionized water giving a liquid to solid ratio of 5- Three experiments were conducted with the same weight of the sample The same volume of extraction reagent was added to the samples with constant stirring lightly while Extraction for a period of time (24 hours) on a rotary device Then an analysis of dissolved heavy metals was performed Away on AAS.

The experiment was repeated for three samples, the percentages of heavy metals were analyzed in them, and an average percentage of all metals were put in the three experiments that were conducted. The highest percentage of magnesium metal that they obtained in this way was 11.3% of the multiple fly samples that they took from several places. Where the following table shows the percentage of solubility of each mineral by this method used by the researchers

The second method that the researchers conducted in their research is the TCLP method Meaning Toxicological Leaching Procedure (TCLP) in this method, a synthetic extraction fluid is needed to take the test. To extract fossil metals in this way, an extraction fluid was made before the test was carried out Whereas a 1M sodium acetate solution was used as the extraction liquid Its pH is 4.99 and this number has been maintained according to US specifications A 4 g sample of fly ash was taken and then liquid and liquid were added equal to 20 times the amount of sample weighing g It was added to the sample, the system was closed tightly, and then placed On a rotary device for a period of 18 hours, it rotates continuously at a constant speed of 30 ± 2 revolutions per minute At room temperature, about 25 degrees Celsius The same experiment was repeated for five samples of fly ash taken from different places of the plant, and they were conducted using the same sample weight and the same volume of extraction liquid. After that, the analysis was performed on AAS and the results were according to the following table, where the percentage of magnesium metal dissolved in this way is 2.39%.

The third method that the researchers used in their research to extract fossil minerals is to use a mixture of acids to dissolve the heavy metals present in the fly ash. The tests were conducted with strong acids to provide a good concentration of dissolving all heavy metals. A direct acid dissolution method has been implemented About 0.5 gram of dry fly ash was used It was chosen and dissolved with 10 ml of nitric acid, added to it 5 Ml of perchloric acid, after which the solute was filtered By means of filter paper with number 42, after which the analysis was carried out, many metals such as Pb, Mn, Mg, Zn, Ni, Cu, Fe and Cd were extracted, which were analyzed by AAS.

Also in 2012, the researchers Lokeshappa and Anil Kumar Dikshit at University of KwaZulu-Natal studied the Single Step Extractions of Metals in Coal Fly Ash, And in their research, they extracted many metals, including magnesium. In their research, the researchers used four methods to extract minerals from fly ash, which are the aqueous method, the ion exchange method, and the acid dissolution method. The fourth and final method is the reduction method.

The Single Step Extractions procedure and the researchers abbreviated the sentence with these letters (SSEP) and is used to make the time of extraction are ideal for extracting optimal Anasservi their research downloaded to conduct four experiments to extract metals first way is was the use of high water purity to extract viable minerals soluble in water The second way is where the The use of 1.0 M of NH4NO3 to extract the ionic altered minerals. The third method targeted 0.11 M of acetic acid as the minerals soluble in acids and the fourth method was in which a solution of 0.128 M of sodium dithionite, 0.3 M of sodium citrate, and 0.1 M NaHCO3 (DCB) were used. In order to extract the reducible minerals in all the experiments conducted by the researchers in their research, a solid to liquid ratio of 5.0 g ash / 500 ml (10 g / l) of the extract was used and the contents were stirred in a magnetic stirrer at 500 rpm. Samples were withdrawn 10 ml after the filtration time between the waltz and the time was from 1 hour to 48 hours, respectively. Each sample was centrifuged for a time of 10 minutes at 10,000 rpm, after which the extract was filtered using a 0.2 μm PTFE filter, and analyzes were performed for the major and minor minerals. Using ICP-AES after which the extract was filtered using a 0.2 μm PTFE filter, and analyzes were performed for the major and minor minerals. Using ICP-AES In their research, they extracted many minerals, but we will focus on the mineral magnesium only

The first method is Water Soluble Fractions, by which they extracted many minerals such as iron, chromium, zinc and many other minerals, but they could not extract magnesium in this way or its percentage was very small.

In the second method Ion Exchangeable Fractions among the main minerals, calcium and magnesium showed a peak leaching at 4 hours. Na and Si leached about 90% and 95% of their maximum filtration concentrations, respectively, at 4 hours, while iron leached about 66% of the peak leaching. Concentration at 4 hr

In 2014, researchers Cordelia Selomulya, Lian Zhang and Tahereh Hosseini in Department of Chemical Engineering, Monash University, Clayton Campus, Victoria 3800, Australia, studied the extraction of magnesium oxide from Victorian Brown Coal Fly Ash. In their study, the researchers treated fly ash containing concentrations of the minerals magnesium, calcium, and iron. Ammonium chloride was used as a lie. Reagent for extracting MgO from fly ash and slag, and the cations were then dissolved in the juice Precipitated by carbonization. In their study A test to assess the leaching capacity of the regenerator Ammonium salt when recycling, and their effect was studied in their study Impurities on the leaching ratio and the carbonation ratio are more than 90 ° C 80% fly ash from hazelnut wood and steelmaking slag It resulted, respectively, in successful extraction of MgO trace Magnesium extraction of Yallourn fly has been confirmed Ash, due to the strong link between MgO and $Fe_2O_3$ such as spinel.

Researchers in their search for fly ash that they used in their research found that the main elements present in it are magnesium, calcium and iron. They investigated the leaching behavior of pure MgO, CaO and $Fe_2O_3$. Experiments were conducted on mixtures to clarify the basics of the issues underlying the extraction of the mentioned oxides.

Pure magnesium oxide was obtained in their research by claiming magnesium carbonate at temperature and time of calcination. They used a muffle furnace that was repaired at 800 ° C and for 12 hours the resulting magnesium oxide analysis was performed by thermo gravimetric analysis (TGA). Several experiments were carried out for each trial using 10 g of magnesium oxide and it was mixed with 60 ml of ammonium chloride at a concentration of 4 M (L / S = 6) Different temperatures were used in each experiment (25, 40, 60 and 80 degrees Celsius) and a different time for each experiment (10, 20, 30 and 60 minutes). From ammonium chloride after adding a solid to it and after leaching results were obtained

Researchers in their research conducted the leaching in a closed flask capacity (500 ml) with continuous stirring on a hot plate. The leaching process was performed to count. The files were filtered by filter paper, then the filtration was dried at a temperature of 120 degrees Celsius overnight in an oven after which it was weighed to calculate the oxide percentage Dissolved magnesium.

Also in 2014, researchers Rada KrgoviT, DušankaMilojkoviT-Opsenica, Jelena TrifkoviT, JelenaMutiT and Dragan ManojloviT in University of Belgrade They conducted scientific research on Leaching of Major and Minor Elements during the Transport and Storage of Coal Ash Obtained in Power Plan, in the power plant they studied, coal ash from combustion is mixed with river water and transported to landfill. In their study, the sequential extraction procedure was conducted. In order to assess the pollution caused by leaching of the elements during the transport of ash through the pipeline and in storage. 80 samples were collected from filtered ash plus ash from active (currently filled) and inert (previously filled) cassettes.

In their study, samples were extracted by many solvents, including distilled water, ammonium oxalate / oxalic acid, ammonium acetate, an acidic solution of hydrogen peroxide and hydrochloric acid and were in multiple concentrations and the following minerals were obtained with different concentrations for each solvent (Al, As, Cd, Co, Cu, Cr, Fe, Ba, Ca, Mg, Ni) We will mention here only the magnesium mineral concentrations that the researchers obtained.

The percentage of minerals in the ash was determined by inductively coupled plasma atomic emission spectrometry (Thermo Scientific, United Kingdom), model 6500 Duo, And the proportion of the mineral magnesium is 279.5nm, In the first stage, a large amount of magnesium metal was extracted, especially in the active cassette. They did this by mixing the coal ash resulting from combustion with water and transporting it to the landfill. Negative cassette samples showed a high percentage of Mg metal compared to samples from the ash filter and this was confirmed by taking several samples and examining their chemical composition. This can be explained by the periodicity of the washing lines process. The tubes with hydrochloric acid dissolve the carbonate precipitated and they also extracted the magnesium in the fifth stage with slightly higher content in samples from the ash filter and active strips, the first stage is characterized by a high amount of Ni metal extracted from the samples in active.

In 2017 Researchers Rabia Nazir and Iman Meer They did research Removal techniques for heavy metals from fly ash, in Kinnaird College for Women. In their study, the researchers used different techniques to extract minerals from fly ash using several means and methods such as biological bleaching by using microbes, the method of the carrier in the pulp, as well as the method of chemical extraction using acids, the method of alkali filter and chelating agents and the process of evaporation of chloride, and they studied them by conducting a study For precision electrical and thermal analytical treatments. They also made a comprehensive comparison of all the techniques that they used, and it is also done through a detailed study of the conditions used in the reaction, after which the minerals that they extracted were filtered and investigated the percentage of extraction and among the minerals that they extracted the magnesium. We will mention what the researchers did in their research on how to extract the mineral magnesium.

In their research, the researchers used several methods to dissolve the minerals in the ashes, such as damaging them with water, as well as using acids and bases, or combining two or more methods to dissolve the minerals in the ash Filtration using acids or bases is usually a two-step process, the first of which begins with an initial WW followed by dissolution with acid or washing of the base. A simple WW alone can be used only to remove surface minerals that expose the nucleation elements, which can then be removed with more WW leaving the insoluble minerals at the back, the first water washing process is accompanied by a reduction in particle size.

The process of washing with water or dissolving with water does not preclude avoiding the use of other methods of dissolution required to filter minerals in other ways, but these initial methods also provide a large amount of acid / base used later to dissolve minerals in the ash otherwise it may be required to filter simple minerals such as Na, K And Mg and Ca that can be extracted from fly ash in just 5 minutes. Some other minerals also get washed away with water like zinc. In their research. The researchers used several solvents to obtain minerals from fly ash. When they used sulfuric, nitric and hydrochloric acid at specific and specific molar concentrations, magnesium metal was obtained from fly ash, and the above table shows a comparison between the proportions of the minerals obtained, as well as the types of solvents used and their molar concentrations.

In 2019 researchers TING-AN ZHANG, LONG WANG, GUO-ZHI LV and ZI-MU ZHANG in Ministry of Education, Northeastern University, Shenyang 110819, China. They studied Kinetics of Magnesium and Calcium Extraction from Fly Ash by Carbochlorination. The researchers carried out a process of mineral extraction where valuable elements can be recovered from fly ash, which are of good economic value and can be utilized as they extracted Mg and Ca from fly ash and used the carbon
chlorination method and the temperature of the carbonic chlorine was the variable that they studied its effect on the extraction process. As well as other variables, including time, the percentage of carbon it contains and the diameter of the grains, as well as the rate of flow of chlorine gas during heating, the kinetic system of carbon chlorination of Mg- and the calcium-containing compounds in fly ash were determined. The results showed that the control of the chemical reaction was the best in Mg carbon chlorination at a temperature of 800 ° C to a temperature of 1050 ° C, however for the carbonate calcium chloride as well, the carbon chlorination reaction was controlled through the diffusion process of morphological changes such as fracture and the disappearance of the spherical particles showed that the original Spherical structure of fly ash is destroyed in the chlorination process Carbonaceous.

