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Research Article

Modeling a storage tank of carbon capture technology in a power plant in Southern Iraq

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Abstract. The IEA's unique study on CO2 collection, utilization, and storage, published in 2020, shows global capacity for carbon dioxide (CO2) storage between 8,000 and 55,000 Gig tons. The most important thing in the outcome of carbonize into the energy market is the improvement of carbon storage and creation of more efficient distribution systems to grow the volume of carbon that is stored as the liquid while reducing storage pressure. This study will focus on the "systems" assessment of efficiency of adsorption-based devices with respect to carbon storing units. The finite element technique, which is provided by COMSOL Multi-physics™, is used to build up an adequate 2-dimensional axisymmetric structure that is based on the energy, mass, and momentum, which are conserving the thermodynamic extinction rules. Ice water cooling is used to cool down the storage tank initially with the temperature of 302 K. The charging and discharging operations take place at 9 MPa pressure rate. These research results showed that storage operations can especially benefit from the most advanced simulators because of fluctuations in pressure and temperature. At the end of the charging period, the grades of temperature in the center of the tank are higher than at the entry and along the walls, but they are lower at the discharge time. The velocity in the regions near the entry is high and gradually declines as the flow goes through the axis of the tank. Consequent to this, an 8,000 Gt is by far much more than a maximum of 100 Gt of CO2 to be drawn down by 2055 under the "sustainable development" scenario. The study by IEA also expressed that the land potential is larger than the offshore potential. Estimated oceanic carbon storage ranges between 6,000 and 42,000 Gt if land-based sites are considered, whereas the same value drops to the interval of 2,000 to 13,000 Gt, if sites less than 300 kilometers from the coast, at depths less than 300 meters, and outside the Arctic and Ant Upscale an algorithm for modeling a novel CO2 adsorbent during the cycle of adsorbent-desorption that considers all transports. Validate model with data published to confirm H2 storage. Forecasting the influence of pressure and temperature gradients over multiple storage tank locations.

Keywords*:* Storage capacities, Capture carbon, Storage unit, Thermal effect, Pollution, Enhance environmental, liquid carbon

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1. Introduction

Most developed countries aim to achieve net-zero CO_2 emissions by 2050, and they are taking a keen interest in advancing CCUS technology. However, only a few researchers report any work on CCUS technology development in the developing and undeveloped nations, mainly in the Middle Eastern countries where a significant number of high-tonnage CO2 sources exist. Iraq is a developing country in the Middle East, with a population of approximately 38 million and an annual rate increase of approximately 2.2%. Iraq's rapid economic growth requires a steady supply of electricity, causing the government to prioritize the installation of new power plants that emit a large amount of CO2 .This paper aims to collect field data from a working power plant in southern Iraq, model a storage tank of carbon capture technology for that plant, and simulate mechanical properties such as pressure and stress.

The rapid industrial revolution and the increasing reliance on fossil fuels have significantly contributed to the rise in greenhouse gases (GHGs) emissions resulting in global climate change (Saad 2016). The severe impacts of the global warming have driven the entire world to work toward a holistic goal of net zero emissions. One critical pathway to achieve the holistic goal is the implementation of the carbon capture, storage, and utilization (CCSU) technologies. Among different CCSU technologies, post-combustion carbon capture (PCC) technology is most beneficial because it can be retrofitted to the existing fossil fuel-based power plants and other industrial energy-intensive processes, such as cement, iron and steel, and metal. The hybrid membrane–adsorption carbon capture technology offered optimization of the biomass fluid, so engineering constraints for both membrane and adsorption modules will be considered (Negri 2020). Importantly, the implementation of multiple Carbon Capture, Utilization and Storage (CCUS) technologies is believed to be more successful than the individual technology implementation. India's National Enhanced Oil Recovery (EOR) program is also experiencing high carbon delivery rates. EOR program is the region's major EOR projection and has been operating effectively 5km downstream of the suggested plant site.

Global warming is considered to be one of the most critical issues we are currently facing. Over the last few decades, greenhouse gas emissions, mainly CO2, associated with various sectors of the economy have soared. The energy industry is the greatest contributor to this increase due to the extensive use of conventional fuels in fossil-fuel-fired power generation. To moderate the effects of greenhouse

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gas emissions and global warming, carbon capture and storage (CCS) has been highlighted as an essential technology in controlling CO2 emissions as the energy infrastructure is unlikely to alter in the next few decades. The importance of carbon capture is in harmony with the approach of the 1992 Rio Convention to encourage international countries to drastically reduce carbon emissions, in which it was easy to bear fruit in the field of energy production. This is where most of the growing scale of the fuel farm has led to controlling carbon emissions. Power plants work to convert the heat emitted from the combustion of fuel sources by turbines into sound-based electrical energy, but most power plant processes result in very large amounts of heat that cannot be reused or expelled. Separated in space, but in existing power plants the carbon emissions associated with the exhaust gases are great safety problems and must be accounted for. Meet many countries, especially the developing ones in the act of retreating and then the developed countries, others.

There is a significant greenhouse effect that leads to atmospheric heating, and more attention to it. Carbon dioxide has a larger direct contribution to the greenhouse effect than other major greenhouse gases. Therefore, the carbon dioxide gas concentration was as high as 280 ppm before the industrial revolution, and predictions suggest that the concentration will reach approximately 760 ppm from the current 415 ppm levels by the end of the century. So the world must control these greenhouse gas emissions. Reducing CO2 emissions in the world is a major challenge, as it is important to build large plants that can handle a considerable amount of gas (many are more than one million ton/year capture), which can traverse transport distances through pipelines with unnecessarily large cross sections (moose and relate to earthquakes in several countries) from the storage system under pressure, and the economic factor is important in the technology's feasibility study.

The prevalence of carbon capture and storage (CCS), either with storage or utilization, has increased around the world, and it is destined to grow globally in the climate-friendly scenario proclaimed by the Intergovernmental Panel on Climate Change (IPCC) (Mirgaux 2021). It is a strategic asset for affluent energy producers, among them the countries of the Persian Gulf that coordinate their course of the energy transition with the petrochemical industry (Naseeb 2022). However, the predictive capabilities of system models are restricted by the many uncertainties related to carbon capture and utilization (CCU) processes. It is essential to highlight different types of uncertainties in the design phase, some of them refer to process models, physicochemical properties, thermodynamics and energy balance, as well as reaction rates and mechanism or transport phenomena in phase equilibria models (Jablonka 2022). In contrast, other types of uncertainties are associated with market research, engineering judgment and techno-economic data such as operation and maintenance costs, pollution control costs, VA benefits, supplies and demands or quantity of produced goods.

2. Literature review

Being an oil-driven economy, 94% of the emissions in the state of Kuwait are from the Oil & Gas sector. This service provides an insight into the economic feasibility of CO2 capture for oil refineries and integration with enhanced oil recovery. The cumulative cost for the first 10 years of the CCS integrated with CO2 enhanced oil recovery (EOR) ranges from USD 34/ton of CO2 to USD 54/ton of CO2. In the second study, an economic overview of the least expensive approach for the retrofit of the higher capacity electric power plant (E.P.P.) and captive power plant (C.P.P.) to perform CCS is given. It is found that the total additional percentage increase in the cost of electricity due to implementation of the commercial CCS is equal to 94% . The geographical location of the Southern part of Iraq goes from 30.32 to 34.32 degrees north and from 45.59 to 48.35 degrees East, with an area of 43672.93 km^2. The climate of this region is expected to be hot and dry in summer while it is cold and wet in winter with an estimated average temperature of 54 °C and 24% relative humidity during summer, and an average temperature of 5 °C and 61.8% relative humidity in the wintertime. The Northern part of this region is bordered by Tigris River and the Western and Eastern parts are surrounded by Euphrates River. There are no accurate data available on the total number of chemical plants and power generating stations in the Southern part of Iraq, but we can find a general idea on the numbers of power plants and their potentials in the Southern part of Iraq in the past few years (Saló-Salgado 2022).

