A Domain Specific Modelling for Monitoring Operations in a Digital Oil Field

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Abstract

The focus of this paper is about how data can be gathered in a typical oil and gas smart field and related experts in the oil and gas industry whose primary line of business is tied to the field of pipeline mechanisms. The software is domain specific i.e. specific to Smart Field Oil and Gas Flow Station Operations. The software is a language similar to any programming language where in this case code generation and optimization and crude syntactic bottlenecks will not be necessary rather, interpretation through a parser (Translation Engine) will enable any stakeholder in the domain to easily manipulate data in the Smart Field without being encumbered with high technology acquisition to get a desired job done on the Smart Field.). The functional components will be interacting with the smart field specifications for operation and control through user input. The key performance indicators are always visible to get the information of the course of operations. The information can be viewed on a number of large screens, with interactive multi-touch desktops and portable devices. The entire value chain from the reservoir to the customer is represented and tracked in real time. The monitoring of the development is an observation system designed to achieve a continuous operation and to get the maximum performance of the subsea production center. The system is to help in monitoring & controlling numerous parameters: temperature, Pressure, Voltage, current and others. A graphical logical structure is suited to enable stakeholder do inputs for relevant data gathering via the architecture with the functioning paths.

Keywords: Pipeline Engineering, Domain-Specific Modelling (DSM), Smart Field, Integrated Data Gathering.

1. Introduction

Domain concept descriptions characterize the important aspects of processes from which models can be derived. One purpose of a model is to reflect the control-flow of the design process without incorporating nonessential properties. The objective of modelling is to extract the meaningful properties of the design scenarios and reproduce its behaviour in a metamodel [2]. In order to effectively check the digital operations of a typical smart field, a formal notation (i.e., language) is required to specify the model. This language description in this context is a domain specific language with the attendant properties capable of gathering the intended integrated data [7]. As shown in figure 1, the DSL formalism is housing the real time operations center as the

Programmable Logic Controller (PLC). The Real-time Operations Center (RTOC), which comprises the programmable components, the power supply, the memory and the modules into a central processing unit, is the place where well planning, real-time monitoring, well delivery, and a wide variety of operations execution workflows are performed [21]. The Real-time Operations Center is the catalyst in creating an environment where the key players can communicate in a collaborative environment with the proper technologies at critical moments to take decisions. Real Time" namely is the ability to gather the right data at the right time for the right person, team, or, to some extent, for a Real Time Operation Center ("RTOC"). The goal is to help ensure that any qualified person can access any data, any technology, any asset, anywhere, anytime with the proper expertise needed to do a job. With the advent of widespread real-time technologies and the drastic cost reductions the majority of international oil companies (IOCs) and national oil companies (NOCs) are learning to use this type of technologies in order to take advantage of the global expertise [6].

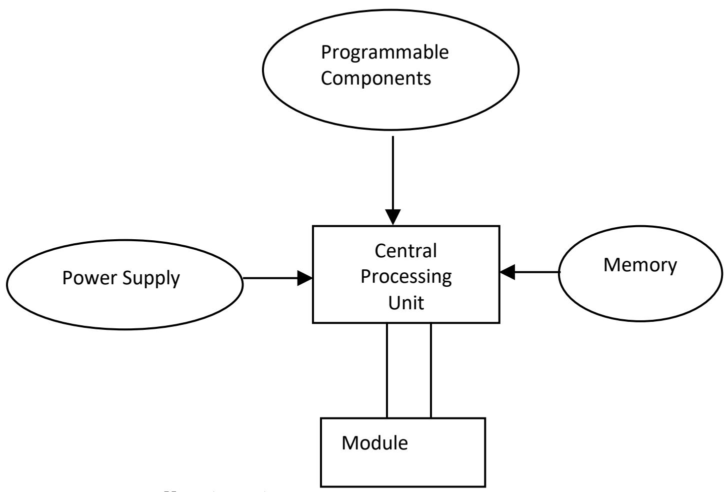


Figure 1 Programmable Logic Controller (PLC)