# PART 3

# THEORETICAL BACKGROUND

The previous studies that were mentioned in the previous papers showed that the magnesium metal is of great importance for its extraction, and heavy fuel combustion ash is considered one of the important sources of the magnesium metal. In this chapter we will mention the theories, processes, tools and mechanics for extracting it from heavy fuel ashes. The following flowchart illustrates the processes to be performed for ash from burning heavy fuel oil to extract magnesium from it.

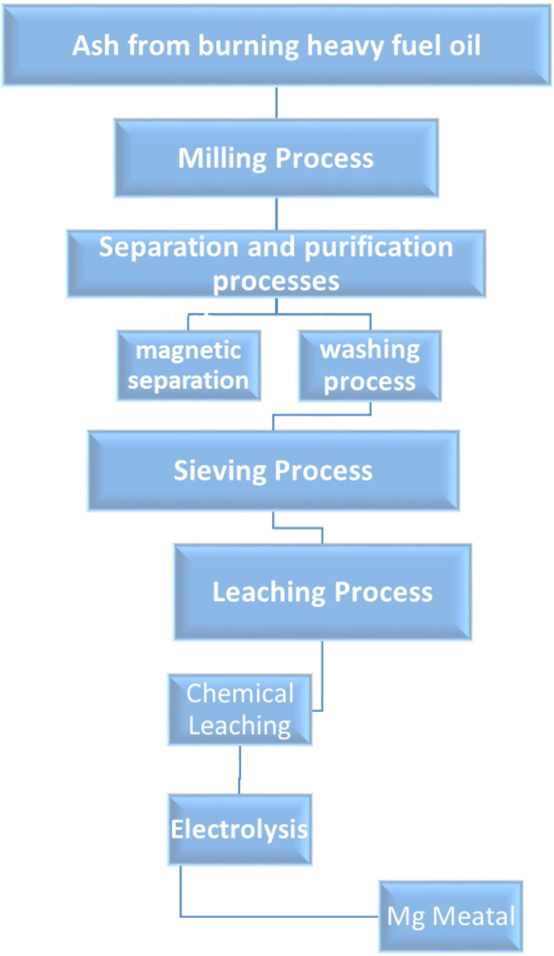


Figure 3.1. Flowchart shown the all processes to extract Mg from the ash reduces by burning fuel oil.

## 3.1. ASHES FROM BURNING HEAVY FUEL OIL

### 3.1.1. Heavy Fuel Oil Combustion Ashes Brought from Confiscation

Heavy fuel is extracted from crude oil by refining operations. Heavy fuel is used widely in power generation plants such as electric power plants or oil refinery stations. When these heavy fuels are burned, high energy is generated which is used to operate these plants, and the combustion plants are ashes.

We collected the ashes found in the oil refinery stations to be used in our research and conducted studies on it that clarify the ideal conditions for extracting the magnesium mineral from this ash.

### 3.1.2. Ash Chemical Analysis

The ashes of heavy fuel combustion contain many minerals such as vanadium, nickel, iron and magnesium in different proportions. The following table shows the chemical analysis that was performed for a sample of heavy fuel combustion ashes weighing 10 grams, as mentioned in the table below.

Table 3.1. The metals contained in 10 grams of heavy fuel ashes after conducting chemical analysis.

| Element | V | Ni | Fe | Mg | Su | Si | Co | K | Ba | C |
|---|---|---|---|---|---|---|---|---|---|---|
| Concentration, % | 29.8 | 10.2 | 2.6 | 2.4 | 2.2 | 1.3 | 0.02 | 0.018 | 0.008 | B |

## 3.2. MILLING OPERATIONS AND REDUCTION OF THE PARTICLE SIZE OF ASH FROM BURNING HEAVY FUELS.

Grinding in ball mills is an important process that is used to reduce the size of particles that have a different nature and a lot of mechanical, chemical and physical properties. Among the materials in which the grinding processes are used are various raw materials and minerals, etc. Ball mill devices are widespread in many industries such as ore processing, mining, cement production and preparations. Cosmetic and ceramics, chemical industry and pharmaceuticals, and they are used for different types of studies and tests. Ball mills are not only used to reduce particle size, but ball mills are also used in mixing and mixing The ball milling device consists of a cylindrical vessel installed and installed at both ends, allowing the vessel to rotate around the central axis and it is turned on. The mill is driven by a gear bolted to the bowl housing and the gear shaft is driven by the motor.

The raw material is placed in the bowl and the grinding process takes place during the rotation as a result of transferring the kinetic energy from the motor to the grinding bowl and thus to the product to be grinded. Ratio of (length to diameter) and this ratio ranges in most cases from 0.5 to 3.5 adding the materials to be grinded through a feed unit, which is a spout or spiral ladle. Vertical ball mills as for the grinding balls, there are three types of grinding balls are steel balls and metal balls, the second type is cylindrical metal bodies called cylindrical and the third type is ceramic balls of normal or high density. Steel balls and other metal balls are the most common types of balls used in grinding. The sizes of the balls range from (10 to 150) mm in diameter.

A ball mill will be used at this stage to make the ashes of a micron size to increase the efficiency of the process of extracting magnesium from it as this machine is highly efficient to reduce the granular size and make it with different microbial sizes less than 20 microns. A ball mill is a kind of industrial mill and it is one of the basic pieces of grinding equipment, and a ball mill is widely used in many industrial processes such as grinding mineral ores, cement industries, refractory materials, ferrous metals, non-ferrous metals, and glass ceramics. And many other materials, as well as metal ball mills can be used for dry and wet grinding of all kinds of raw materials and grinding materials, and we will use them in our research to grind ash resulting from burning fuel used to generate energy in power plants.

The working principle of the ball mill is explained through the following, as inside the ball mill there is the inner liner and the steel balls that work on the collision principle due to the rotation of the vessel containing the steel balls very quickly, where the inner liner raises the balls and granules and then they are thrown by the

Earth's gravity with the process of rotation Continuous ore can be grinded to any degree required depending on the grinding time, the number of balls inside the bowl and the rotating speed We will use in our research these three sizes of granules for laboratory experiments to study the conditions and the ideal method for extracting magnesium from the ashes of heavy fuel combustion.

The world Bond made several experiments in which it was possible to calculate the cost of grinding in kilowatt hours per ton for any ore and any material. Thus, the law can be relied on at the bottom in accounts related to the production costs of the ores and minerals that are extracted from these ores. .

The grinding process takes place after adding the raw material to the bowl containing the balls, so the smoothing process starts from a large size to very small sizes, and the more time and the speed of rotation of the vessel containing the raw material in the grinding process, the resulting granules become smaller as shown in the figure below.

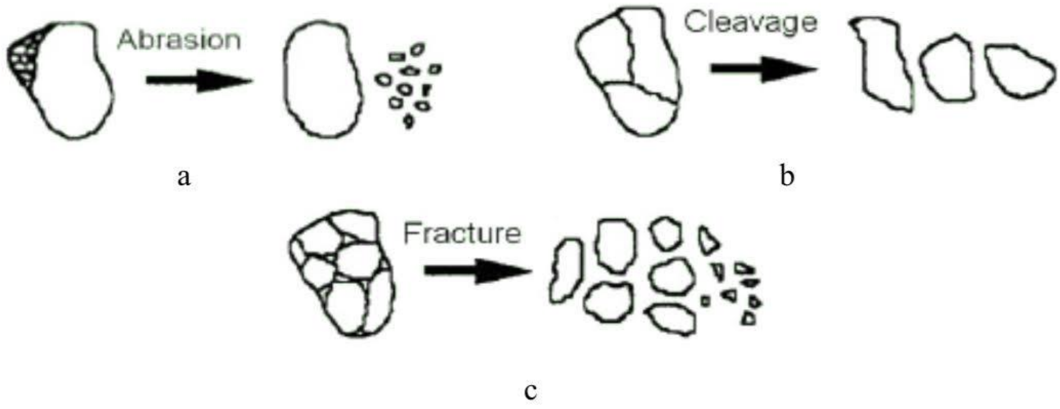


Figure 3.2. The shape of the ore inside the ball mill during the coal reduction stages.[25]

The ball mill that will be used in our research is a small-sized vertical ball mill that is used in the ore processing laboratories. It consists of a container with a lid and inside it is 10 steel balls. The mill contains buttons and a control screen through which the speed of rotation of the bowl is controlled as well as the time of the grinding process.

## 3.3. SEPARATION AND PURIFICATION PROCESSES FOR MINERALS IN ASH FROM BURNING FUEL OIL

After bringing the ash from the power station (crude oil refining plants) it is prepared for the subsequent operations by purifying it and separating it from the impurities and the iron.

Likewise, one of the important purification processes is the process of washing with water for ash. Washing with water leads to the purification of the ash from the impurities that are soluble in water and thus improve the process of extracting important minerals.

### 3.3.1. Wet Magnetic Separation Process to Separate Iron from Ash

At this stage, the ash produced from burning the fuel is concentrated by separating metals that can be separated by physical methods, we will use the magnetic separation method to separate the iron in the ash. The wet magnetic separation process was carried out for the iron present in the ashes resulting from burning the fuel and is present in the form of magnetite. The device is equipped with a rotation feature at different speeds to mix water with ash and increase the efficiency of separating iron from ash.

In the high sensitivity wet magnetic separator the magnetic separation is mainly based on the combination of the magnetic force and the hydrodynamic pulling force of the device, so the particles give the force and can be calculated through the equation below.

$$F_m = XV_P \, (B_O \, . \, VB_O)/\mu_O \qquad (3.1)$$

Where x is the magnetic susceptibility of particles with volume $V_p$, $B_o$ is the applied magnetic field, $YB_o$ is the magnetic field gradient, #o is the constant, 4rxl0 -3 H/re.

If we only consider particles of 200 micrometers diameter or less the drag force Fd can be derived by the Stokes law expression,

$$F_d=3\pi \text{л} d\ (u_p-u_o) \tag{3.2}$$

Where n is the fluid viscosity, d is the particle diameter, $u_p$ is the particle velocity and $u_o$ is the fluid velocity.

A chemical analysis of ash was carried out before the wet magnetic separation process to find out the percentage of iron and other minerals in it and compare it with the mineral ratios present after the wet magnetic separation process, where we will conduct a chemical analysis of minerals after the separation process. (300 g) of ash was added to (1500 ml) of water in the separation basin, and the device has been running for (30 minutes) with blending speed (450 rpm). Then the filtration process was done for the remaining minutes after the washing process, drying them and analyzing them using an atomic absorption device to find out the amount of iron separated and the loss in the magnesium metal. The illustration below shows the wet magnetic separation mechanism.

