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Artificial Intelligence Based Optimizing Solutions for the Geothermal Power Plants

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ABSTRACT

The geothermal power plant situated at Dholera, Gujarat like every power plant is designed for long term electricity generation. Hence it gets crucial to determine the present production flow rate in order to ascertain the future power demands. While designing the plant, the calculations and estimations are done based on the current future production predictions. These predictions come in handy while designing the surface equipments in order to make the plant cost effective. One of the most prudent problems related to geothermal power plants is inability to accurately estimate the future production rates and hence makes the plant operations inefficient. Artificial intelligence (AI) has the potential to empower the system with intelligent behavior, learning and informed decision making capabilities for the geothermal energy sector. These tools can be used to predict accurate future production prediction as they rely on reliable field data instead of assumptions. A predictive model is designed and the results are correlated with the past data. The results generated by this model are very encouraging. AI can also be developed as an alternative approach to conventional methods to eliminate dealing with uncertainties in the geothermal reservoirs.

1. INTRODUCTION

Geothermal systems mostly can be encountered in volcanic, magmatic or metamorphic areas. Due to high heat and pressure, minerals or geological structures of rock reform without melting into liquid phase. The process occurs around 200°C and the rock starts melting around 850°C in which solid phase emerge to liquid phase. Since geothermal reservoir rocks are massive and conductance of fluid flow is low, fluid transfer will occur through fractures and fissures. For the fluid to flow through a porous media, permeability is the key factor which can be provided along fault, fractures and fissures. Formation of fractures is also dependent on tectonic movements. Geothermal field consists of many faults, fractures by occurring horst and graben structures. Due to the presence of complicated cases such as multiple horst and graben in the reservoir may make imprecise location of the boundaries of the reservoir. Temperature at various zones in the reservoir may vary. While setting up a power plant for a geothermal location, future flow forecasting is very important for determination of the efficiency and power plant capacity. Conventional reservoir models to predict future prediction might be challenge due to various gases present in the field, unknown reservoir boundary, non isothermal fluid, computational time and reliability. To solve these uncertainties it would cost time, money or both.

Instead of using conventional methods for prediction, Artificial Intelligence techniques can provide efficient solutions based on field measurements of the geothermal wells with huge dataset. For conventional technologies that forecast production, decline curve analysis and capacitance/resistance modeling CRM are used, but main problem with these technologies is that they do not make use of a large data. However, Machine Learning ML integrates all available field measurements, such as production and injection history to have comprehensive full-field reservoir modeling using machine learning and pattern recognition methodology (Mohaghegh, 2017).

2. SUMMARY OF PAST AND CURRENT STUDIES

The history of geothermal power plants dates back to the 18th century when the first industrial use began in Italy (Conserve energy, 2020). Over the years technological innovations have revolutionized the energy sector in many ways. The use of emerging technologies in energy sector especially the power plants has brought significant improvements in the security and safety measures, optimizing assets, enhancing business models and human resources. Geothermal power plants can be built on certain locations only with geological hotspots. The emerging technologies like AI, ML and data analytics can help in identifying the potential locations for the geothermal power plants based on the geographic and environmental data collected over a period of time. Machine Learning models have been used in the past to develop suitability maps for the assessment of potential geothermal plant sites (Coro, G., & Trumpy, E. , 2020). Artificial Intelligence techniques also help to cut the associated costs and exploration risks by facilitating automation of various processes.
Artificial Intelligence and Machine Learning can be sub grouped into supervised learning, transfer learning, reinforced learning and unsupervised learning. The supervised learning requires a large set of labeled data. Therefore, performing the supervised learning will be convenient for geothermal fields since various measurements from the fields generate huge volumes of labeled datasets.

