Simulating the Performance of Electrical Submersible Pump in Oil Well for Production Optimization Using PROSPER Software

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Abstract: Initially the hydrocarbons are produced by the natural pressure of the reservoir, by the passage of time its pressure starts to deplete and at a certain point it does not cover the economical limit of a producer well. To overcome that depletion artificial lift methods are widely used. To meet the economical limit more than 90% oil wells require artificial lift method. Different ALM are used to suck out the oil from producing well and Electrical Submersible Pump (ESP) is one of the ALM that will be used for increasing the production of an oil well. The decline of Production occur due to mismanagement of wells, improper perforation method and oversized tuning so consequently wells cannot produce expected rates so the company will not meet their economic criteria and may go for the economic losses.

Keywords: *Artificial lift method, Water cut, Production Decline Rate*

1. Introduction:

Artificial lift refers to increase the overall pressure in such an effective manner that it is possible to get certain desired rate, by the injection of a gas, water in the zone of interest. It is also used to reduce the hydrostatic pressure and with different types of pumps at the bottom of the well to provide additional lift pressure in the hole. The basic object of the artificial lift method is to maximize the production rate by adding the energy to the subsurface fluids. The different types of artificial lift methods are used in the later life of field, when the reservoir pressure declines and the productivity falls.

1.1 Electrical Submersible Pump

ESP Is the most reliable efficient method of the artificial lift when moderate to high volumes of hydrocarbons needs to be lifted from the well. Lifting ability of ESP varies from 150 bpd to 1500000 bpd. ESP comprises both surface and down hole equipments. ESP consists of multiple centrifugal pump stages mounted in series within a housing mated to a submersible electric motor. These pumps are connected to a surface controls and electric power by armor protected cables.

Functions of various components:

1.1.1 Sensor

Alteration in the speed of the electric motor is allowed by Frequency drive. By experiments it has been shown that a 60Hz frequency is able to be operated between 35Hz -80Hz. The Frequency losses from some 3% to 5-15% of total power supplied are increased by the frequency drive installation.

1.1.2 Guards for cable

The surface cable and down hole cables are separated by the vent box. Through this it will ensured that any type of gas, which can flow through the cable in the down hole does not reach to switch gear.

1.1.3 Cables

The well head is penetrated by down hole cable which is banded to the tubing at regular intervals. Cable protectors give the additional protection for reducing the damage when the completion is being run into the hole. To lower the width, flat cable shape equipment across the components of completion is used. The cable then enters from electric motor housing on the Pothead and to carry the electrical supply to the motor as well as for measuring of the down hole sensor which is placed under motor.

1.1.4 Pumps

Pumping assembly is usually composed of a stacked series of centrifugal impellers which rotates and running on a central drive shaft inside stack of diffuses which are stationary. The increase in pressure is proportional to the number of stages while the capacity of pump (volume) increases as the diameter of the impeller increases. The number of pump stages (impeller/Diffuser) pairs may range between 10 and 100. Depending on the required pressure increase.

1.1.5 Gas Separator

Pump intake can contain a rotary gas separator if the gas fractions are greater than 20%.I IT consists of a centrifugal instrument, which separated the lower density gaseous phase from the denser liquid phase.

1.1.6 Section of Seal

The seal unit connects the shaft of the motor with pump. It also performs a:

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I. An isolation supporter between the motor oil and the well fluids.
II. When motor oil reaches operating temperature if performs as expansion buffer.
III. It stabilizes the motor pressure with well annular pressure
IV. When any thrust is generated by the pump it absorbs.

1.1.7 Motors

The power is supplied to electric motor by three phases and additional alternating current if required is supplied by the cable connected to the motor at pothead. They are available in different sizes between 15-900 HP to the manufacturers.

2. Problem Statement

Initially the hydrocarbons (Oil and Gas) are produced by the reservoir natural pressure, by the passage of time its pressure starts to deplete and at a certain point it does not cover the economical limit of a producer well. To overcome that depletion artificial lift methods are widely used. Different artificial lift methods are used to extract the oil from producing well and Electrical Submersible Pump (ESP) is one of the artificial methods that will be used to increase the production of an oil well. The decline of production occur due to mismanagement of wells, improper perforation method and oversized tuning so consequently wells cannot produce expected rates so the company will not meet their economic criteria and may go for the economic losses.