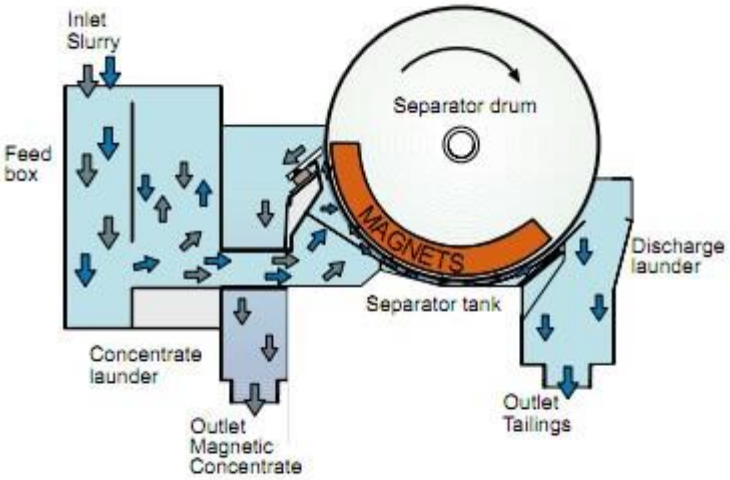


Figure 3.3. illustration shows the wet magnetic separation mechanism [40].

### 3.3.2. The Washing Process with Water for Ash from Burning Fuel Oil

The process of washing with water is one of the basic methods of disposing soluble solids and is used to a large posting in which incineration is used in a very large manner because it fulfills the condition of waste disposal and the damage is minimal and the reuse is completed. Burning waste also has its drawbacks and the main residue fly ash contains with a high concentration of minerals and harmful substances, this fly ash is classified as a hazardous waste because it contains a high concentration of minerals and toxic substances such as dioxins.

Many soluble salts are removed by washing with water. These impurities must be removed before using fly ash because their removal facilitates the extraction of minerals in fly ash and soluble chlorides such as NaCl, KCl, $CaCl2$ and other soluble impurities contained in the ashes where they have been removed. After washing with water there are other methods of washing operations, where other liquids are used to carry out the washing process, such as ethanol, which has a greater ability to dissolve impurities in fly ash, however, much of the wastewater that contains a high concentration of chlorides and heavy metals is then generated.

The water washing process was carried out in multiple steps, where the periodic washing process with water is carried out several times to determine the optimum conditions to remove soluble impurities such as chlorides in fly ash resulting from burning fuel. The laboratory experiments that will be conducted are based on the ratio of liquid and solid and the temperature during the process. Washing, time during washing, as well as rate of vibration and repetition of the experiment. All these conditions greatly affect the rate of removal of soluble as well as soluble impurities.

Experiments of washing with water using deionized water as an agent to remove water-soluble impurities and bath vibration tank (AULTRASONIC) were performed the washing process of the used sample two or three times during the experiment. The drying of the ashes in the filter paper is carried out in the filter furnaces at a temperature of 150 ° C, after which the ashes in the filter paper are weighed and compared with its weight before washing to extract the percentage of water-soluble impurities and are extracted through the equation below.

$$S_i = WFA_b - WFA_a \quad (3.3)$$

Where the,

Si= water-soluble impurities.
$WFA_b$= Weighing the ash before washing with water.
$WFA_a$= Weighing the ash after washing with water.

When setting the conditions for the experiments to the optimal parameters of the water washing process, it is carried out according to the flowchart as shown below.

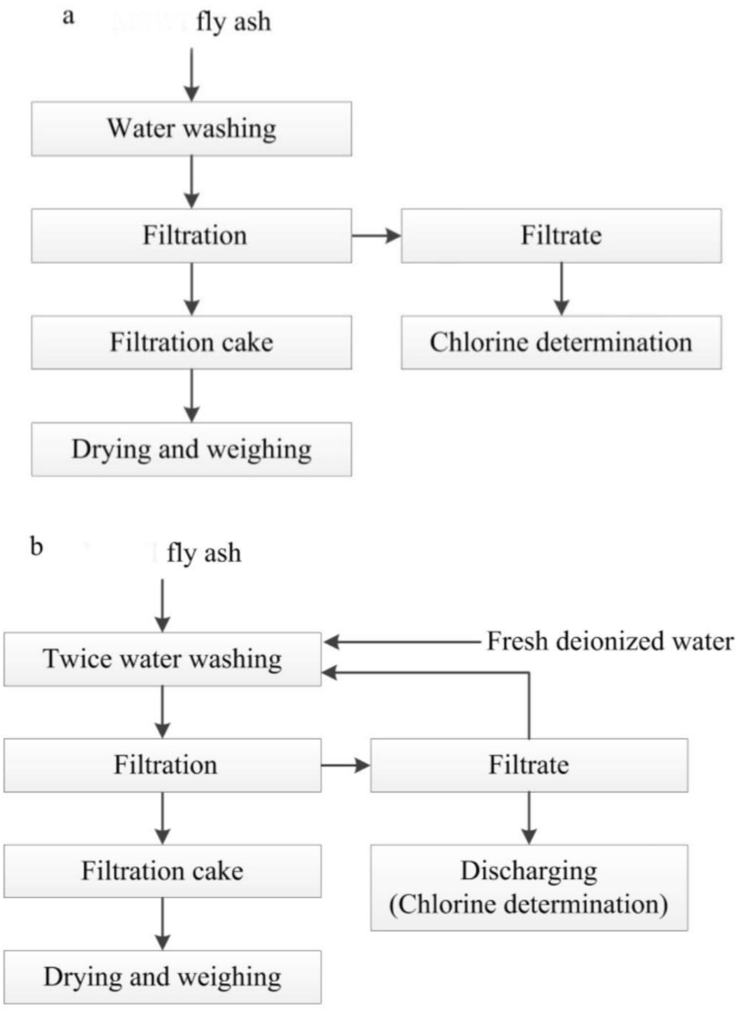


Figure 3.4. Flowchart shows the first and second stage of the washing process with water for ash from burning fuel oil.

## 3.4. THE VOLUMETRIC DIFFERENTIATION PROCESS FOR ASH FROM BURNING FUEL (SIEVE)

A sieve or meshwork can be defined as a tool that can separate parts of a material, with which materials can be separated and extracted either for use or disposal. The sieve consists of a mesh and a frame, and its operation depends on the mesh that traps parts of the material that cannot pass through the mesh holes. There are sieves that are manual and non-automatic.

The main function of the sieve is separating the different volumes and collecting the similar volumes with the granular size. It is responsible for chemical properties such as solubility, flow, and surface reaction which are important in several industries such as food, pharmacy and traditional chemistry. Monitoring the quality of powders and granules and there are several advantages of volumetric analysis using a sieve such as ease of handling, low investment costs, accurate and reproducible results with the same granular size and also affects the time of experiments. This method is considered an alternative to methods of analysis using laser light or image processing and is used to ensure a high degree of diffusion and reliability and increase the surface area of the granule and thus give an ideal interaction the screen used to be a vibrator and its accessories must meet the requirements of international standards.

During the screening process, the sample is subjected to a vertical or horizontal vibratory motion. During this process, particles of equal or less granular size enter the sieve opening into the openings of each sieve, so the particles pass through the sieve mesh, which determines the percentage of particle passage through the sieve openings. It is the ratio of particle size to sieve openings, particle direction, and the number of encounters between the particle and the mesh openings. Three sieves will be screened to select three granular sizes with a specific mesh size. The granular sizes collected in the sifters are used in the experiments that we will undertake to extract magnesium from the ashes of the burning fuel oil.

To calculate the percentage of particles that pass through the sieve openings and settle at the bottom, it is calculated through the following equation,

$$\%\text{Retained} = (W_{\text{Sieve}} / W_{\text{Total}}) \times 100\% \quad (3.4)$$

Where,

$W_{\text{Sieve}}$ = the mass of aggregate in the sieve
$W_{\text{Total}}$ = the total mass of the aggregate.

In our research we will use a vibrating sieves device that vibrates in a horizontal and market movement. We choose three micro-volumes to study the effect of granular size on the process of extracting magnesium from the reflux resulting from burning the fuel oil, as shown in the figure below.

Figure 3.5. Vibrating sifters with three micro-sized sieves.

## 3.5. LEACHING PROCESSES TO EXTRACT MAGNESIUM METAL FROM ASH FROM BURNING FUEL OIL

The main goal of the leaching processes used to extract minerals present in ores is the selectivity of the minerals of importance in ores, meaning that they are to be melted and extracted, and the solution carrying the dissolved metal is separated from the solid materials that are useless and the available minerals are recovered either in metal compounds through further processing of the mineral There are two types of leaching process used to extract minerals, the first type is through the use of chemical solutions such as acids. The second type in which microorganisms are used to dissolve minerals in the ores.

Leaching with hydrochloric acid. The leaching process is carried out using organic or inorganic acids, and the acid is chosen depending on the process parameters, as well as the nature and size of the materials to be treated with acidification to extract minerals from them, and the acid used in the leaching process is chosen according to the following standards, where the following important factors must be taken into consideration when choosing the acid First, after leaching, the products of the leaching process must be separable. Second, the acid selected for the leaching process must be inexpensive. Third, the acid used in the leaching process can easily be subject to the recovery process, as this step is very important economically for its recycling.

In our study, all the criteria mentioned above apply to hydrochloric acid, and hydrochloric acid is a relatively strong acid, a small molecule of it may be faster in the rate of diffusion than some other acids in the leaching processes used to extract minerals.

Another good characteristic of hydrochloric acid is that its salts are soluble in water, so after the leaching process they can be separated by a simple filtration process. One of the important and also good characteristics of hydrochloric acid is that the time required for the leaching process when used is relatively small compared to the rest of the acids, where the time is from 15 to 60 minutes.

Acids in general carry out a surface reaction controlled by several factors such as the temperature of the reaction, the concentration of hydrochloric acid used in the leaching process, the spread of the reactants on the surface and the products from the surface, the agitation strength and the particle size of the reaction.

For the present study, the following reactions occur when hydrochloric acid is used to dissolve the magnesium metal in the ash from burning the fuel oil.

$HCl \rightarrow H^{+} + Cl^{-}$ and,

$$(N-2)H^{+} + MgCO3 \rightarrow H2CO3 + (n-4)\ H^{+} + Mg^{2+} \tag{3.5}$$

Where the Reaction between $Mg^{2+}$ and $Cl^{-}$ ions may proceed as,

$$Mg2^{+} + 2Cl^{-} \rightarrow MgCl_2 \tag{3.6}$$

So the final reaction as shown below,

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H2O \tag{3.7}$$

The composition of magnesium chloride will depend on several different conditions, such as the concentration of hydrochloric acid where three molar concentrations of hydrochloric acid will be used and also depends on the time of the reaction as three different times will be used and the temperature also will change the temperature during the reaction and also depends on the size of the ash particles The result of burning the fuel. All these are experimental conditions that will be exhausted in each experiment to reach the ideal conditions for extracting the magnesium metal from the ashes of burning the fuel oil.