The key objectives of Real Time Operation Centers (RTOCs) are: reducing non-productive time (NPT); personnel discharging (POB), reducing risks and uncertainties; improving the decision making; and increasing the performance. Real Time Operation Centers (RTOCs) functions are: well planning: 24/7 monitoring; drilling optimization; continuous accompanying of drilling; monitoring reservoir parameters of flow intensification monitoring; cement flow monitoring; data management; real time IT support [6]. There are three main models of Real Time Operation Centers (RTOCs): 1 - RTOC is an integral part of the oil and Gas Company, 2-RTOC is included in the infrastructure of the operating oil and Gas Company, but it is controlled by the contractor, and 3 - the remote RTOC which is included in the infrastructure of the contractor. The three above-described operational centres in real time (RTOC) provide a more efficient operation and allow you to control several exploration teams at the same time. The RTOCs create an environment of cooperation, in which experts from a variety of multiple disciplines cross thus providing the rapid mastering and the development of production skills both for the new employees and the young professionals, and therefore, creating an intangible value to the company [20]. The RTOCs help the asset teams of the company share the gained experience in using the technologies in real time for the planning and the development new fields and wells.

2. Related Work

As a result the fields are controlled from the remote control centers; sensors for monitoring in real time are installed in the wells, the equipment and in the pipelines; the system for remote control and production optimization was created; a new concept of exploitation and maintenance was developed [11]. A smart Field is a complex of new digital technologies for the control and management of hydrocarbon production facilities. This complex includes the multiple fiber optic sensors that can withstand high pressure and temperature, which are placed in the well and are connected with a single control center. The main objectives of the control centers are: production monitoring in real time; integrated interaction in production operations; adaptation of development history; optimization of operation control system. The main part of the information on oil reservoirs comes from the seismology, geophysics, geology and development [1]. The data processing, the interpretation of the results, the modeling of the development processes and the storage of the mass of constantly updated information require the high-performance computer systems that can load, process and unload mega volumes of geological field data in real time. To monitor and to analyze the parameters of the well in real time different systems are used. The virtual analyzers acting as the conventional measuring devices can be used instead of them or in conjunction with them. As the immeasurable parameter often characterizes the performance of the entire automation system and wider the process facility in general and may be included in the objective function of optimization or restriction (e.g., quality of the output product, the dew point temperature, etc.) the virtual analyzers are a basis of construction of the optimization system. Technical and economic optimization is usually calculated for the whole unit (for example, distillation, catalytic cracking, etc.) and is implemented as a larger unit that controls a set of multiply regulators [7]. The control through the system is used to solve the problems of two classes: high quality stabilization process based on the minimization of the integral criterion of the quality of the transition process and the optimization of the process as the higher-level tasks. The field preparation is to extract moisture and mechanical impurities from the formation gas and to ensure the dew point temperature of 20 ^oC in summer and -10 ^oC in winter, according to the requirements [10]. Duration of operation of the deposits, the main sources is a very significant period. Over such a period there was a significant drop in reservoir pressure, which led to the need to transfer the field to the compressor stage of development. Due to the significant increase of the gas temperature after the compressor station the conditions of glycol dehydration are deteriorating and it becomes more problematic to achieve the required quality factors of the gas dehydration determined by the dew point temperature.

3. Smart Operations Architecture

3.1 Performance Indicators

The key performance indicators are always visible to get the information of the course of operations. The information can be viewed on a number of large screens, with interactive multi-touch desktops and portable devices. The entire value chain from the reservoir to the customer [1] is represented and tracked in real time. The monitoring of the development is an observation system designed to achieve a continuous operation and to get the maximum performance of the subsea production center. System to help in monitoring & controlling numerous parameters: temp, Pressure, Voltage, current [9]. A graphical logical structure is suited to enable stakeholder do inputs for relevant data gathering via the architecture with the functioning paths as shown in figure 2.