Generating technologies are continuously evolving to ensure fuel efficiency, competitiveness in electricity rating, and regulatory constraints for the retained emissions. Clean energy innovation is required to embark energy transition, and carbon capture technology is seen as one of the solutions to realize this energy transition. Carbon capture and storage (CCS) of 250 metric tons per year (Mtpa) is a strategic approach for the mitigation of carbon dioxide (CO2) emissions. Challenges for the National Authorities (N.A.) or power plant owners are to define the CCS technical and economic feasibility. The carbon capture cost per ton of CO2 of the power plant installations range from USD 82 to USD 107 depending on the carbon capture technology used Wen, Li and Long (2022).

2.1 Carbon Capture Technology

Carbon capture and storage (CCS) is a good way to support sustainable development in the field of environmental protection and economic development. This study mainly focused on the section of carbon capture using CO2 absorption technology and storage in the gas power plant. The using commercial process simulators for calculation the concentrated data is not available at the moment. We can provide any data of concentration of CO2 using MATLAB v8.6 or in the absence of this code. We can calculate the concentration of the incoming gas and CO2 gases used an online software to measure the concentration by the gas plane (Mohammad and Ehsani 2020).

The incoming gas and CO2 had 85% and 4% the amount of the CO2 gas which absorbed by the solution in absorption column reached 99% per this study. CO2 is separated from the absorption column and then sent to the part of scrubber with diluted amine solution in it (the titter solution) is designed as the storage tank by this chemical and physical process. To separate the gas from the CO2 the electro pumps and the pressure system are used. At the same time, the scrubber's parameters (temperatures, pressures, velocity, and pressure drops) are used to be analysis and this is calculated by MATLAB v8.6 program under the steady state operation. The results of this work are showed by the graphs and tables for different concentrations (Carroll 2020).

This is GAS Work from Texas A&M at Qatar. In the southern oilfields of Iraq, the large amounts of the gas flaring and released CO2 have led to the environmental pollution in recent years. Decreasing the amount of the contaminated gas and CO2 in the atmosphere, the gas storage, and using the technology of CO2 absorption are utilized in site gas power plant . The purpose of this work is utilized the liquid amine solution as a solvent to absorb the produced gas and CO2 gas in the absorption column. The feed first blocked to the vertical absorption column which is designed compressor process flow then the gas after that entered to the scrubber to assure the qualified gas then the gas is stored in a part of the scrubber (a gas storage tank) (Kontogeorgis 2021).

2.2 Power Plants in Southern Iraq

It was expedient to show where the pilot plant was built and the methodology of the capture technology and the conventional absorption process (Hofmann 2015). Also for that could be able to understand the model and the performance of the selected capture process. This study was built on the assumptions that only 90% from total emissions were emitted due to capture efficiency and 70% from 90% of CO2 was possibly combined with Ca and Mg to form solid carbonates minerals. Then we had potential of sequestration equal to 0.804 ton per every 1383.5 ton of CO2 flue gases. The capture and compression cost of CO2 was calculated to be 125 $/ton and the price level of CO2 emitted from the gas-fired boiler was calculated to be as 0.09 $/m3 after the stacked. Finally, it reached to the attractive result to achieve 20 million dollar /year as profit from the utilization of the CO2 available from the flue gases for the carbonation process in the selected power plant

Power plants in southern Iraq utilize two types of fuel for their operation. Natural gas is the main fuel and it comes also with an auxiliary amount of light fuel oil. The plants operate with oil as the sole fuel during the time when the natural gas supply is interrupted or shut down. The 'Alshuiaba' power station is one of these big power plants in power grid that has capacity of 1010 MW and equipped with nine gas turbines. The selected coagent for carbon capture equipment is the upgraded 'Ammar Al Basyri' plant, which is located in northern Hilla. It consists of 2 parts with totally capacity of 190 MW. They are operating and maintained by the Ministry of Electricity in Iraq.

3. Method

Carbon capture technology integrated with a power generating plant results in a new process known as a power plant. A mathematical description of the model is necessary for an integrated carbon capturing and power generation plant; thus, a great amount of interest is present in the dynamic behavior of its components and the entire plant. The measurement model gives the mathematical relations of state variables and the output variables of the system; it provides an algebraic relation that maps the state variables trajectory. The dynamic behavior of the power plant considered are the rates of chemical and thermal reactions that take place inside the carbon emission, carbon consumed in the CO2 adsorption, temperature profile, pressure drop, and water-wall temperature, as well as the rotating speed of the turbine. The measurements taken are the states of the plant.

Two units are designed to contribute to the extrusion of 180 MW from each unit. In general, each of these units is committed to a gas turbine, a steam turbine, and a power generator engine. There is a large number of other devices and mechanisms that regulate, control, and emit gases and emissions. On the other hand, the electricity needed for the transmutation of natural gas (gas regeneration) consumes only 4 kWh of electrical energy for every 1000 normal-of-gas-processed-Nm (53/h). As long as there is no equipment to create electrical energy or take into account the overall power consumption, it should be considered the general-power-based construction of 0.004 kW of natural gas. For a processing capacity of 250 $t.hr^{-1}$, the electrical energy needs for 675.7 m^2/Nm, 60.1 per year, are around 2,495,250.8 €.

3.1 Data Collection

After collection of the information worked out models are utilized to present optimal size of the power plant and operation of the CCT in an economic formation. This is done as the lignite is the dominant source of lignite in the power plants in southern Iraq. There are also a few papers that handled CCT problems of the power plants by a few researchers while the design of some models and the layout helped them to control emissions of pollutants. ℝ3, when drawing CCT to the integrated gasification combined cycle (IGCC) power plants in southern Iraq, we may use a made flow sheath IGCC model to simulate the technical slides if the application of the required power Let (which can be produced once during internal digestion). These hatched-heat furnace panels are fueled by the products inside the cylindrical plant of the industrial gas works . We used HT Test Levenberg-marquardt optimization solver in the heat exchanger and SIG flash in the separator With flow Boundary data of north at the out-of-the-earth boundaries of the heat exchanger and separator are provided and inspection of samples from inside the heat exchanger to pressure gas production and from inside the separator to the pressure product Streams for the heat exchangers and separators are closed in the at-(P,1) flash mode of aspen to find the temperature and pressure of the necessary modification of the power plants we have a series of investigations of the necessary modifications to collect the techno-economic data. Grid tests were carried out screwing through all dimensions of heat basicness, heat ex-caliber and separator. We compare the conclusions of the eight models of some examples that differ only in their density (resolve slither thickness) (Wang and Zechner 2018).