### 3.6. ELECTROLYSIS CELLS TO SEPARATE THE MAGNESIUM METAL FROM THE METAL-BEARING FLUID

The pure magnesium dissolved in hydrochloric acid is obtained by placing the acid in the electrolyte cell, where the magnesium metal is deposited on the electrode of the electrolysis cell. The following method explains a basic study of the electrophoresis of magnesium in ($MgCl_2$ – $CaCl_2$ - NaCl). Magnesium from us through electrophoresis is a process because they are nobler than Mg by means of electrochemical analysis with liquids loaded with magnesium metal. Therefore, electrophoresis is carried out in molten salt it is a filter for mineral purification, but under the conditions required for good electrolysis, the recycling process of magnesium metal must be an important method for extracting metals the future. Recycling technology is applied using the electrolysis method to obtain the magnesium metal with high purity and eliminate impurities such as iron and other impurities dissolved in the solvent. It is also expected that a scrap of magnesium metal will be obtained in the final position of the electrolysis process.

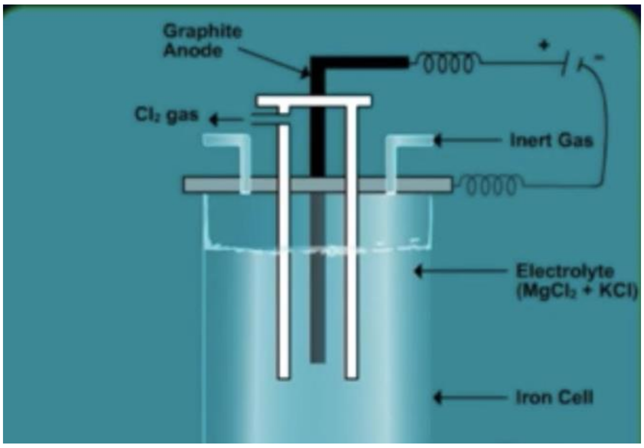


Figure 3.6. An illustration of the electrolysis cell used [58].

The electrolysis process is carried out between the cathode vessel and an anode made of graphite material, and the cell is installed at the top and the bath composition is made of 50% NaCl, 25% $CaCl_2$, and 20% $MgCl_2$. The newly formed magnesium metal is extracted after it accumulates on the surface of the bath and also the generated gas is formed. At the anode and it is a $Cl_2$ gas. This electrolysis is specially designed for the frequent replacement and repeated loading of the anode electrode made of graphite material because the graphite is consumed quickly due to interaction with water and MgO and the figure below shows the electrolysis cell and an electric current exceeding 100 kA is used. Figure (3,6) shows the reactions that take place inside the electrolysis cell.

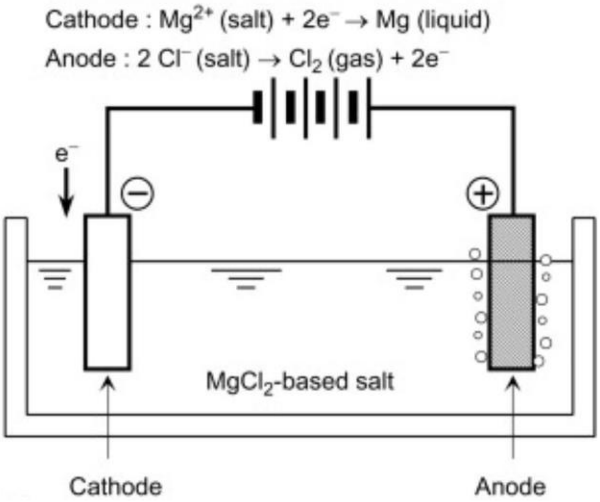


Figure 3.7. Shows the reactions that take place inside the electrolysis cell [57].

# PART 4

# METHODOLOGY

The leaching experiments that will be in our research are two types. The first type is leaching using chemical acids and the second type is leaching using microorganisms. The processes of dissolution of the magnesium mineral present in the ashes result from burning fuel oil. The leaching process is preceded by several processes to prepare the ashes resulting from burning heavy fuels to extract magnesium from it, which are milling processes, separation, washing and screening.

## 4.1. ASH GRINDING PROCESS BY BALL MILL

The grinding process was carried out in two stages by a type ball mill (Retsch) PM 100 it is made in Germany to soften the ashes resulting from burning heavy fuel, as the milling process was carried out for the first time for the ashes with a time period of an hour and at a speed of 250 revolutions per minute to soften the granular size of the ash and reach the micro-particle, after which the milling process is carried out for the second time to reach the required microbial volumes. Grinding process for half an hour at a speed of 300 rpm to reach granular sizes (150, 75, 53) microns.

Figure 4.1. A ball mill device used to grind the Ash from burning fuel oil.

## 4.2. SIEVING OPERATIONS FOR ASH FROM BURNING FUEL OIL

Sieve operations for the ash resulting from burning heavy fuel by means of a vibrating vacuum device, where a quantity of 100 grams was placed at the top of the device in the upper sieve and the sieves were placed in order according to the required size and at the end the base was placed and after that the device was operated for half an hour and the following weights were obtained in the sieves How many times the screening process is repeated, where the screening process was carried out for 1500 grams of the ashes resulting from burning the heavy stove. Each time, 100 grams are placed in the device only, and an ash size of 150 microns, 75 microns and 53 microns was obtained with good quantities to conduct the leaching process.

## 4.3. THE WATER-WASHING PROCESS FOR ASH FROM BURNING FUEL OIL

he washing process of the ashes was carried out using distilled water, where 100 grams of the ashes resulting from burning heavy fuel were placed in a glass beaker and 250 ml of distilled water were added and the mixing process was carried out for 30 minutes at room temperature by a mixer, after which the process of separating the ash from the distilled water is done by means of Filter paper and then the ashes from the washing process are dried by a drying oven at a temperature of 150 ° C to remove the liquids in the ash.

The washing process was repeated again, but at a temperature of 90 degrees Celsius, after which the water filtration process was carried out with filter paper and the ashes were dried in the drying oven and then I weighed the ash sample after washing with a sensitive balance. The new weight showed a clear increase in the weight of the impurities dissolved in the water during The washing process is at a high temperature, and this experiment shows that the process of washing with water is more efficient than the high temperature .

## 4.4. WET MAGNETIC SEPARATION

The wet magnetic separation process was carried out using the device designated for this process, where a device with high magnetism was used to separate the iron in the ash from the ash resulting from burning heavy fuel

All these steps are taken to prepare ashes for leaching processes to extract magnesium from it. All these steps lead to an increase in the effectiveness of the leaching process.

## 4.5. LEACHING PROCESSES OF HEAVY FUEL ASH TO EXTRACT MAGNESIUM

Leaching processes are carried out to extract magnesium from the ashes resulting from burning the fuel with the use of hydrochloric acid with multiple molar concentrations. Many experiments were conducted under different conditions to obtain the magnesium metal with new purity and the results showed good concentrations of the magnesium metal.

The conditions studied are the particle size of the ash, the temperature during dissolution, the molar concentration of hydrochloric acid, and the time during the dissolution process 27 experiments were conducted at room temperature, 9 experiments with a grain size of 53 microns, 9 experiments with a grain size of 75 microns, and 9 experiments with a grain size of 150 microns. The samples were examined with a device (Atomic) to check the percentage of dissolved magnesium in hydrochloric acid.

When the experiments were conducted at room temperature and an atomic volume of 53 microns, and when using hydrochloric acid at a concentration of 3 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 53 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.4 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.51 grams.

The first experiment was repeated for the third time with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.72 grams.

In the fourth experiment, it was used room temperature and an atomic volume of 53 microns, and when using hydrochloric acid at a concentration of 6 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 53 microns and the leaching time was 30 minutes after filtering the acid loaded with

magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.42 grams.
The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.56 grams.

The forth experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.74 grams.

In the Seventh experiment, it was used room temperature and an atomic volume of 53 microns, and when using hydrochloric acid at a concentration of 9 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 53 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.48 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.59 grams.

The Seventh experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.77 grams.

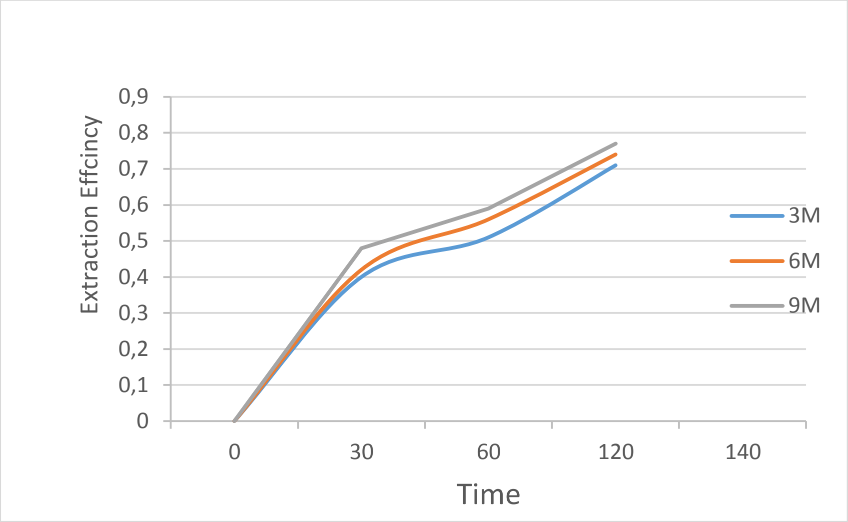
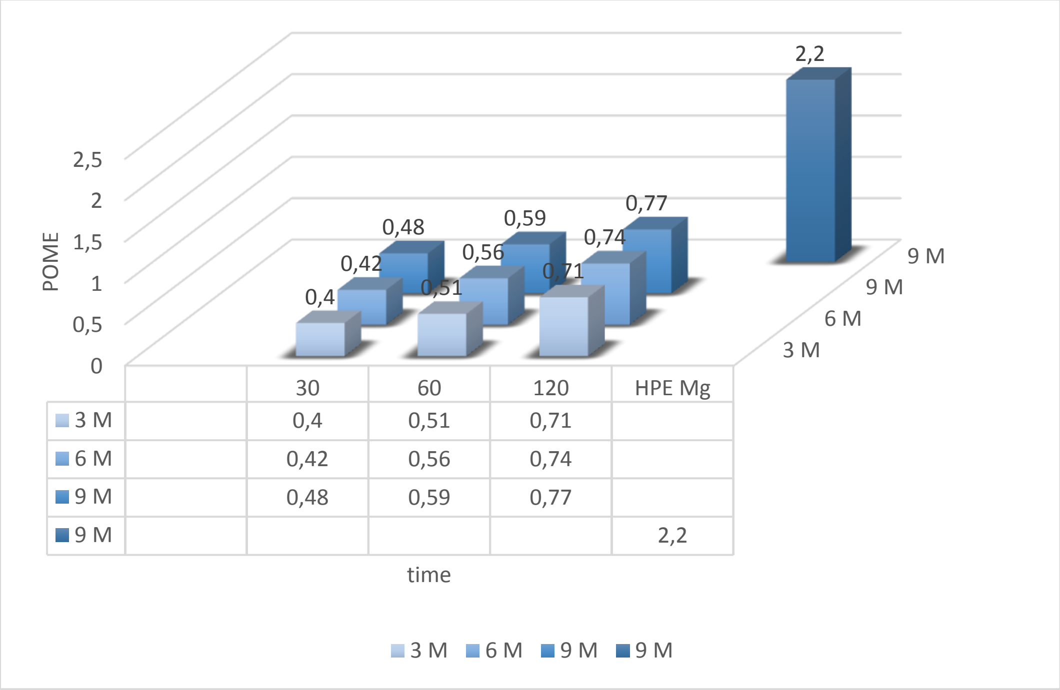


Figure 4.2. A chart showing the efficiency of the extraction process with the difference in time and the molar concentration of the acid HCl.



| | 30 | 60 | 120 | HPE Mg |
|---|---|---|---|---|
| 3 M | 0,4 | 0,51 | 0,71 | |
| 6 M | 0,42 | 0,56 | 0,74 | |
| 9 M | 0,48 | 0,59 | 0,77 | |
| 9 M | | | | 2,2 |

Figure 4.3. A chart showing the percentage of magnesium mineral extracted and the different conditions used during the extraction process.