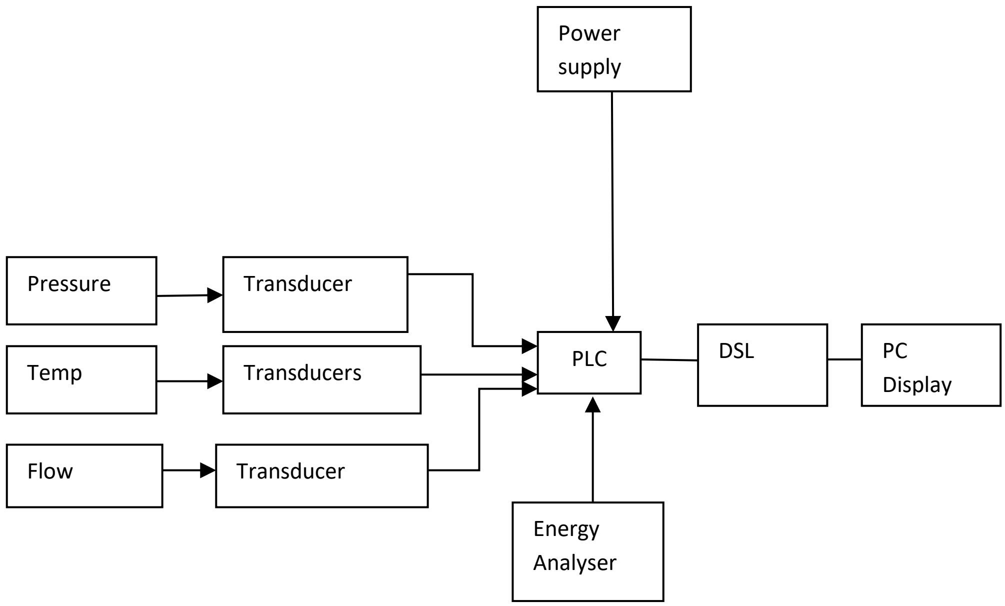
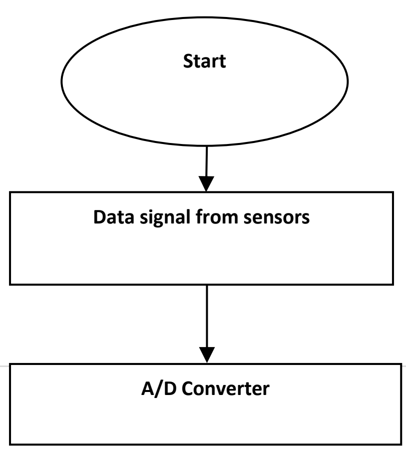


Figure 2 Data Acquisition System Architecture

The data acquisition system is an electronic computer based multi-tasking Well-Test management system. It acquires and processes data (Crude oil flow rate, Oil Specific gravity, Water flow rate, Gas flow rate, Operating pressures, Operating temperatures, Liquid retention time) in real time through a large number of sensors located around the process equipment.

The data is displayed on a monitor which can simultaneously display up to eight(8) trends or more depending on configuration in real time or historic data. All values can be displayed in a real time mimic of the plant. Historic data can be retrospectively re-activated while simultaneously continuing with real time data acquisition. The system also incorporates a complete visual and audible alarm system which can be incorporated to alert the operator of potentially hazardous parameter levels or trends.



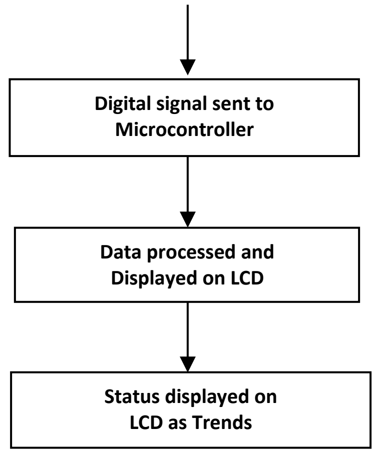


Figure 2.1: Flow Chart of Data Acquisition System

The availability of reliable information on the production process and the underwater complex and also the continuous updating of this information is critical to making the right decisions at the right time [19]. The monitoring of the development allows to receive the information on the status of the sensors and equipment (checking the basic functioning of the sensors and testing the reserve devices); to ensure the collaboration with subsea control module (communication, distribution of hydraulic and power generation and analysis of hydraulic and electrical parameters); to detect and to prevent the leaks of hydrocarbons; to monitor the subsea equipment (compressors, multiphase pumps, separators, coolers); to monitor the state (the integrity of the system, deposits of sand, erosion); to create a database (history of the data, event log, and documentary support) [5]. The systems of early prevention of potential failures offer the opportunities to improve the efficiency of the use of the equipment, the impact of the planned maintenance. The support control center of subsea field development is made up with the specialists on fluid extraction technology, cybernetics, hydrodynamics and providing a continuous production.