3. Objectives

- Designing a new ESP lift System for an oil well.
- Performance analysis and optimization of ESP Method.
- To Study the performance of ESP in Depletion Stage, whenever well produces larger water cut.

4. Methodology

The research methodology of this is to first collect information/data of an oil well of vertical well and the causes of reduction in production. After that by using simulation software, analysis is done for measuring the changing in production rate and for water cut at different intervals.

5. Related Work

Following are some research papers which are based on ESP, water cut and their solutions in different fields around the world. In this research paper author has given the importance of the ESP as an effective Artificial lift method and he concludes that, It is most reliable when moderate to high volumes off hydrocarbons needs to be lifted from the well. Energy administration agency (EIA) reported that world daily consumption of crude oil is about 85.64 million barrels, which is equivalent to 2.0 liters per day per capita **[1].**

Additionally, in this research paper, John Bearden stated that among all artificial lift methods, ESP is the most competent and consistent artificial lift method when moderate to large volumes have to be lifted from the well. And through ESP about 150 barrels per day to 1500000 barrels per day can be produced **[2].** Tracks clarified that 10 % of oil supply is produced through ESP **[3].**

Furthermore, IPM Prosper may be used to analyze or study the optimization of production through ESP. IPM PROSPER is the mostly used software and currently common in practice in the world wide oil and gas industries. Prosper helps in forecasting the production in effective way. It may help the reservoir or production engineer to predict fluids mechanics of tubing and casing and their pressure with high accuracy **[4].** In this research Paper, its defined as the decline of Production occur due to mismanagement of wells, improper perforation method and oversized tuning so consequently wells cannot produce expected rates so the company will not meet their economic criteria and may go for the economic losses **[5].**

In this Paper Author describes about ESP that its the most reliable efficient method of the artificial lift when moderate to high volumes of hydrocarbons needs to be lifted from the well. Lifting ability of ESP varies from 150 bpd to 1500000 bpd **[6].** Arifano Sassim in his paper stated that 60% of the global crude oil production is supported by ESP **[7].** In this paper author describes that ESP is a multi staged centrifugal pump, each consists of a diffuser and impeller. As impeller start Rotate, it not only creates a rotating motion to the pump liquid but also implies tangential force to the outer diameter of impeller. Consequently this motion will creates centrifugal force that will cause the liquids to flow in a radial direction **[8].**

In this paper Murat Kece Stated that, "Water cut is the main cause for the decline of production, which are produced without artificial lift so ESP may be the part of long term production maintainability solutions in the fields which produces higher water cut in depletion states" **[9].**

In this paper author describes that in order to increase the hydrocarbon production and maintain the field target flow rates, optimization of production and revisiting of artificial lift selection that proves to be cost effective solution **[10].**

In this paper Monte Verde suggested that ESP must be installed at the depth where the pressure must be higher than the bubble point pressure so that gas liquid mixture cannot be produced because gas phase has adverse effect and causes high deteriation in the performance of ESP. It can be also used in Offshore for heavy oil production **[11].**

In this paper Methew Amao suggested that in order to get required results from ESP, Following parameters which are mentioned in chart must be considered in designing of ESP **[12]**. In research paper according to author Golan & Witson, VLP tells us about how much effectively the well bore can deliver up to the surface. The VLP depends upon the fluid properties, True Vertical Depth, Casing dimensions, Pressure, Water cut and Gas oil Ratio **[13].**

Case 1: Modeling of Well, Produces with Natural Potential.

In the first case, well is produced through natural energy i-e without any artificial lift method at the assumed zero water cut. After putting all the required parameters and calculating the IPR curve was generated on a graph.IPR is also called back pressure curves. The basic tool for diagnosing the reservoir pressure is IPR. Usually Vogel, Standing, Darcey, correlations are used. But here, the Darcey correlation is used.

Case2: Modeling of well with ALM (ESP)

Now at initial stage i.e. at the zero water cut, the ESP is installed in well. Nodal or system analysis is to be done to know the optimization in production. Graph was generated with ESP at Zero water cut.

Case3: The Modeling of Well at Different Water Cuts.