The tenth experiments were conducted at room temperature and an atomic volume of 75 microns, and when using hydrochloric acid at a concentration of 3 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing

10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 75 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.17 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.25 grams.

The tenth experiment was repeated for the again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.33 grams.

In the Thirteenth experiment, it was used room temperature and an atomic volume of 75 microns, and when using hydrochloric acid at a concentration of 6 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 75 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.19 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.28 grams.

The Thirteenth experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.35 grams.

In the sixteen experiment, it was used room temperature and an atomic volume of 75 microns, and when using hydrochloric acid at a concentration of 9 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 75 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.24 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.29 grams.

The sixteen experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.36 grams.

The nineteen experiments were conducted at room temperature and an atomic volume of 150 microns, and when using hydrochloric acid at a concentration of 3 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 150 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.08 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.13 grams.
The nineteen experiment was repeated for the again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.15 grams.

In the Twenty-Two experiment, it was used room temperature and an atomic volume of 150 microns, and when using hydrochloric acid at a concentration of 6 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 150 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.09 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.17 grams.

The Twenty-Two experiment was repeated for the again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.17 grams.

In the Twenty-fifth experiment, it was used room temperature and an atomic volume of 150 microns, and when using hydrochloric acid at a concentration of 9 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 150 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.12 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.18 grams.

The sixteen experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.19 grams.

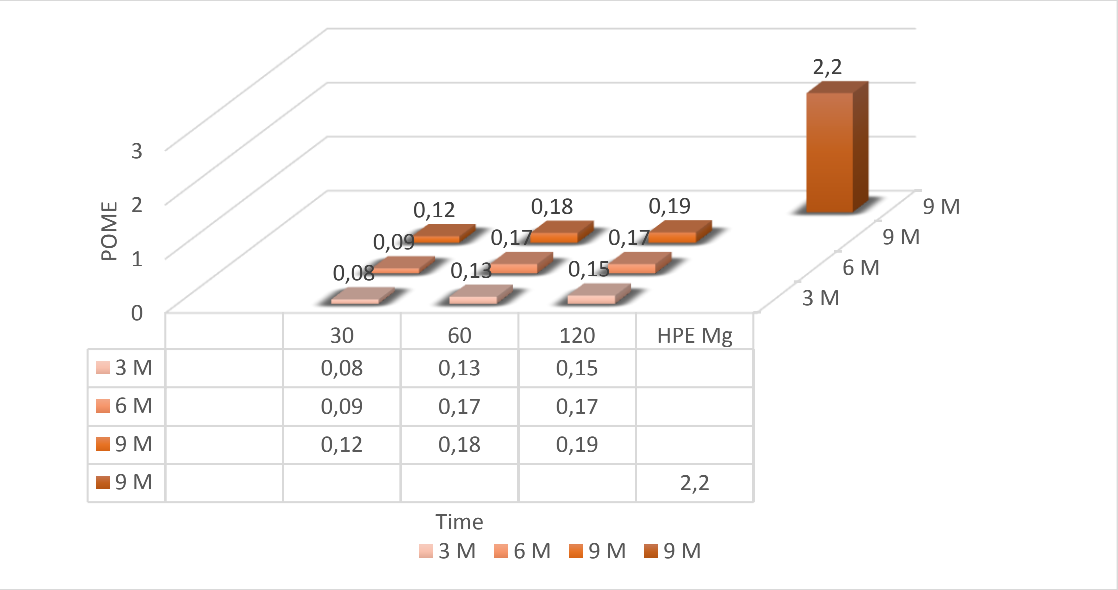


Figure 4.4. A chart showing the percentage of magnesium mineral extracted and the different conditions used during the extraction process.

The results show that when the granular size is increased from 53 to 50 microns, the efficiency of the leaching process to extract magnesium metal decreases, as shown in the diagram below.

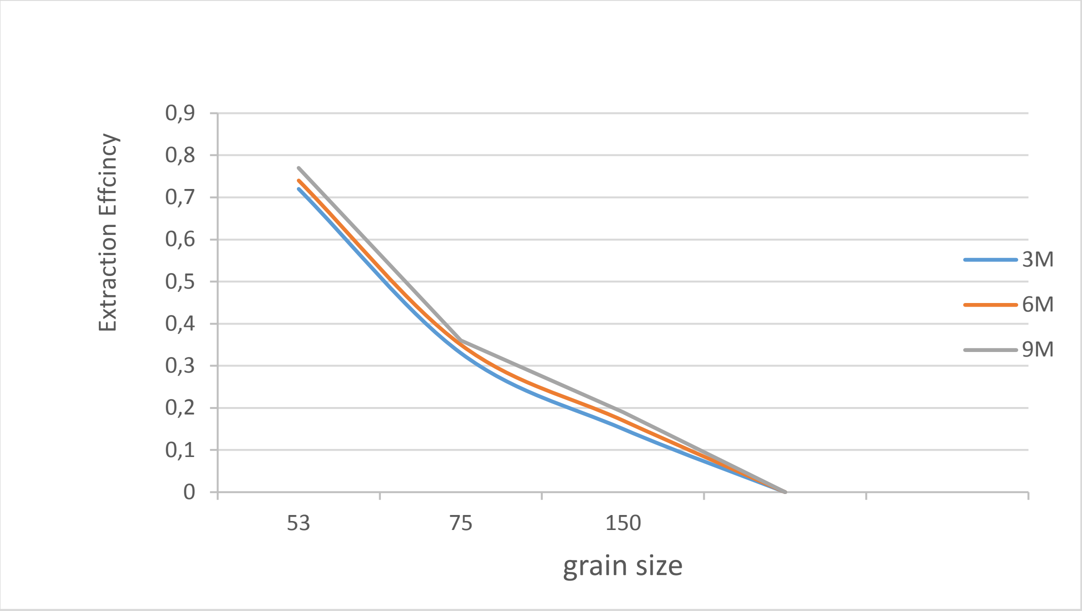


Figure 4.5. Scheme showing the efficiency of a magnesium extraction process by changing the grain size and molar concentration.

The experiments Twenty-eighth were conducted at 60 C and an atomic volume of 53 microns, and when using hydrochloric acid at a concentration of 3 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 53 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.9 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 1.12 grams.

The first experiment was repeated again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 1.31 grams.

In the Thirty One experiment, it was used 60 C and an atomic volume of 53 microns, and when using hydrochloric acid at a concentration of 6 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 53 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 1.2 grams.

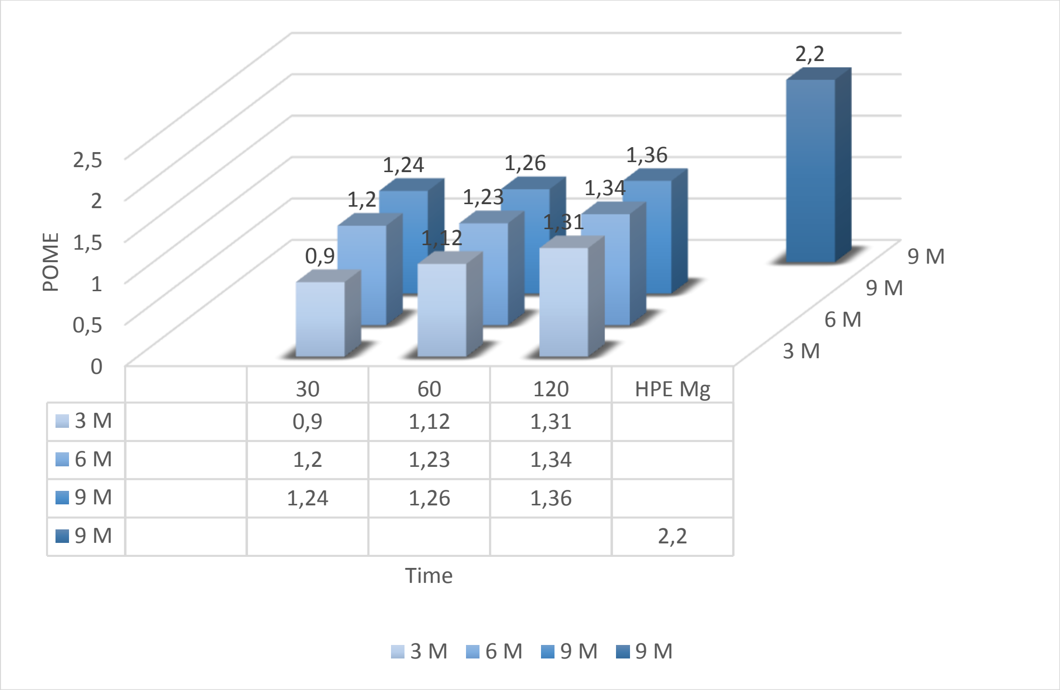
The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 1.23 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 1.34 grams.

In the Thirty-fourth experiment, it was used 60 C and an atomic volume of 53 microns, and when using hydrochloric acid at a concentration of 9 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 53 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 1.5 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 1.26 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 1.36 grams.



| | | 30 | 60 | 120 | HPE Mg |
|---|---|---|---|---|---|
| 3 M | | 0,9 | 1,12 | 1,31 | |
| 6 M | | 1,2 | 1,23 | 1,34 | |
| 9 M | | 1,24 | 1,26 | 1,36 | |
| 9 M | | | | | 2,2 |

Figure 4.6. A chart showing the percentage of magnesium mineral extracted and the different conditions used during the extraction process.