3. PROPOSED METHODOLOGY OF IMPLEMENTATION

The proposed work highlights the significance of using emerging technologies like AI, ML and big data analytics in the geothermal power plants to enhance the existing processes and bridging the gaps between the expectations and reality. The study has two aims. First, missing data prediction: the data provided from geothermal field has missing flow rates for some wells. The data values form the

well-head pressure, well-head temperature, flow rates, valve positions and bottom-hole pressures can be used for predicting the missing values. The available parameters can be used as an input for the ML supervised learning algorithms for forecasting the missing flow rates. Second, the field has both production and injection wells, upon completing missing flow rates, future prediction of the flow rates of the production wells will be forecasted. Reinjection surplus geothermal brine ′amount can be operated manually with injection pumps, various injections rates effect will be discussed for future prediction.

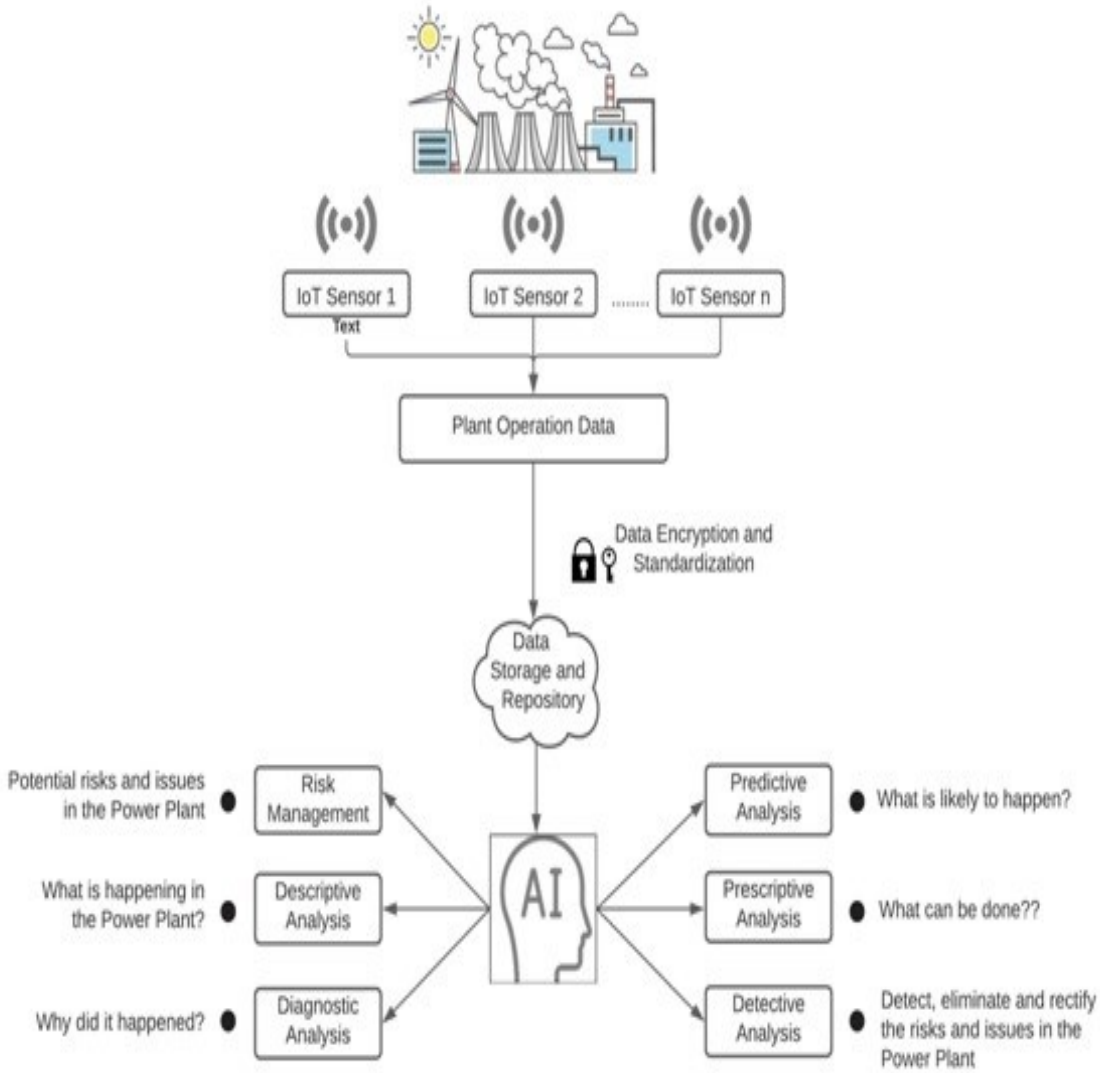

Fig. 1 Basic integration framework of AI, IoT and data analytics with geothermal power plant

Figure 1 presents the basic framework for integrating the emerging technologies like AI, Data analytics, ML and Internet of Things (IoT) for enhancing the various processes in the geothermal power plants.

IoT enabled devices can be deployed at various points for sensing and data collection like the fluid path of the plant, steam water gathering systems, separators, turbines, condensers etc. The Plant operation data collected from the various sources and IoT devices is encrypted and standardized for future use and predictions. The encryption and standardization process ensures the security, privacy and usability of the data for future processes. The encrypted data is then stored in a cloud repository. The data from the cloud repository can be analyzed for the realistic modeling of the plant processes, easy and timely updating, efficient problem solving and continuous improvement using feedback mechanisms.