There are 4 parts of this objective:

I. Comparison of oil production with and without ESP at 50 % water cut.

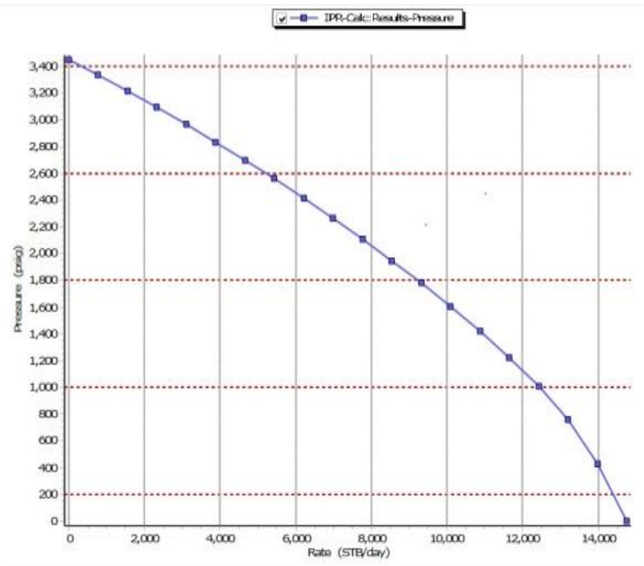
II. Comparison of oil production with and without ESP at 60 % water cut.

III. Comparison of oil production with and without ESP at 70 % water cut.

IV. Comparison of oil production with and without ESP at 80 % water cut.

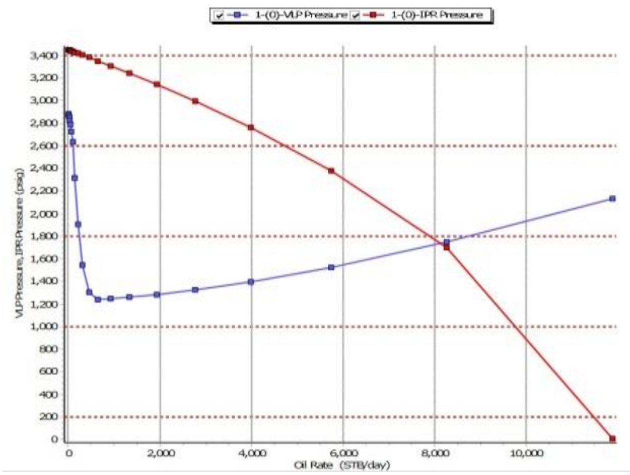
6. Results

Case 1:With Natural Reservoir Pressure



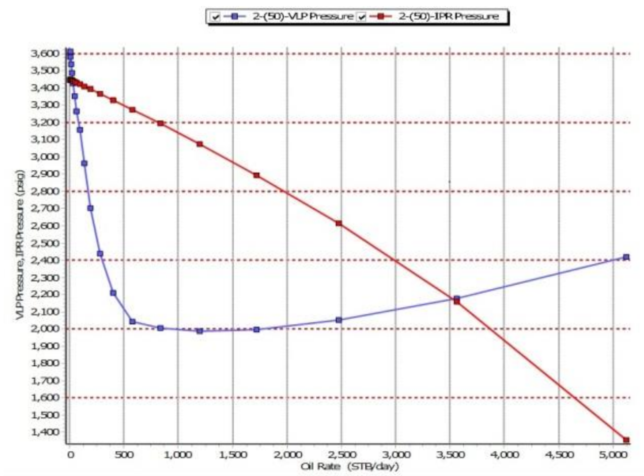
This graphs shows trend decline in the reservoir production. As first reservoir pressure is 3450 psig, but with passage of time the reservoir pressure is slowly and linearly declines. The above IPR pressure shows that when the well is produced at the large rates near about 15000 barrels per day (BPD), the corresponding pressure or potential of reservoir will be zero.

Case 2: With Artificial lift method using ESP



The intersection point between IPR and VLP i.e. Operating point simply shows that the expected rate is about 8250.35 STB/d and VLP pressure is about 174796 psig at which well will produce. If two cases are compared then it will be clear that with the installation of ESP, the production has been optimized. Without ESP, well produces 7475.95 STBD and VLP pressure are high enough about 1900.25psug but when ESP is installed then head is decreased and reached at 1740.96 and corresponding rate is about 8250.35 STBD. Hence, with the installation of ESP at initial stage, Production has been optimized.

Case3: At different water cut 50% ,60%,70%,80% with & without ESP.