The Thirty-seventh experiments were conducted at 60 C and an atomic volume of 75 microns, and when using hydrochloric acid at a concentration of 3 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 75 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.21 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.43 grams.

The experiment was repeated for the again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.52 grams.

In the Forty experiment, it was used 60 C and an atomic volume of 75 microns, and when using hydrochloric acid at a concentration of 6 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 75 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.25 grams.

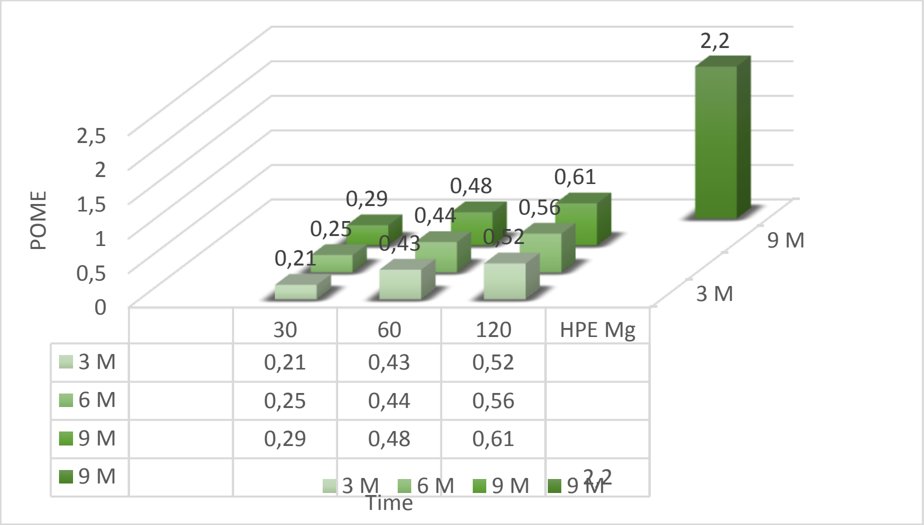
The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.44 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.56 grams.

In the Forty-third experiment, it was used 60 C and an atomic volume of 75 microns, and when using hydrochloric acid at a concentration of 9 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 75 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.29 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.48 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.61 grams.



|  | 30 | 60 | 120 | HPE Mg |
|---|---|---|---|---|
| 3 M | 0,21 | 0,43 | 0,52 |  |
| 6 M | 0,25 | 0,44 | 0,56 |  |
| 9 M | 0,29 | 0,48 | 0,61 |  |
| 9 M |  |  |  | 2,2 |

Figure 4.7. A chart showing the percentage of magnesium mineral extracted and the different conditions used during the extraction process.

The Forty-six experiments were conducted at 60 C and an atomic volume of 150 microns, and when using hydrochloric acid at a concentration of 3 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 150 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.09 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.14 grams.

The experiment was repeated for the again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.17 grams.

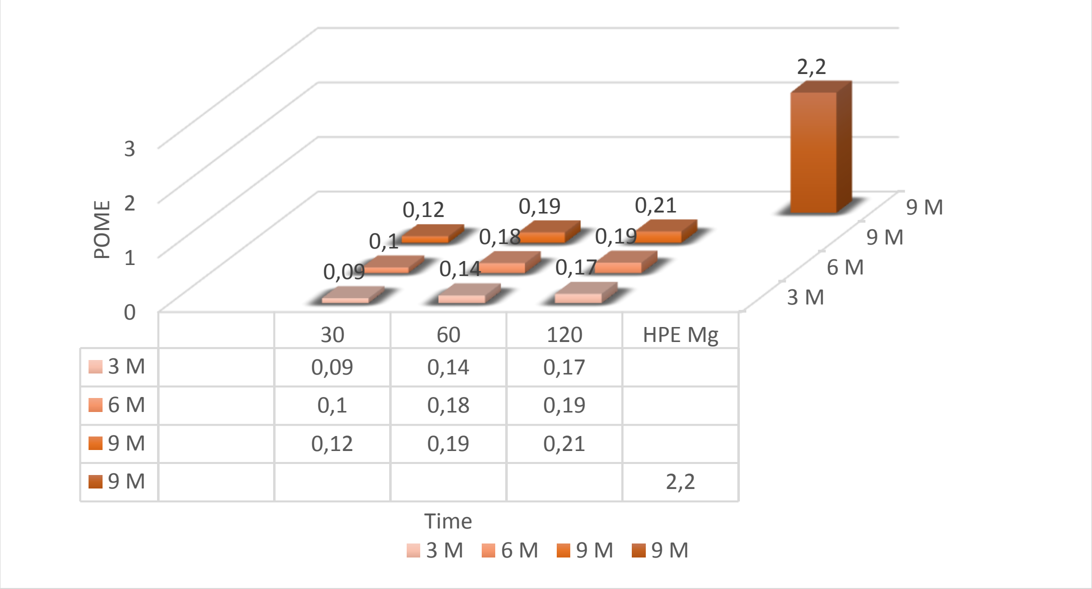
In the Forty-nine experiment, it was used 60 C and an atomic volume of 150 microns, and when using hydrochloric acid at a concentration of 6 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 150 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.1 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.18 grams.
The experiment was repeated for the again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.19 grams.

In the Fifty-two experiment, it was used 60 C and an atomic volume of 150 microns, and when using hydrochloric acid at a concentration of 9 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 150 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.12 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.19 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.21 grams.



| | 30 | 60 | 120 | HPE Mg |
|---|---|---|---|---|
| 3 M | 0,09 | 0,14 | 0,17 | |
| 6 M | 0,1 | 0,18 | 0,19 | |
| 9 M | 0,12 | 0,19 | 0,21 | |
| 9 M | | | | 2,2 |

Figure 4.8. A chart showing the percentage of magnesium mineral extracted and the different conditions used during the extraction process.

The experiments Fifty-fifth were conducted at 80 C and an atomic volume of 53 microns, and when using hydrochloric acid at a concentration of 3 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing

10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 53 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 1.35 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 1.82 grams.

The first experiment was repeated again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 2.02 grams.

In the Fifty-eighth experiment, it was used 80 C and an atomic volume of 53 microns, and when using hydrochloric acid at a concentration of 6 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 53 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 1.39 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 1.86 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 2.15 grams.

In the Sixty-first experiment, it was used 80 C and an atomic volume of 53 microns, and when using hydrochloric acid at a concentration of 9 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 53 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 1.51 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 1.89 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 2.2 grams.

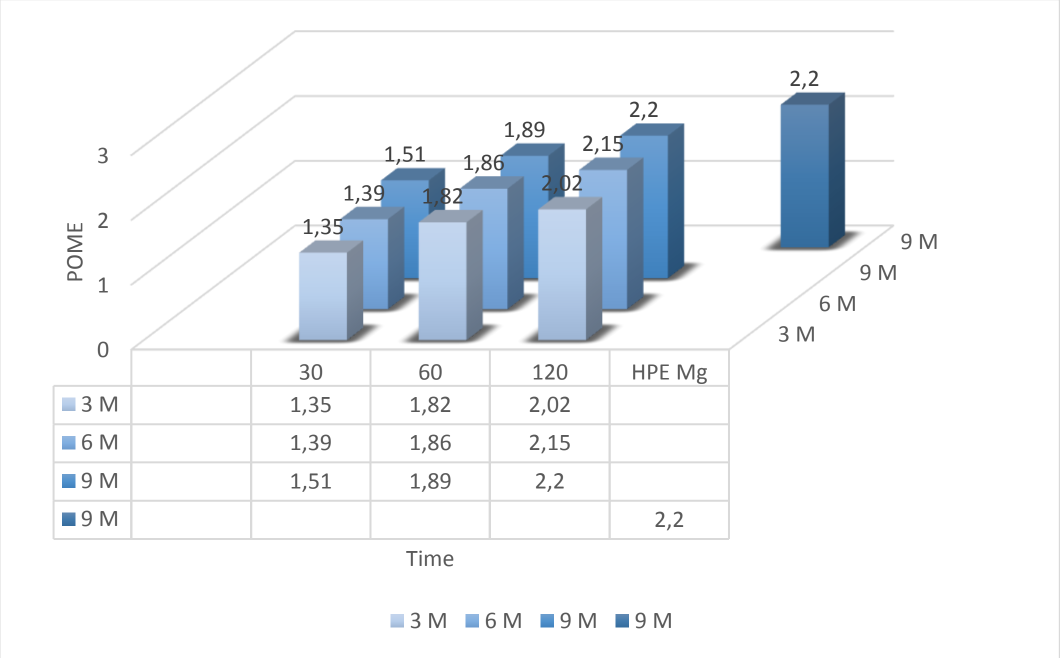


Figure 4.9. A chart showing the percentage of magnesium mineral extracted and the different conditions used during the extraction process.

The Sixty-fourth experiments were conducted at 80 C and an atomic volume of 75 microns, and when using hydrochloric acid at a concentration of 3 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 75 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.28 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.51 grams.

The experiment was repeated for the again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.74 grams.

In the Sixty-seventh experiment, it was used 80 C and an atomic volume of 75 microns, and when using hydrochloric acid at a concentration of 6 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 75 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.29 grams.

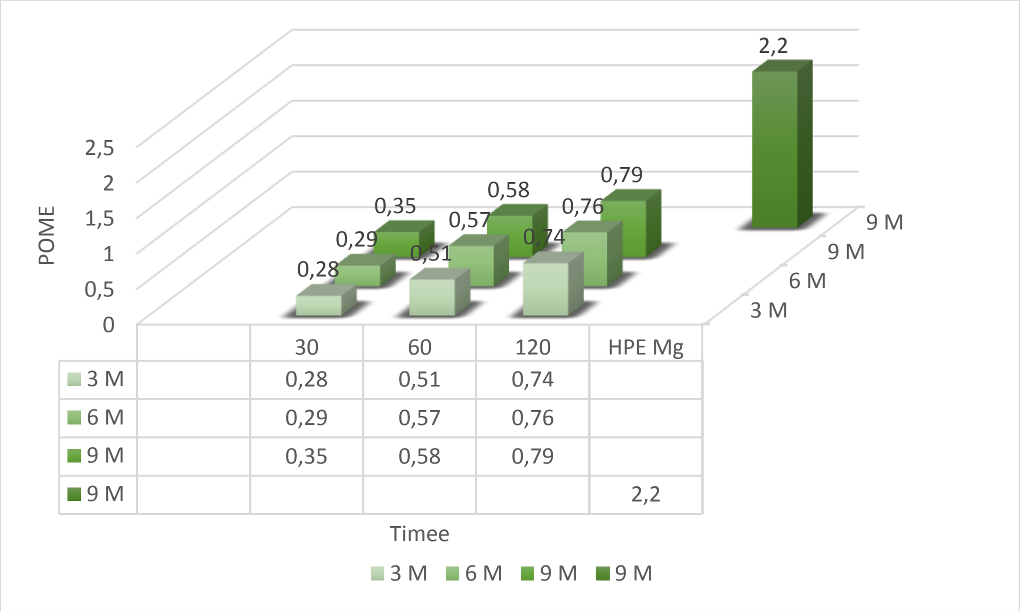
The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.57 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.76 grams.