Although some energy simulation techniques are used specifically in commercial work in relation to CCT design and supply, in the instruments of the contactor they are contained. That is due to the fact that essentially the solid-gas contact unit is a capillary-flow SO2 ABS processes problem, which in some studies was introduced with fuel cell systems due to the simple flow configuration. Additionally, these studies show the results that have influence of different structure SO2 channels in contrast to individual SO2 operating parameters such length of CCTs, electrodes and such electrical power and absorption rate, in comparison of such electro disbalance. New similar models are the core lines of the effectiveness of SO2 reactors hence in negative and EPA test results. There are for investment projects of the analysis in CCT several data available such as monitoring, CF and TC. Technical data or chosen simulation software can also be used for contactor synthesis brand demonstrations and to support specific simulation characteristics and electrolyte handling capacity requirements (Ley and Meggouh, 2015). CO2 and other contaminants are stored in underground geological formations like saline aqueous formations and annual oil and gas in a few miles to 2 miles but 5 to 6 miles to prevent chemicals from getting into water supplies coal beds. Co2 also be used the of the investment project of coal beds using the CO2 EOR technology to improve the recovery of the remaining fossil fuels present in a final forma for some .

The core of most CCT practices is the contactor. In such contactors, gases are absorbed by a solvent that removes the carbon dioxide from recirculating flue gases. You can bring the solvent then to a higher pre5sure at a low expense as shown in above By minimizing investment costs on extraction plants, the expense of CO2 transportation grows. Efficient CCT plants also have relatively much smaller power consumption for flue gas compression and repress treatment. Generally, these potential advantages can offset additional costs or possibly tax impacts, contributing to renewed interest in carbon markets on the concept of CCT practices located in regions that are optimal for infrastructure, such as fully-distributed electricity, existing storage and transportation (Babagoli-asl and Samzadeh, 2009). In general, the aim of a pre-combustion contactor in Africa is to meet a stripping steam demand and an environmental constraint (corrective makeup solvent for ammonia and carbamate removal requirement). Giamore contacted an additional overhead process in his detailed work on the concept of CCT where C2 + components can be processed further as an immobilization via a continuous process during vacuum treatment which enables storage at a pressure of about 4.3 bar close to individual energies. Subsequently such treatment technologies have grown. The gas physical performance of this solvent contactor in carbon capture is crucial (Møyner, 2015).

For controlling the climate changes, carbon capture technology is using to decrease the emissions of greenhouse gases -especially CO2- from different points like fossil fuel consuming, steel plants, organic effluent exhaust, and via storing in underground geology or transport this contaminant through pipelines (Shah and McPherson, 2016). The fall of this technology is increasing the cost of the energy generated from the power plants using fossil fuels, therefore controlling the cost and improving the efficiency of this technology are important issue. The variable costs of Carbon Capture Technology (CCT) at the power plant include energy and operating states required in order to capturing CO2 at the rate needed to extraction. There are also costs related to the efficiency toll and design of a plant (mainly construction). The degree to which improving CCT's variable costs will enhance power plant economic feasibility and attractiveness will depend on the potential for CSP power generation: Exports and other sources of revenue (Youssef 2023)

3.2 Modeling Approach

In the power plant designed for southern Iraq, feed gas that is natural gas, is treated and compressed in a gas treatment plant. There are two CO2 absorbers in the capture plant where natural gas – used as the solvent – is washed. The absorbers operate at 40oC and at a pressure of 2500 kPa. The stripping step is carried out in two trays of a stripper column that are cooler than the feed gas. After water and CO2 are separated in the flash drum, the CO2 stream is chilled by cooling tower water in a gas cooler before being compressed to a pressure of 15 MPa by the electric compressor. The main component of the capture plant is the absorber where the CO2 is selectively washed using the water-wetted natural gas . The absorber passes a counter-current gas-liquid mixture. The lean solvent enters from the top and the solvent is allowed to flow downward. The CO2-rich from the bottom of the absorber is composed of natural gas, and the top portion of absorber is composed of the scrubbed CO2 (Wang 2017).

The modeling approach for modeling a CO2 storage vessel in the southern Iraq power plant involves mass and energy balances modeling. The gas stream with a CO2 concentration of 19% was chosen to be the input gas stream flow rate to the storage tank. The main components of the CO2 capture plant (CO2 absorber, stripper column, re boiler, flash drum, and gas cooler) were modeled based on the fundamental principles of operation. The SCD IRWIN software package was selected to carry out the calculations because it provides a simple interface, meaningful diagnostics, and useful output data. The current industrial scale operational data and public design criteria for a CO2 storage tank were used (Venkataramani 2022).

4. Design of the Storage Tank

An investigation was done to explore minor industrial improvements in the new integrated carbon capture storage in a power plant in Southern Iraq. A modeling of its storage tank was elaborated until its construction stages before the equipment of sections and the originated components. For a future plant that is not yet built with the included carbon capture system implemented in the new plan that is going to be constructed in Iraq, a plant with the longest CCS channel implemented in a real industrial scale that is being introduced in the port of Meditte. Many investigations have been done to remove the existing errors and to understand the innovations needed to realize the reduction of CO2, in addition to other gases that exist in the emissions of fuel combustion.

The first complete optimization of the CO2 impurities transport and storage operations for the geological sequestration is first presented. The decision-making process under uncertainties and partial observability is modelled as a Partial Observable Markov Decision Process (POMDP) and the objective function includes terms for the profit related to the CO2 transport and storage and a cost term for the amount of impurities stored and their spatial distribution. The compression of the mixture (mainly CO2) and the transport in pipelines do not change the layout of the impurities in the mixture and the only source of information is the couple depth/impurity content at the injection point .The effect on the quality of the impurities injection location for the depth and the impurity content hydrogeological site characterizations and for different monitoring strategies and the effect of the fidelity of the surrogate used to mimic the decision stage are discussed for the first time. distance between storages the worse the CO2 spreading. Observe the CO2 intruded depth and impurity content is a very effective monitoring strategy and is increasing the quality of the decision. Also the fidelity of the surrogate used have a significant effects on the monitoring decision quality. Most probably the CO2 will remain on the geological timescale in the underground standard trapping mechanisms avoid preferential flow paths existence of the slow viscous fluids flow and that enhance the risk due to the gravity and the traps are complex multi-parametrical structures require an high-quality information. The vulnerability footprint and the enhanced leakage through the trapping formation are increasing with decreasing the solubility, but even if less effective it is still technically feasible to locate an almost pure CO2 as if brine were charged.

The first comprehensive study on the optimization of carbon storage is presented. A novel work for the development of an accurate predictive model for the pipeline transport of mixtures of CO2 with key impurities (nitrogen, oxygen and hydrogen) and the calibration of the mixing rules between CO2 and the impurities for the first time (Gunawan 2021) .The new model is based on the application of the equation of state for the non-ideality of the mixtures and covers a wider range of temperatures, pressures and mole fractions. The mixing rules are also derived for a wider range of the mixture composition and the best approach to calculate the critical point of the mixtures of CO2 with nitrogen, oxygen and hydrogen is identified. The model and the mixing rules are validated with experimental p-v-t data and with the literature data showing an improvement between 0.7% and 1.7% for the CO2-rich phase and between 1.1% and 1.8% for the lean phase.