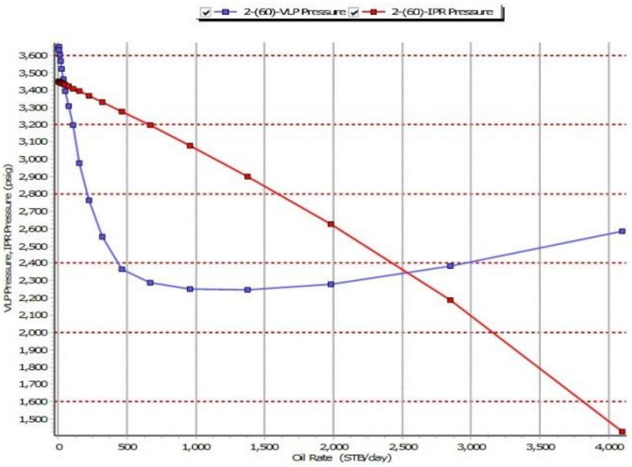


As the water cut is 50%, which is quite high percentage so it is obvious that this water cut will highly effect on oil rate. The operating point is about 3040.75 STB/day & corresponding flowing wellbore or VLP is about 2350.25 Psig.

Now at the same water cut i.e. 50% the ESP is installed in well bore. The operating point at graph depicts the rate of 3555.13 STB/day and pressure of 2175 psig. As without ESP flows rates and pressure were 3050.75 STB/day and 2350.25 respectively. If both results are compared then it will be clear that ESP give optimum results at water cut.

Now with and without ESP at 60% water cut models are to be generated to analyze the effect of ESP on Production rates 60% water cut. The oil rate at operating point is about 2070.67 STB/day and the corresponding VLP pressure is about 2550.5 psig. Now, the ESP is installed at 60% water cut.

In this graph the operating point is 2540.15 STB/day and corresponding VLP pressure is about 2340.3psi, so well will produce at this rate VLP pressure.



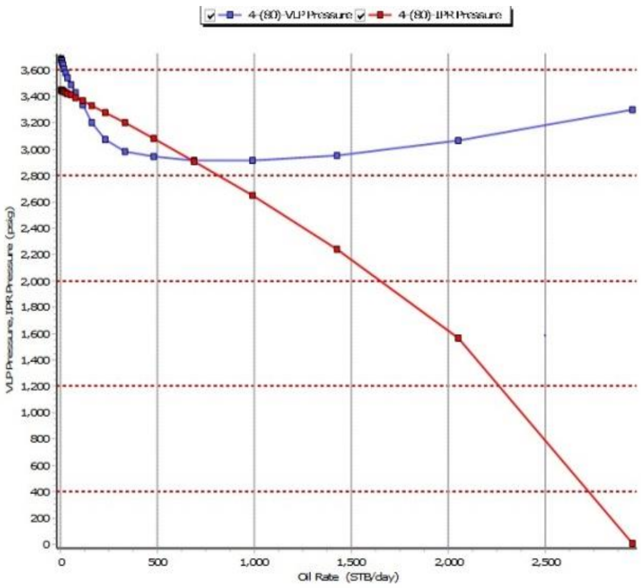
As Without ESP, the flow rates and following pressure were 20700.67 STBD and 2540.5psig respectively. IF both result i.e. with and without ESP at 60% water cuts are compared then it will be cleared that ESP give the optimum results at given water cut.

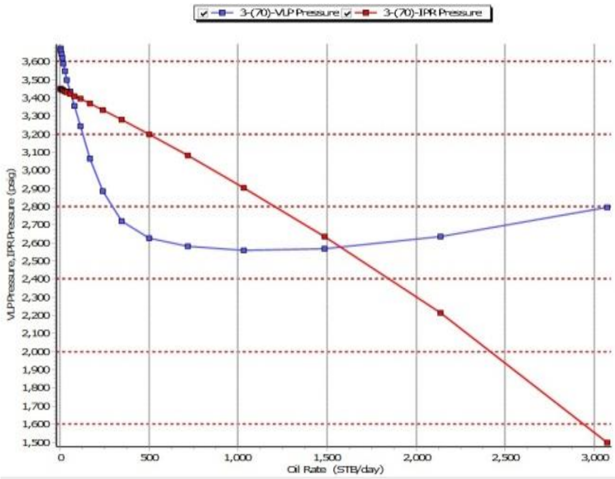
Now the well is modeled with ESP at the same water cut of 70%, so the following graph shows the nodal analysis wit EST at 70% water cut

Operating points in this graph simply shows the expected rate and VLp Pressure at which well will produce are about 1600.06 STB/day and 2625.25 psig respectively.