In the Seventy experiment, it was used 80 C and an atomic volume of 75 microns, and when using hydrochloric acid at a concentration of 9 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 75 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.35 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.58 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.79 grams.



| | | 30 | 60 | 120 | HPE Mg |
|---|---|---|---|---|---|
| 🟩 3 M | | 0,28 | 0,51 | 0,74 | |
| 🟩 6 M | | 0,29 | 0,57 | 0,76 | |
| 🟩 9 M | | 0,35 | 0,58 | 0,79 | |
| 🟩 9 M | | | | | 2,2 |

Figure 4.10. A chart showing the percentage of magnesium mineral extracted and the different conditions used during the extraction process.

The Seventy-third experiments were conducted at 80 C and an atomic volume of 150 microns, and when using hydrochloric acid at a concentration of 3 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 150 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.11 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.16 grams.

The experiment was repeated for the again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.19 grams.

In the Seventy-sixth experiment, it was used 80 C and an atomic volume of 150 microns, and when using hydrochloric acid at a concentration of 6 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 150 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.12 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.19 grams.

The experiment was repeated for the again with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.21 grams.

In the Seventy-nine experiment, it was used 80 C and an atomic volume of 150 microns, and when using hydrochloric acid at a concentration of 9 Molar, three experiments were conducted with this concentration and the conditions mentioned above and three leaching times, where the first experiment was carried out by placing 10 grams of the ash flowing on it in the aforementioned preparation processes in a glass flask. The volume of 500 ml and the addition of hydrochloric acid at a molar concentration and the volume of 250 ml at room temperature was placed on the machine magnetic stirrer and the granular volume used in this experiment was 150 microns and the leaching time was 30 minutes after filtering the acid loaded with magnesium dissolved in it by filter paper The chemist has to detect the percentage of magnesium metal, which is present in it, and the ratio was 0.15 grams.

The previous experiment was repeated with the same conditions, but the leaching time was 60 minutes, so the percentage of magnesium obtained was 0.22 grams.

The experiment was repeated again but with a different leaching time, which is 120 minutes, so the percentage of magnesium metal dissolved in hydrochloric acid after the chemical analysis process of the sample was 0.25 grams.

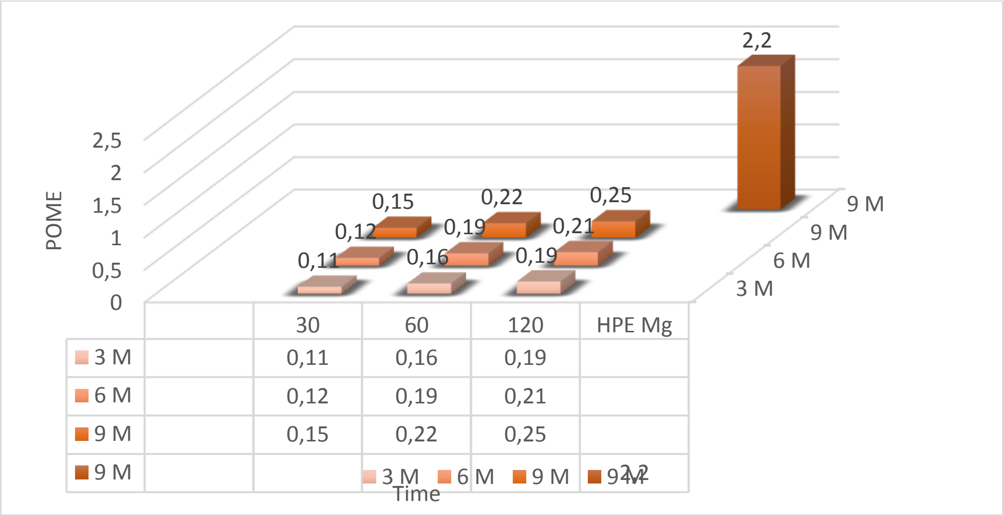


Figure 4.11. A chart showing the percentage of magnesium mineral extracted and the different conditions used during the extraction process.

## 4.6. FABRICATION OF A CELL FOR THE ELECTROLYSIS PROCESS AND A PROCESS OF SEPARATION OF THE MAGNESIUM METAL (DOW PROCESS)

We manufactured a cell to perform the electrolysis of magnesium chloride to extract pure magnesium metal The cell consists of an iron container that was manufactured in a cylindrical shape that contains a movable base from the bottom that can be separated, as well as a cover on the top connected to a graphite electrode The cylinder also contains a tube for entering Archon gas to protect the reaction from oxidation.

The electrolysis process was performed by applying 22% $MgCl_2$, 54% NaCl and 23% $CaCl_2$ The aforementioned elements were placed in the cell, sealed tightly and tied to Arcon gas, and the electrical energy was connected, and the iron cell was the cathode and the graphite electrode was the anode, and the current was passed with a power of 7 volts, and heat was applied to the body of the iron cell by a thermal torch at a temperature (600-800 C).

The magnesium metal separated by this process collects on the surface and after it cools and under the Alarcon gas it is collected and examined for it.

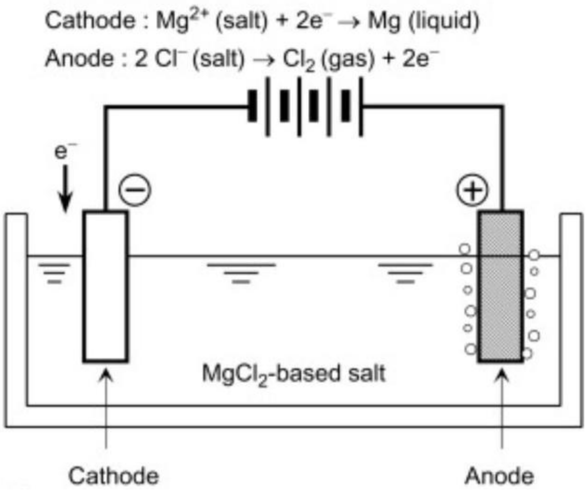


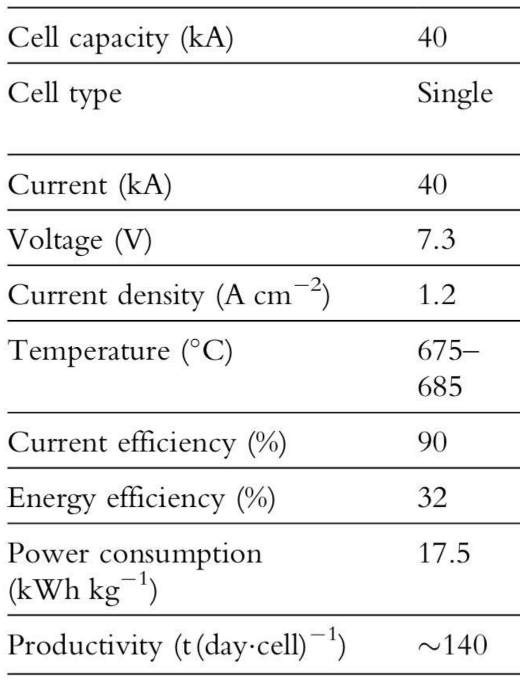
Figure 4.12. Illustration of the Dow cell.

The Dow cell was designed to conduct the electrolysis process, where the cell body was made of iron and a graphite electrode was placed inside the cap, and openings were designed to insert arcon gas into the cell to prevent air from contacting the reaction to prevent the oxidation process of the extracted magnesium, and another opening was made in the cell for the exit of the resulting chlorine gas of interaction.

Figure 4.13. A Dow cell that was designed for electrolysis

Figure 4.14. Argon gas is an electrical energy regulator used in the electrolysis process.

Table 4.1. Conditions used in the electrolysis process in a Dow cell.



| | |
|---|---|
| Cell capacity (kA) | 40 |
| Cell type | Single |
| Current (kA) | 40 |
| Voltage (V) | 7.3 |
| Current density (A $cm^{-2}$) | 1.2 |
| Temperature (°C) | 675–685 |
| Current efficiency (%) | 90 |
| Energy efficiency (%) | 32 |
| Power consumption (kWh $kg^{-1}$) | 17.5 |
| Productivity (t $(day{\cdot}cell)^{-1}$) | ~140 |

The electrolysis process was carried out using the Dow cell and the conditions mentioned in the above table were applied, so pure magnesium metal was deposited on the cell surface near the carbon electrode, and the magnesium was skimmed in the presence of Arcon gas and separated and extracted from the cell.

# PART 5

# SUMMARY

This process is performed to remove water-soluble impurities present in ash from burning fuel oil. The water washing process improves the concentration of minerals and increases the efficiency of the extraction of magnesium from the ash from burning heavy fuels.

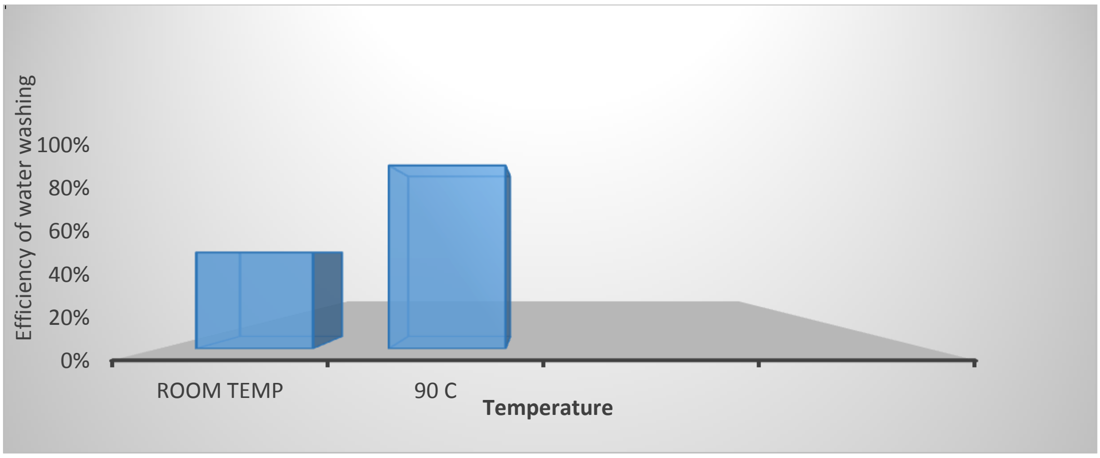
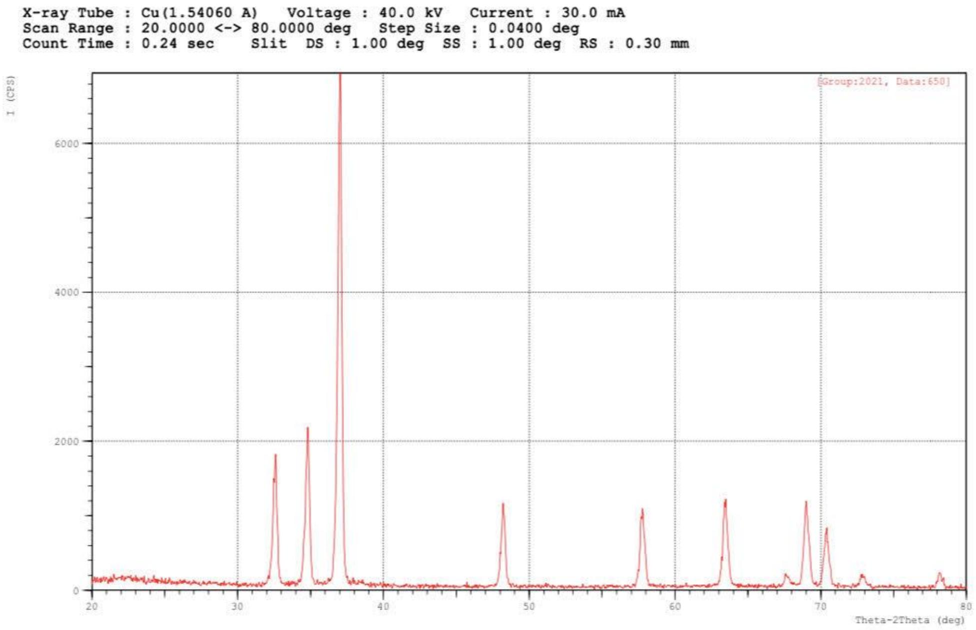