The purpose of the storage tank is to provide the time needed to collect and purify the CO2 before it is compressed to the final form (concentration of CO2 up to 95%). The entire CCS plant at the power plant includes three stages of tanks of CO2 : portable (0.1MPa) - intermediate (0.15MPa) -storage-kh (3.5MPa) storage tanks Foldvik Eikeland O (2021). The total mass of captured CO2 is divided into six portions, each of which is then equally distributed to the appropriate storage tank. A new mathematical model is suggested base on the perfectly mixed reactor (PMR) assumption, the mass conservation, and the compression process of CO2 in a heat exchanger. Using the equation of state for pure CO2, the mean volume of the tank is calculated at mean annual of 2010. It is found that an amount of 101866.69 ton of pure CO2 is the maximum level should be in the tank before compressing process.. It is estimated that these storage tanks can be stored with a total capacity of 1.1t CO2/s or 3.7t CO2/h. Each of the six storage tanks was designed to store 50 kg CO2; therefore, the total CO2 storage capacity in a CCS plant of every 0.2 GW plant is 300 kg or 1.0 t/h. Comparing this result, the maximum capacity of a CCS plant for some power plants might be estimated, and the ratio of the capacity between the CCS plant and the original power plant can be defined as 1:1000 Based on the maximum and minimum capacity of original power plants and the mean capacity, the volume of a CCS tank might be given accordingly. The result is well consistent with the design capacity of CO2 storage Marcut I (2022).

4.1 Tank Capacity Calculation

The aim of CO2 storage will be the same like the aim of solar or wind energy, to have clean, cheap, secure and reliable energy sources without CO2 emissions. The prices per kg of CO2 stored in each strategy are distinct, however different studies establish that prices of geological sequestration and mineral carbonation could cost from 15 $/system per ton to 210 $ / system per ton, notably cheaper than DAS of CO2 from air technologies. Even so, the cost of those strategies and the potential leakage of CO2 limit the capacity of CO2 that these strategies can store. In Fig 5 the market price of CO2 has been plotted, this graph can be very useful for policy makers on CO2 emission taxes decisions. Therefore, it is reported as a reasonable price to storage 20 $/ton. The data for the revenue of the facilities working with EUAs show how uncertain this market is. However, reporting this price can guide the decision making of cement producers or boxside producers. These industries use approximately 1.1 tons of Ca or Mg rich materials per 1 ton of CO2, and their production quantity is huge, while no energy is jeopardized during the purifying process. The report prices for the Bayer and soda method is calculated with an aluminum unit price of 1.2 $/kg, the price of box side before the dehydration of 50 $/ton and 300 $/ton respectively. The assumed market price of the EUAs is 42.4 $ / system.

There are different ways to sequester CO2. The technologies under consideration in this work are geological sequestration, ocean and mineral carbonation, enhanced oil recovery (EOR), and cultivation of algae. Trapping is the geological process by which CO2 is stored in the subsurface in pores, fractures, and interstitial spaces in the rock. There are three mechanisms of CO2 trapping in rocks: structural, hydrodynamic, and dissolution. The crucial point of geological storage is to guarantee the trapping of the injected CO2 and to secure that it will not leak. Many studies have shown that geological storage can be prospective and safe for several million years. The mechanisms of trapping allow that the CO2 injected can be retained efficiently in a porous reservoir. Ocean sequestration involves the natural photosynthesis of carbon dioxide through the use of phytoplankton. Mineral carbonation, also known as carbonate mineralization, is a process for long-term sequestration of CO2. This process involves the reaction of CO2 gas with CaO to give CaCO3. The rate of carbonation increases with increasing pH, which in turn depends on the concentration of base-cation in the feed solution. The molar ratio of Ca to CO2 is 1:1, and that results in 44.0 mass units of mineral sequestered per each mole of CO2 inlet. The equation that represents this reaction is: CO2(g) + 1/2 CaO(s) → CaCO3(s).

Table 1. Properties of tank material

▸▸	Property	Variable	Value	Unit	Property group
✓	Rotation	lrot	0.0	deg	Shell
✓	Initial tensile and shear yield stress...	{ys1, ys...	{381e6, 38...	N/m^2	Elastoplastic material model
✓	Thickness	lth	th	m	Shell
✓	Young's modulus	E	205e9[Pa]	Pa	Young's modulus and Pois...
✓	Poisson's ratio	nu	0.28	1	Young's modulus and Pois...
✓	Density	rho	7850[kg/...	kg/m^3	Basic
✓	Mesh elements	lne	5	1	Shell
	Thermal conductivity	k_iso ;...	44.5[W/(...	W/(m·K)	Basic
	Relative permittivity	epsilon...	1	1	Basic
	Hill's coefficients	{Hillco...	{0, 0, 0, 0,...	$m^2{\cdot}s^4/kg^2$	Elastoplastic material model
	Heat capacity at constant pressure	Cp	475[J/(kg...	J/(kg·K)	Basic
	Electrical conductivity	sigma_i...	4.032e6[S...	S/m	Basic

4.2 Material Selection

Abstract. Carbon capture and storage (CSS) technology is one of the effective greenhouse (GHG) gas reduction methods. Southern Iraq that has an electrical energy generation rate close to 5,000 MW, which emits 7,130 Ktas/year of CO2 as the same rate sulfur dioxide emission is also close to 165 k/ch/year. Twenty-six percent of the emitted CO2 is coming from power generation industries. The lowest natural gas prices in Iraq, resulted in a significant increase in the rate of using this kind of fuel by the power plants and only these kinds of power plants perform carbon capture technology. In this study, the carbon capture technology and storage with pipe transporting are research. First absorption is performed in amine solution. In the captured CO2 stream, the partial pressure of the CO2 and H2S reaches from 7 up to 10 bar/g and 2.2 up to 3 bar/g, respectively. Only the CO2 is recovered from the captured stream. The main pipeline starts from about 250 up to 450 kilometers. The storage tank is located in southern Iraq. It has two different diameter parts that their material are Steel St 37 and SA 335 Gr. P22, respectively. The best Carbon steel is selected to the cylindrical part that the minimum weight and the minimum thickness obtain for it Bouallou C (2020) The weight is a main part of the expenses that needs for a pipeline with this length. The calculation of the stress and the displacement of the storage tank are performed as well. The net present value and the internal rate of return (IRR) obtained 0.741 and 21.5%, respectively.

4.3 Structural design

Position storage tanks that hold the weight of water (flat bottom tanks) on multiple concrete foundations or piles, long plates. The storage tank steel plates are typically pre-stressed. The use of pre-stressed steel has improved the performance of water and petroleum storage tanks. These kinds of steel plates are pre-stressed by pulling the steel plates due to elongation of the metal. They generally act as synthetic muscles within the overall storage system. Due to that, the pre-stressed material, commonly used for flat bottom storage tanks, is widely used globally as one of the most significant and effective cost-effective structural solutions available in storage tanks. As opposed to ambient oil tanks, the shop assembles 'field assembles' elevated temperature storage tanks using lower levels of industrial breakdown. These potential savings of money and commodity are of significant economic benefit.

- The internal surface of carbon steel and high-temperature tanks shall be examined and coated with an inhibitor by the manufacturers. One coat shall be applied with an airless sprayer machine.
- Sheet metal used for nozzle connections is recommended not to exceed 1 mm to 3 mm.
- The sealing gasket of the tank shall not deteriorate if it is used for insulation for a small range of temperature changes.
- Storage tanks should be confined by noncombustible buildings to reduce the explosion potential.
- Administrative aspects of transferring without placing this are located 30 feet off the outside of the yard traffic.
- Boilers should be at least 200 feet (60 meters) apart.