Comparison of oil production With & Without ESP at 80 % Water Cut.

Sometimes the water cut is severely increased and reached up to 80%, which adversely affect on oil production. The following graph depicts the oil production at 80% with ESP

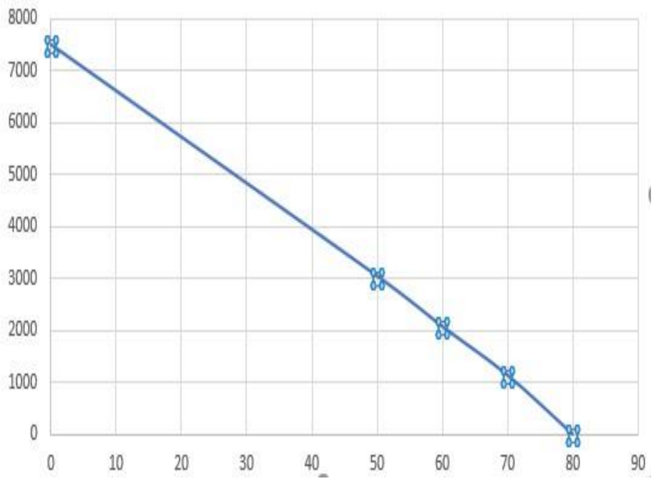




The operating point in above graph depicts the expected flow rates and pressures, at which well will be produced. It shows that well will be produced at the rate about 650.25 STB/day and the pressure of 2880.25 psig. About results at 80 % water cut clearly shows that how effective ESP is working in extremely high water cut wells.

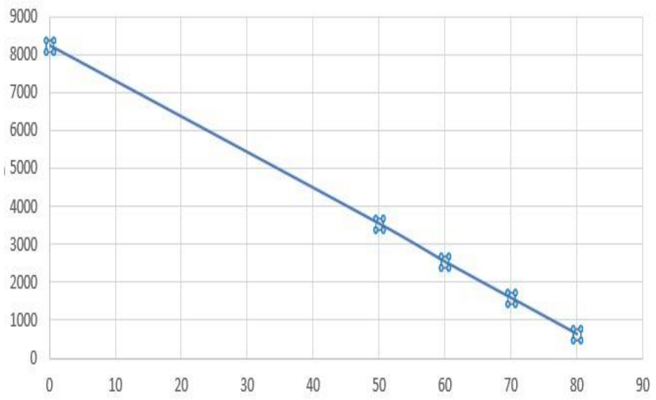
Sensitivity plot

As this thesis is done on initial stage of the life of well i.e. zero water cut and in depletion stage that is at the water cut of 50%, 60%, 70% 805 with and without ESP. So, following graph shows the effect of water production on oil without ESP.



(Sensitivity Plot without ESP)

At the initial condition, the water cut is assumed to be zero so accordingly to above sensitivity plot, at the zero water cut the oil production rate is about 8250.35 STB/day. By the time, the water starts to produce hence percentage of water is increased and oil rate declines. When water cut reaches at 50% water cut, the production rate declines and reaches at the value of 3555.13 STB/day. As the time passes the more increment water cut is observed so when it reaches 60% the more production declines and stands at the value of 2550.5 STB/day. If control measures are not taken at 70% water cut it’s about 1600.06STB/Day. While at severe water cut of 80%, the oil rate is about 650STB/day.



(Sensitivity Plot with ESP)

Whenever the values of above two sensitivity plots were compared with each other than it was clear that the production of oil without ESP was highly effected with increasing water cuts. While in case of ESP, the oil production is optimized in higher water cuts. Hence, it is proved that ESP can perform efficiently and produce commercial rates in larger water cuts.

7. Conclusion

The following results have been obtained through using IPM Prosper.

1. The first objective of this thesis was to study make the ESP model and study the optimization in the production. For this, it was further classified into four more parts with and without ESP at different water cuts.