3.1 Modules of the integration methodology between Artificial Intelligence and Geothermal Power Plant

Different modules could be deployed for an efficient integration between Artificial intelligence and geothermal power plant. The mechanisms of each of these modules are as following:

Risk Management: The data collected from various IoT devices, cameras and sensors can be utilized to detect cracks and other potential defects in plant equipments. Further the AI and ML techniques can be used for predictive maintenance to prevent future emergency situations and reduce dangers.

Descriptive analytics: The analysis of the historical, comprehensive, accurate and live data from multiple sources helps in effective visualization and studying the various processes in the power plant. It also helps in future comparisons to study the rate of energy generation, cost analysis, appropriate pricing and consumption statistics. This further helps to prescribe the best solutions and modes of operation based on the inputs.

Diagnostic Analysis: Techniques like correlations, data mining, data discovery can be used to identify the reasons for the behavioral aspects of various processes and the faults.

Predictive Analytics: Uses causation and correlation for the near past data analysis that helps in predicting future behavior, biases, trends etc. Big data analytics can be used for the predictive diagnostic of anomalies for predicting any inappropriate behavior and processes ahead of time (Figure 2). This helps to lower the rate of problem occurrence on the power plant, reduces the outages, monitor the generation costs and detect potential issues and problems in the functional processes during the normal functioning go the power plant.

Prescriptive Analytics: The data patterns from plant processes can be analyzed to prescribe control measures. The machine learning algorithms helps to automate the decisions and recommendations.

Detective Analysis: The inappropriate values and behavioral patterns in the plant's functioning can be detected, eliminated and rectified.