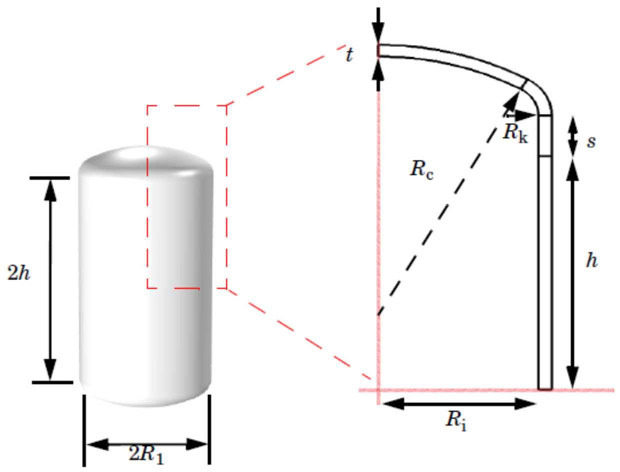

Figure 1. Schematic description of the storage tank geometry and dimensions

Table 2. properties of model

Name	Expression	Value	Description
pressure	1[N/m^2]	1 N/m²	Internal pressure
th	2[cm]	0.02 m	Wall thickness
De	52[cm]	0.52 m	External cylinder diameter
Di	De-2*th	0.48 m	Internal cylinder diameter
Ri	Di/2	0.24 m	Internal cylinder radius
sf	3.5*th	0.07 m	Straight flange height
Rk	0.1*De	0.052 m	Internal knuckle radius
Rc	0.9*Di	0.432 m	Internal crown radius
hi	Rc-sqrt((Rc-Ri)*(Rc+Ri-2*...	0.10176 m	Internal head height
alpha	atan((Ri-Rk)/(Rc-hi))	0.51753 rad	Angle at intersection cro...
hcyl	40[cm]	0.4 m	Half cylinder height

Modeling carbon storage operations for the long term to ensure safety requires a combination of real-time monitoring of injection and long-term planning based on the predictions of large-scale, fully implicit models. Therefore, there is an increasing interest in developing combined models informed by real-time data for carbon storage to locate the injector and monitoring wells under uncertainty in heterogeneity of geological structures 8. For these models to be tractable and make effective use of real time and available historical data, vertical equilibrium or multi-resolution coupled vertical equilibrium models can be useful.

4.4 Safety considerations

The thematic concern is sequestration using the safest available reservoir and aquifers in the range of suitable depths. A significant proportion of aquifers are unsuitable for storing much CO2. The final candidates for CO2 sequestration are the Khashab Formation, Shiranish Formation, Mishrif Formation, Tharthar Formation, Akashat Formation, and the Injana Formation. From the deterministic results, the final storage capacity estimate is 640 million tons of CO2. Returning to safety considerations, the operational approach to mitigating risks are recommended such as regular and remote monitoring of stored CO2, developing stringent injection pressure and volumetric requirements, and ensuring public trust through increased public information, education, and community consultation, adjusted reservoir pressure as CO2 sequestration is performed, reduced buoyancy force induced stress, implementation and construction of structural mitigation barriers, horizontal direction orientation, closed loop well system, and comprehensive studies beyond strictly CO2 storage motivations.

Carbon capture and storage (CCS) technology allows electrical power production with reduced carbon dioxide (CO2) emissions by separating the CO2 exhaust gases at power plants and injecting it into a geological formation where they are stored. In the developed southern regions of Iraq, large amounts of CO2 are emitted from power plants. The pore space and the integrity of the cap rock are the critical factors, along with other secondary safety considerations in the selection of reservoir rocks for CO2 geological storage. In this research, the Khashab reservoir in the Gulf Inter-Montane Basin of southern Iraq is suggested for geologic CO2 sequestration, wherein a commercial size power plant with a flue gas rate of 5828 kg s^{-1} and a CO2 separation efficiency of 85.02% is selected. CO2 stream, mass, and total moles are determined monthly through CFD software package and then retrofitting the model to extract the area of separation equipment along with the flue gas rate and CO2 fraction.

5. Simulation of carbon capture process

The simulation study carried out to model the amine-based CO2 capture post CFD software process from a power plant located in southern Iraq, which has a generation capacity of 5.4 GWe. The contacts studied the combustion of natural gas, fuel oil, and heavy used (UH) by burning them in a gas turbine, a power plant boiler, and diesel generators. The results showed that the MEA (Mon ethanolamine) absorption technique can be used to capture 90% of CO2 from the flue gas leaving the flue gas and heating it to a suitable temperature between 50–70 °C and have more secure than storage applied in the saline formation of the Garraf oil field, with a storage capacity of 9.63–11.03 Mton/year, which was used for 45 years.

Carbon dioxide is one of the pollutants produced, particularly in power generation plants. There are three main techniques used to control or mitigate the carbon dioxide concentrations emitted from these plants: absorption, membrane games, and cryogenic process. Absorption is one of the most available techniques and relies on the solvent that is related to the power of carbon molecule attraction to absorb the carbon dioxide molecule and make the separation possible. The amine solvent is one of the commercial absorbers used to remove CO2 from the flue gas of a power plant. The conventional MEA transmitter represents the most industrial advancement in post combustion absorption technology.

6. Performance Analysis

The integration of a storage tank as a carbon capture storage (CCS) system at the post-fossil fuel power plant in Southern Iraq has gained the attention of the international community for improving the efficient use of energy sources to generate electricity for the first time in this country. The large power plants are among important and large carbon emitters, which give about 25.7% (5352.4 Gg) of the total greenhouse gases (GHGs) from electricity production globally and about 1.8% (34-43 M tons) of carbon emissions from electricity in Iraq. The development and implementation of carbon capture storage in many fields such as fossil fuels, chemical, and petrochemical have proved that the GHGs can be reduced per year by about 80-100% from the power plants. This paper deals with the cost analysis of storing a mineral carbonation (CCS) as the tank model at the post-fossil fuel power plant, one of the largest emitters for the purpose of preventing the atmosphere from being polluted due to the GHGs at the local or regional scale.

This paper deals with cost analysis for modeling a carbon capture storage (CCS) system as a tank model of the post-fossil fuel power plant in Southern Iraq using CFD software. The cost includes process unit capital, installed equipment capital, direct fixed capital, total product, and fixed capital. The results show that the installed equipment capital, process unit capital of the tank as the model have disposed a direct and full fixed capital of about 77.3% and total product. The results also show that it is profitable to invest in the CCS system; the fixed capital is 0.5 US Dollars, total product, 3.0 US Dollars.