- ❖ First model was generated through PROSPER without the use of ESP, the operating point in that graph suggests that the expected rates and pressure at which well will produce are 7485.9 STB/day and 1876.25 Psig respectively.
- ❖ While if ESP was enabled through PROSPER, the oil rate production was optimized upto 8250.35 STB/day and flowing well bore pressure was reduced to 1747.96psig. Hence, it is clear that, at initial stage, ESP has optimized the oil production and gives 764 STB/day additional oil production.

2. Second objective of this thesis was to study the performance of ESP at different water cuts that are 50%, 60%, 70% and 80%.

- ❖ At 50% water cut, first model was generated without ESP at 50% water cut. This model at 50% water cut shows that the expected rate and flowing pressure at which well will produce ware 304075 STB/day and 2350.25 psig respectively. While ESP at the same water cut has taken and it gives the production 3555.13 STB/day and 2175 Psig. Hence it is clear that ESP has optimized the production and added more production of 514 STB/day.
- ❖ At 60% water cut, without ESP the expected rate and flowing pressure were 2070.67 STB/day and 2540.5 Psig respectively. While with ESP at the same water cut the expected rates were 2550.5 STB/day and 2340.3 psig, hence it is clear that ESP gives additional production of 480 STB/day.
- ❖ At 70% water cut, the model without ESP depicts that the expected rate and flowing pressure at which will flow is 1135.56 STB/day and 2872.2 psig. While with ESP, the expected rate an pressure were 1600.06 STB/day ad 2625.25 psig respectively. In this case, ESP produces extra 465 STB/day hence it optimize the production at 70% water cut.
- ❖ In the last 80% water cut was taken. The model without ESP shows that 80% water cut has severely affected the oil production and caused seizing of production. While when ESP was used at the same water cut the production was optimized up to 650STB/day at the flowing pressure of 2880.25psig.

8. References:

[1] Alemi and Undheim, The comparative study for an oil production rate by employing ESP and Gas lift.156435-MS-SPE

[2] W.M Monte Verde, state university of campinas; J. Biazussui, A.Banwart, state university of campinas; N.Arrifano Sassm, Cetetro, V.Estevam, PETROBRAS. Gas and viscous Effects on The ESPs Performance. SPE 165072.

[3] Stanghelli Basset, Lonie. Norway 2010, Case history using ESP. 133464-MS-SPE

[4] Murat Kece, "Study on the effect of water cut on production in depletion stage" 14567-MS-SPE"

[5] Arifano and Sassim." Comparative study of performance of sucker rod pump and ESP in AIbel American Petroleum Company:. 14563-MS-SPE"

[6] John Bearden, "Electrical Submersible Pump manual: design, Operations, Maintenance", Published ny Elsevier Inc., May 2009

[7] IPM prosper manual v.10 User Manual, Petroleum Experts.2008

[8] Brown,K. "The Technology of Artificial Lift Methods," Vol.2b Penn Well Books,Tulsa,Okalahoma,1980

[9] A.Suat Bagci, SPE, Murat Kece, SPE, and Jocsiris Nava, SPE, Eclipse Petroleum Technology Ltd. Paper SPE 131758

[10] Methew Amao, Clegg, J.D, Bucaram, S.M and Hein, N. M. Jan 2009. "Recommendations and comparisons for selecting artificial lift methods" JPT, Papers SPe-112867-MS

[11] Mazen H.Modhai, Dalhousie University Halifax, Nova Scotia July 2012. The Importance of ESP in Maximizing oil Recovery.

[12] Hake Nice. Sweden 2011. The Comparative Study for an Oil Production Rate by employing ESP and Gas Lift. 15643-MS-SPE.

[13] Al-Bakir, Husain, UAE, 2015. ESP Design Factors and optimization of oil production. 134563-MS-SPE.

[14] Danial Cooper, Risa Rutteret, al (2017). This paper illustrates fiber optics measurement of temperature and

vibration using FBG methodology has been demonstrated to be currently feasible.

[15] Ashwin Chandran, Yi liu Et, al (2017) ,This Paper describes the development and preliminary testing of a new down hole corrosion sensor to be integrated into ESPs for providing continuous monitoring.

[16] Moradeyo Adesanwo, Oladele Bello et, al (2017) In this paper ESP points were set and implemented on smart alarming system, which focus on big data platform and alarm processing.

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