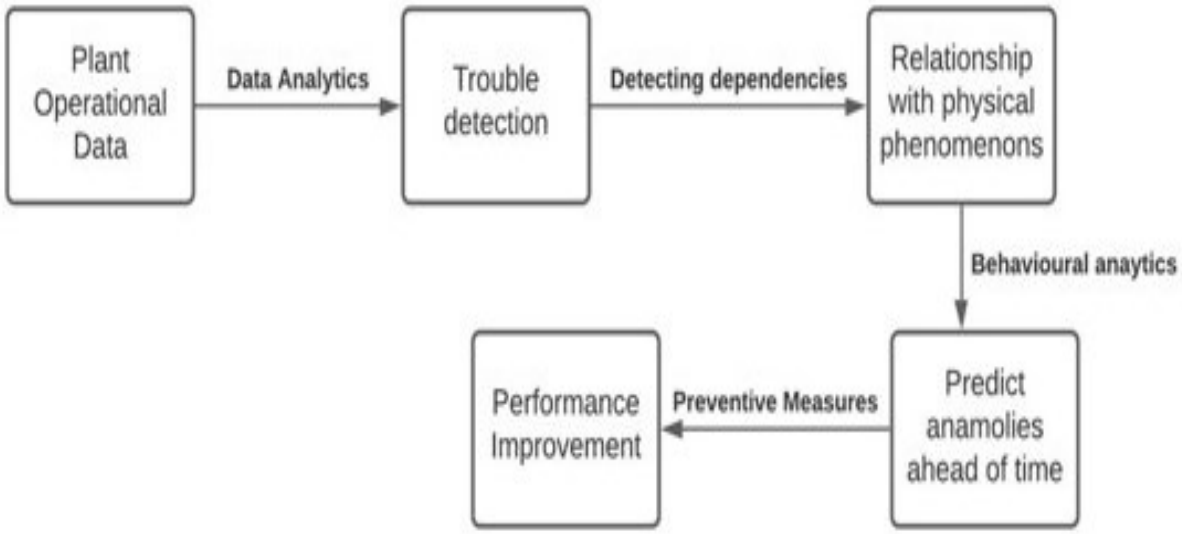

Fig. 2 Predictive anomalies diagnostic in the Geothermal Power Plant Operations

4. CONCLUSION

The advancement and development of the power sector is one of the initial steps for the development of other industries. Hence, there is an urgent need to enhance the efficiency and capacities of the existing processes. The implementation of AI in the existing processes will enhance the efficiency by forecasting scenarios based on flow rates. Conventional reservoir models for future predictions might pose challenges due to various reasons. Existence of condensable and non-condensable gases in the field, sometimes unknown reservoir boundary, non-isothermal fluid flow makes the problem very complicated. There are many uncertainties that can affect the results directly. Machine Learning ML integrates all available field measurements, such as production and injection history to have comprehensive full-field reservoir modeling. The integration of technologies like AI, IoT and ML in the existing geothermal power

plants can help to utilize its full potential. AI can be leveraged to provide solutions at various levels including design, production, promotion and services. The efficient data analytics along with supervised ML techniques can help to forecast the electricity consumption and production. Further, the predictive maintenance helps to optimize the various operations during the peak hours.

REFERENCES

Arthur, G. D., Aremu, A. O., Moyo, M., Stirk, W. A., and van Staden, J. : Growth-promoting effects of a seaweed concentrate at various pH and water hardness conditions, *South African Journal of Science*, **109**(11/12), (2013), 1-6.

Coro, G., and Trumpy, E.: Predicting geographical suitability of geothermal power plants. *Journal of Cleaner Production*, (2020),**121874**.

Rumelhart, D.E., Hinton, G.E. and Williams, R.J.: Learning representations by back-propagating errors Nature, **323**, (1986), 533-536.

Haykin, S.S. : Neural Networks- A Comprehensive Foundation. **Prentice-Hall International**, London, 842, (1994).

Fridleifsson, I.B. : Geothermal; energy for the benefit of the people, *Renewable and Sustainable Energy Reviews*, **5**, Issue 3,(2001),299-312.28.

Lashari, Shan-e-Z: Application of Artificial Intelligence (AI) in Petroleum Engineering Problems, West Virginia University, Master' Thesis. (2018).

Mohaghegh, S.: Data-Driven Reservoir Modeling, Textbook, Society of Petroleum Engineers. (2017).

Philipp, Sonja L. , Gudmundsson, Agust and Oelrich, Asdis R.I.: How structural geology can contribute to make geothermal projects successful. Geoscience Centre, University of Göttingen, Goldschmidtstr. 3, 37077. (2012).

Stauffer, D. and Aharony, A.: Introduction to Percolation Theory. Taylor and Francis, London. (1994).

https://www.conserve-energy-future.com/geothermalenergyhistory.php