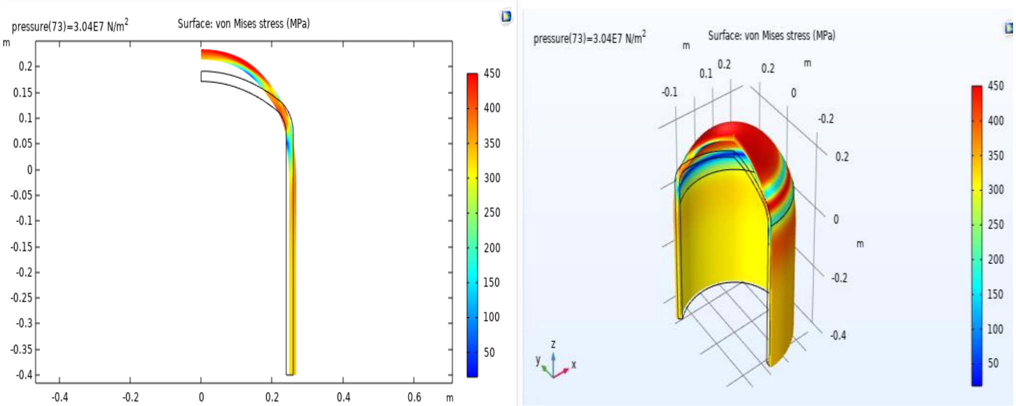

Figure 2. Distribution of von Mises stress at 10% yielded volume.

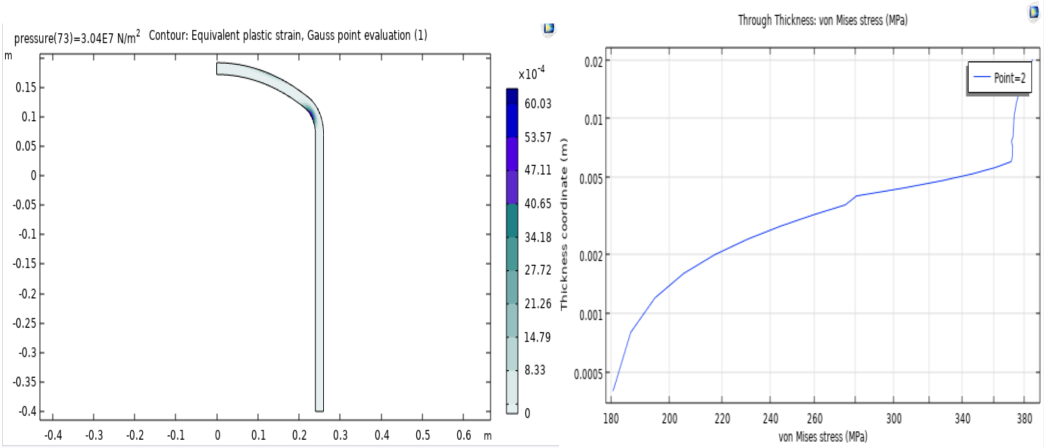

Figure 3. Equivalent plastic strain at 10% yielded volume.

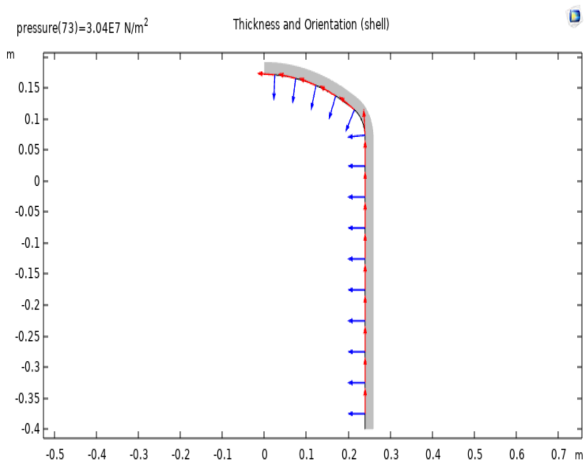

Figure 4. Orientation and amplitude of the applied pressure load.

6.1 Efficiency of Carbon Capture

In the detailed model, the energy consumptions in kW are reported with their relative efficiencies percent-fractions at maximum designed mass flows in the absences and the presence of the storage reservoir operations. With purpose to have an attractive market at least in the Gulf area, the CO2 storage costs are assumed to be reduced down to 14 $/ton. It is found that in this case the attributional and consequential CO2 Capture and Storage efficiencies are a very interesting order of 20% and 30% in the absence of energy storage respectively, and are increased down by around a factor of 2 once the full reservoir energy storage processes are taken into account. Overall, the orders of efficiencies are close to possible industrial applications.

The previous model computes the energy requirements, performance and thus the respective efficiency of the CCT system. The following model utilizes the useful heat obtained from a waste of a simple or a regenerative Brayton cycle that is power by CO2 working fluid at a specific turbine inlet temperature. The most essential difference between the two models is the fact that the first model aims at designing a CCT system with the aid of some redesign of the design with the inclusion of an extra turbocharger, lube oil cooler and the CO2 working fluid heat exchanger, and using the waste heat of the capture technology for that purpose. On the other hand, the second more extensive model aims at specifying more accurately the amount of work required for the capture-technology to operate under continuous steady state conditions assuming the thermal energy due to the heat of combustion of the stored carbon in the storage reservoir has to be large enough to overcome the foundation of any leak of CO2.

The component considered in Carbon Capture Technology (CCT) are rotary pumps, hydro-separators, compressors and a storage reservoir operating under high pressure. The relevant design reports, waste heat sources and many other data required to for the relevant energy analysis are provided in research articles.

6.2 Environmental Impact

About 50 000 tons of CO2 will be deposited in a south sized oil reservoir in the region doing so by itself will raise conditions as discussed in the proceeding chapters. Greenhouse gas concentrations will first drop suddenly as CO2 is absorbed in rock and oil trappings by overcoming electro negation and nutrients and stopped momentarily of the 100 one lecture tons of CO2. The concentration of H2O will usually be about 10.51 percentages to ensure that the humidity reaches the atmosphere and 6.4% for the underground reservoir. In the above, we calculate the volume reduction process in giddy CO2 breaks and absorb coag 49% b. The reaction between isotopes, between acids and carbonations and CO2, has also been involved but this takes a 2/10 large degree of CO2.

CO2 is a major resolving issue to safeguard the surroundings, as a result, professionals are forced to rethink the prospects for smudging CO2 instead of emissions. The goal of this paper is to analyses the environmental effect of a CO2 storage container on the town in which it would be constructed about southern region of Iraq. When CO2 captures it is storage in a reservoir for an unlikely geological step, for instance, a spent oil reservoir. In the event that a storage reservoir will be constructed around the town there are 2 potential environment consequences resulting from the introduction of one particulate power plant THC gas flue and the establishment of a CO2 storage reservoir.

6.3 Economic Feasibility

The international journal of greenhouse gas control has published additional works in design (Jain et al., 2015) and foamed cement (Asali et al., 2015). In sequestration, extensive investigations have been undertaken to increase confidence. For example, integrity risk, slow or fast timescales, residual storage capacities and to manage those risks, we are working with seal geonic CO2. Technologies to enhance or recover CO2 will be addressed in our next report, however, support strategies are often the main control strategies at scale 16.