Figure 5.1. It shows the relationship between the temperature during the washing process with water and the washing temperature.

The results showed that the percentage of magnesium metal extracted from the ashes resulting from burning heavy fuel was the highest percentage when dissolved with hydrochloric acid with a concentration of 9 M and when using a temperature of 80 degrees Celsius and the time required for this experiment was 120 minutes. As for the particle size used in this experiment is 53 microns.

Was obtained from pure magnesium metal after electrolysis of magnesium chloride, and tests were performed for the extracted magnesium XRD and SEM. The following diagrams show the test results.



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X-ray Tube : Cu(1.54060 A)   Voltage : 40.0 kV   Current : 30.0 mA
Scan Range : 20.0000 <-> 80.0000 deg   Step Size : 0.0400 deg
Count Time : 0.24 sec    Slit  DS : 1.00 deg  SS : 1.00 deg  RS : 0.30 mm
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Figure 5.2. A chart showing the result of an examination XRD to for the magnesium metal that was extracted.

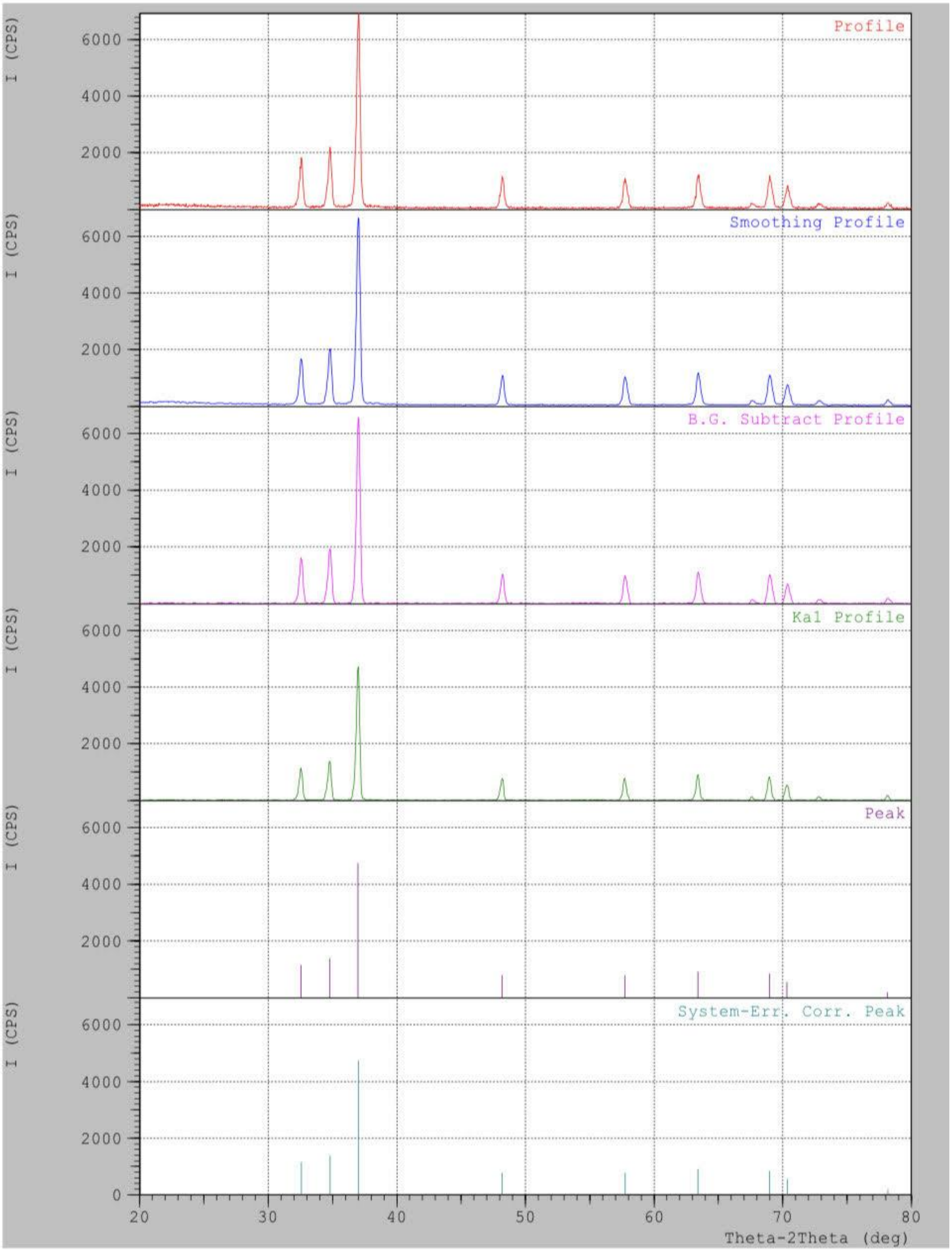

Figure 5.3. A chart showing the result of an examination XRD to for the magnesium metal that was extracted the diagram shows the variables used to test it.

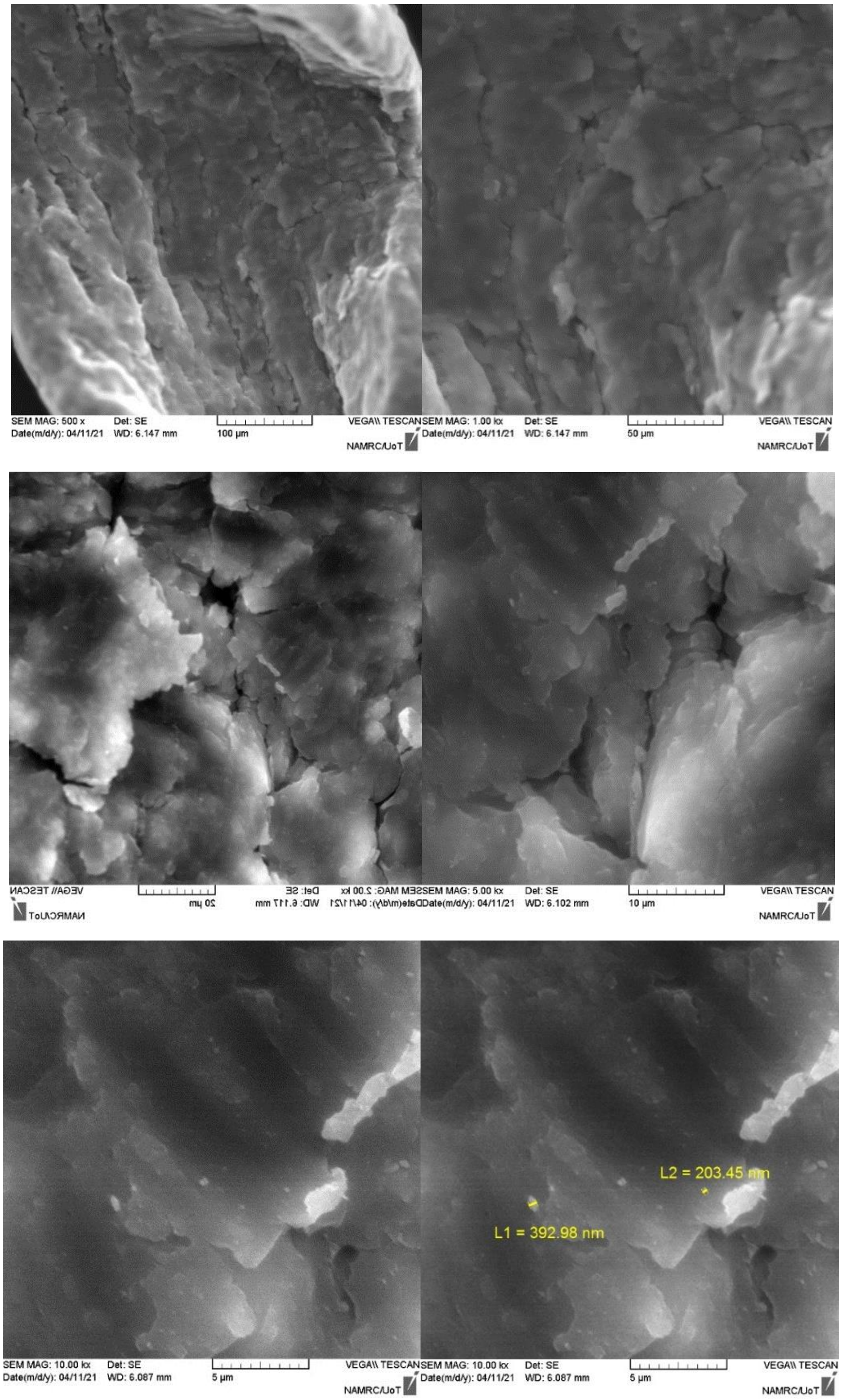

Figure 5.4. Pictures showing the SEM test for the extracted magnesium metal atoms.

These conditions were used in the best percentage of the magnesium mineral extracted from the ashes resulting from burning heavy fuels compared to other experiments that were used. Fuel oil ash is considered a waste that must be treated and utilized instead of making it a harmful source for the environment, as the ash contains, as we mentioned earlier, many minerals, including the mineral magnesium. The results showed that the percentage of magnesium obtained due to the extraction and treatment process is a good proportion and the resulting ash can be considered Burning heavy fuel is an important source of many minerals, including magnesium, so the economic feasibility of this method is good and beneficial, especially in oil-producing countries that do not have seas within their borders.

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# RESUME

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