In the Laurentian basin and the Beijing urban area, other commercial geological sequestration opportunities have been highlighted. A candidate site in Saudi Arabia was modelled and a business case was developed. We have used the current report to highlight recent field tests and economic analysis to seal our facilities which are described there. The previous transparent update or at least permission to do so should be obtained since it will ultimately serve as a plug and play kit. An implementation methodology will be proposed for longer term study. Decommissioning of the CO2 storage system will be necessary in some projects and a plan should be engineered. Proper management and waste management of the CO2 capture solvents will be necessary. However, to be useful rather than producing an excellent study, the above insights must be implemented. Facility design and economics charts At both trading carbon leakage management when CO2 modelling and rate performance in carbon capture thus necessary facility can be added Hoxie hydrogeological descriptions Pressure build-up will be examined in detail CO2 corrosion considerations Formed scale projections Asphalting sorbent will be booking math model to mitigate organic fouling Hydrate control design may be more efficient for now. If hydrates are forming safety systems are in place to depress, if not then the savings from the former spread over product. The carbon capture technology can be used to model this study from the literature. Sabree and Fazlun (2010) investigated the technical and economic aspects of CO2 capture technology from the Battersea power station-gas turbine to remove CO2 from flue gases. At a reduced load, the plant resided from the de-rated operation at the operating conditions specified i.e., the fuel consumption for the existing plant was 102 MW. The economic feasibility of a retrofitted CO2 capture plant is analyzed using a 5–7 t/d capacity.

7. Results and discussion

Geological CO2 storage remains a significant domain of research in the field of environmental science and engineering. The characteristics of the injection site are critical to the effectiveness of the sequestration, as well as to the potential for geo-hazards, including induced seismicity and leakage. Because actual conditions and processes beneath the ground are never known with perfect certainty, computer models are used to simulate the subsurface and assess its suitability for CO2 sequestration. Typically, these models are then sampled in a Monte Carlo or Latin Hypercube Parameter Space to help identify the controls on the subsurface conditions and thus the effectiveness and potential risks associated with CO2 sequestration.

In the absence of federal funding and national regulations, some states have taken the lead on decarburization by in part pursuing carbon capture technology to help meet the climate and emissions goals. One key hurdle of decarburization, in power sector is related to the emissions of carbon dioxide (CO2) from combined cycle and hybrid frames. However, the market deployment of carbon capture and storage technology (CCS) in Iraq can help solve the problem of reduction in capability drop . The number at the top of each column shows the number of the combination of technologies' design parameters, after considering the equilibrium constraints. In the same column, the mean of the CCS area percentage out of the ES, rounded to two decimal places, as well as the average energy loss and average minimal power are reported. The CCS area capacity factor, reported in %. The Costs and revenue, together with emission reduction and storage-profits are also reported separately.

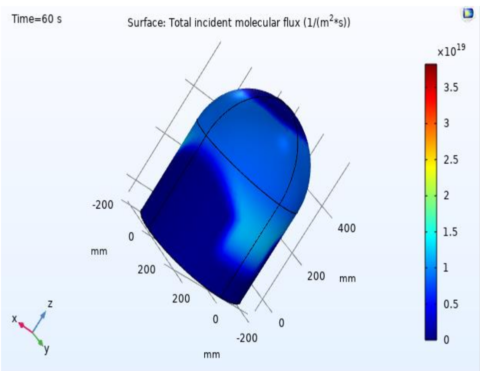

Figure 5. Film thickness on the surfaces of the system, after 60 s of deposition. Molecular flux on the surfaces of the system, during deposition(Film thickness on the surfaces of the system, after 60 s of deposition).

7.1 Tank design results

Cooperation between the Ministry of Electricity's Energy and Ministry of Environmental Planning and Design Department and the Ministry of Environment precludes the capture of carbon dioxide is produced by the power plants required to treat Ein, a compound approved it to a depth of 5 meters, although for greater depths tougher makes it joined to 12 meters. This also requires the excavated part of the borehole to be carefully slit due to the keywords accompanying trenching differences. However, if drilling could be drilled to a depth of 5 meters, only the downhill system would lead to short-term or longer-term damage to surface and underground installations due to land subsidence. When drilling is to a depth of 12 meters, it is highly likely that ground subsidence will not occur at the location of the carbon storage tank. When the foundations under the wall are concerned and classified using the existing Iraqi foundation classification, it is apparent that the seventh foundation is used, while for safer, it is recommended to stiffen the ground using gravel to reach more than 5 meters.

Based on the results, as well as cost- and environmentally-friendly indicators, it appears that the best design is the cabin and pyramid design for the settlement stage, with drains and loops, taking into account the proposed changes. it appears that the best design at home is the sliding type, although this is not very effective in terms of cost in units as a percentage of the tank. For the areas surrounding the tank, design 4 is recommended, whereby the barren lands are used to absorb the effects of the weight of the dangerous part of the tank and the same spreading of the dangerous parts in all directions. For the supporting plate under the tank wall, we recommend in the light of the results that the 6th design is left to 7 types instead of 6, which will increase the thickness and we also recommend the introduction of cracks in both its directions and a spur strip connected by a high reinforcement rate in the footing. Carbon capture technology is essential for any future prospect of clean and environmentally friendly energy generation29Electricity production and necessary power plants cannot be halted for the implementation of any environmental measures without carbon capture technology5Cooperation between the Energy Department of the Ministry of Electricity and the Environmental Department of the Ministry of the Environment of the Republic of Iraq, southern region, led to the design of a storage tank to deposit and remove carbon dioxide produced by the Dhu- Al-Fiqar power plant, located in southern Iraq, alone 20 km in Eastern Nasiriya city, with a capacity of 1500 MW, which has been planned for start-up in September 202231. The results of a simulation of a storage tank with a 37.5 m diameter dome roof are presented.

7.2 Simulation results

Modeling a storage tank of carbon capture technology in a power plant in Southern Iraq. With carbon capture, it is possible to integrate it with the power plant infrastructure. There are also storage systems that are integrated with the power plant infrastructure in reducing the operating costs. The modeling of carbon capture using CFD software is effective. Process modeling is a representation of a real system for the purpose of design, these systems can be chemical plants, power plants, industrial facilities, etc. Modeling is a method to simplify methods of calculations and forecasting of the future behavior of a real system. Commercial process simulators work on windows, based graphical user interface. The software allows you to simulate a variety set of configurations and processes that contains many unit operation and transport operations such as separation, reassembly, heat exchange operations, compressor, pumps, valves, reservoir behavior etc. Modeling in an industrial facility can be divided into physical modeling and process modeling. The film thickness on the sample after 60 s of deposition is shown in Figure 6. The thickness varies between 34 nm and 39 nm across the sample, with radial symmetry about the midpoint of the source. As expected, the film thickness at a point increases linearly with time, as shown in Figure 7.

7.3 Performance Evaluation

Based on the previously described criteria, the index is calculated from the measured data for the outlet flue gas stream to evaluate. The depth of CO_2 concentration is also shown in the graph. Based on the number of days (only 0.05 m3/h), the presence of the CO_2 exceeds the environmental standard. This number is small compared to the summer season during continuous operation, meaning that it can minimize the environmental impact. By varying the time of dust feeding, it will reduce mortality or injury for the people around the power plant. Both processes the flow inside the tower and the interaction between the CO_2 and dust—that occur when the outlet flue gas passes through the tower will be reflected in the CO_2s; the 3–4 kg/m3 CO_2s can absorb 90% of CO_2 captured from flue gas entering the venturi scrubber in the 16th day of operation. Only 0.8 kg/m3 of solid characteristic can be absorbed in the dust waste. This is well above the minimum recommended values. To reduce the CO_2 mortality level, the depth of the ash depth or dust should be adjusted. The amount of air that is in the result of the amount of dust should relate to the density of flue gas. Therefore, the industrial flue gas concentration can accommodate more values of dust when the tower enters the venturi scrubber.

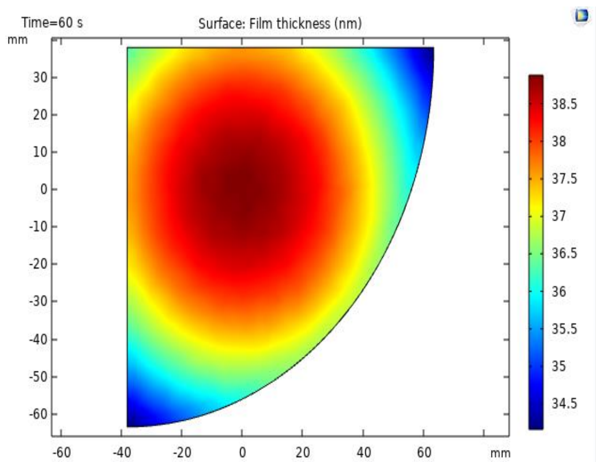

Figure 6. Film thickness on the surfaces of the system, after 60 s of deposition.

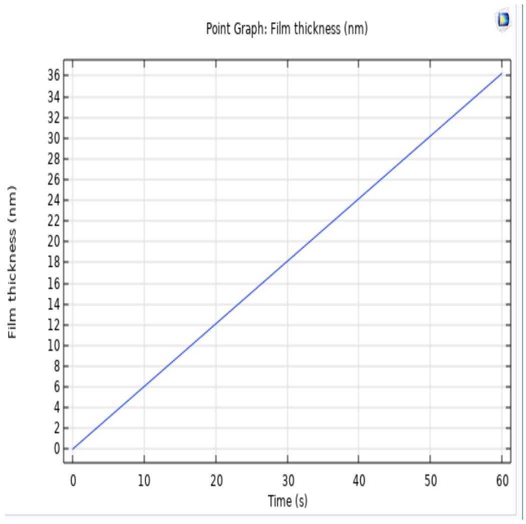

Figure 7. Film thickness vs time at a point on the corner of the sample.

CO2 injections have demonstrated storage efficiency of more than 95% after 100 years. Oil and gas lava volumes of 2,8% and 3,6% correspondingly have made up the entire lava. Public professionals have had to work in the public security and long-overdue permissions of the initial publication that obviously slowed down the project. Safety determinants include: size, local environment, and more. Recommendations included the requirement of more phases for more in-depth analysis. More studies are also needed. The height of the tank is 4 m, the diameter is 15.5 m, and the base plate 15 that covers the storage tank.

It links that project was feasible to implement in the proposed location. Since no previous research has been implemented in that field. Therefore, the need to assess the economic, environmental, and safety perspectives is the objective of this study. The study took into account the accessibility, geology, and public safety requirements to implement the project. The project objectives have been evaluated based on financial revenues, emissions reduction, and public safety. Time zero is taken as an initial year for pertinent computations. Therefore, the investment (in year zero) would be $20 million, and the profit be is achieved at the deletion of the project after 100 years at the account 0 of $90 million.

Carbon capture and storage (CCS) technologies have played a significant role in mitigating climate change by reducing direct CO2 emissions from carbon-based energy systems. In this paper, we have implemented CO2 capture technology from a coal-fired power plant using the HYSYS software within the Abdul Kareem Khalaf storage tank in Southern Iraq with a storage capacity of 20,000 ton CO2 16. Purpose and importance of the study are to invest in techniques that help in reducing the emissions. One major advantage of the abundant availability of natural petroleum traps (depleted gas and oil fields, or deep brine aquifers), or coal seams, facilitates the capture and permanent storage of CO2.

8. Conclusion

The present study aims to predict the performance, size, cost, and optimize carbon capture systems for two coal-fired small furnace systems of two power stations (300 MW) in Anbar and southern Iraq. Since the modeling and simulation of the system require the calculated flue gas flow rate according to the average coal composition, mass, and energy balance, they must be taken into account to determine the basis of calculation to produce the rated power of 300 MW. An ODEs solver model has been proposed to develop MATLAB simulation code. A CO2 capture rate of 85% was obtained using the amine scrubber. It is also found that a flue gas with a high CO2 concentration of 60.5% and with a flow rate of 2279 ton/h will be found at the solutions with an average flow rate of 300 ton/h in enhanced oil recovery. The work also found that the carbon capture system's cost ranges from 4.35 to 5.22 $/MWh. It is thus concluded that the proposed MATLAB simulation model predicts the performance of carbon capture systems.

The flue gas of 60% of the hot gas enters the packed bed absorption column and comes into contact with the amine solution. The solution captures the carbon dioxide. After that, the packed-bed treated gas, which has reduced the volume of CO2 to 90%, is released to the atmosphere and the rich solution flows to the regeneration column. The limit of the flue gas to capture CO2 was reached by 74.25%. Using the carbon capture technology causes a significant increase in both capital and operating costs during various stages. Future research will focus on different aspects of CCs. One of the areas of this research will be increasing the efficiency of power generation and of station CCs. The Iraqi Electricity Ministry has tended to use natural gas in the operation of two types of stations in recent years. The reasons for it are many, but the most important reason is the significant increase in the need for gas by the Ministry of Electricity for generating electricity, to supply the network with energy after the significant deterioration in the silver and non-silver network in the Iraqi provinces since 2003. The amount of Iraqi gas amounts to only 30-35% of the overall need for Iraqi Electricity, which led the electricity ministry to install simple thermocouples and combined gas power stations driven by environmental reasons in the operation of diesel power stations or in the generation of electricity by converting it into a cycle of fuel, since the stations of the four and three fluids of fuel and inefficient to reach their needs in generating electricity using natural gas that has a higher efficiency over the cycle of both of the above-mentioned cycles. The national extraction and import of fuel are scheduled to generate electricity.

8.1 Recommendations for future work

In considering long-term, large-scale carbon capture and storage (CCS) deployment for climate mitigation, one critical issue is to ensure the CO2 plume containment in subsurface storage projects over hundreds to thousands of years. In addition, based on the modeling results obtained by the application of the developed ANN models, it was shown that the injectivity, time until cap rock breakthrough, the storage up to the time of the basal hydrocarbon breakthrough.

Those data can then be used to help energy and industrial facilities to reduce their emissions, or policy makers to steer CO2 tax/credit policy. Authors which address frequent concerns associated with slow CCS deployment are distilled. Future work using SimCCS includes extension to more geographically defined areas (e.g., each of the states in Oman), study the collaboration between oil companies and energy producers/users to determine locations where CO2 can be permanently stored, and/or uncertainty propagation associated with CO2 storage, e.g. injection pressure, storage formation permeability, infectivity, and residual vs structural/stratigraphic trapping. Future work can also include detailed location-based life cycle analysis of each component of the CCS system as part of its optimization. There is also ample opportunity to consider other sources and disposal sites of industrial CO2 emissions in SimCCS.

When incorporating uncertainty in the model, the optimal sequence of CO2 storage and infrastructure build-outs can also be explored as an extension of this work, building upon other modeling efforts that focus on long-term CCS saturation in a specific region 20. Similarly, future work can also consider the incorporation of different CO2 surge-reduction technologies, e.g., unscheduled off-take of the amine absorber, DME pipe feature, re-contactor volume increase, or additional pipe lengths in the model, and subsequent optimization with those extra degrees of freedom.

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