3.2 Adding the Monitoring Components

When the modelling system is launched, the user is presented with a user friendly dialog sub system. The user needs to add the data gathering attributes components to begin a data gathering session by clicking on the flow monitoring concrete syntax [12]. Thereafter, the guided notations for the pipeline flow components will be displayed for the input parameters, giving the user the freedom to input pipeline components attributes and the corresponding values for view and loading. After adding the attributes and values on the destination boxes, the user has to build on each component by clicking on the appropriate build button [2]. The system will then load from the data model into the view logic for the necessary modelling actions to be taken. After these operations the pipeline engineer often referred to as the stakeholder can now run the system by obeying simple prompts to come up with a system curve that pertains to the design scenario adopted by the engineer to solving that particular pipeline modelling intents [3].

3.2 Relationships and Attributes

The modelling system was designed to gather oil and gas pipeline data that is an input from domain experts and stakeholders to a domain module [18]. The domain model contains value relationships and attributes of the oil and gas flow attributes from the smart field to ascertain steady operational parameters measurements; validation of values and model transformation takes place at this point being synchronized with the data model and then loaded for processing. When the user click on the add values and attributes for modelling action in different successions; and then the first one will close and a multiple interface is displayed. Either the attributes or values can be input into the corresponding boxes [7] with the defined parameters such as inner dimensions, outer dimension, length, slope etc. Each component can now be built with the captured data through the build functions in the appropriate buttons; this is completed for all the chosen components for particular design scenario and intent [15]. Typically, if new design intent has been specified, the system allows the user to load new attributes and values, corresponding to the selected component types. Figure 3 displays the attributes and values for the fluid production monitor, depicting different monitoring scenarios according to the particular view point of a stake holder in solving that particular data to be monitored and gathered [16]. The fluid monitor is responsible for keeping track of fluid production levels. It monitors how much crude oil, natural gas and water is being produced by a certain well at every point in time. It also gives an alert if the water production level is too high or crude oil production level is too low, it then tells you which well has the shortage so that you can know what to do.

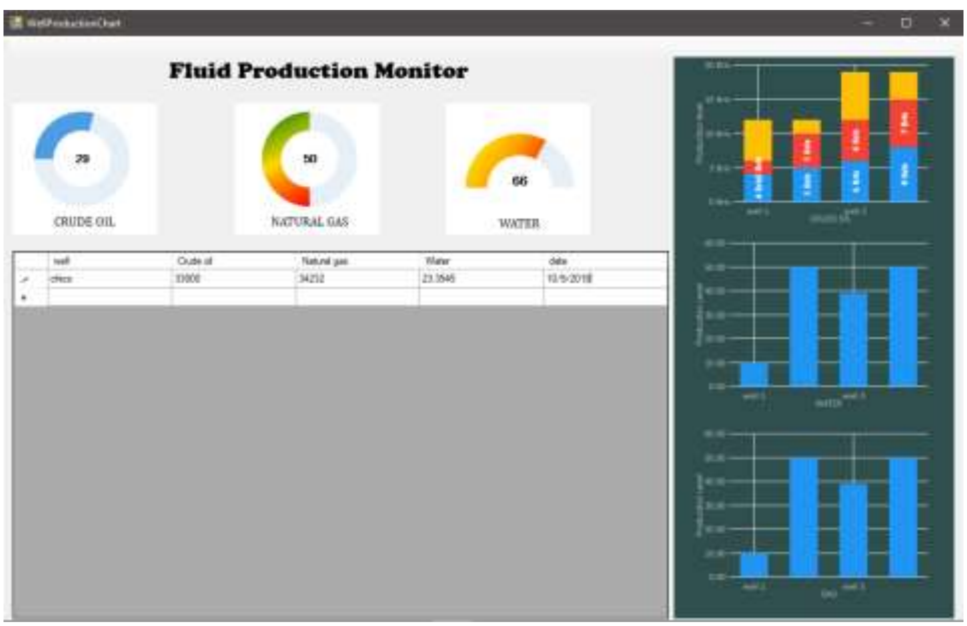


Figure 3 Fluid Monitor

The modern information systems allow you to get information in a convenient form from the operator the necessary data from the wells, gathering station, storage tanks, primary oil treatment plants, the booster group pumping stations in real time. The material basis for the collection of the information is provided by the modern controllers and database management systems that allow you to store and process data in real time, and from the relational databases. As part of the monitoring functions of production processes and the dispatch management in modern information systems, including the following tasks are solved [1]. The user gets the basic values of the monitored parameters (flow rate, pressure, temperature, etc.) of the wells, group metering stations, processing plants of surface facilities, storage and delivery of products, etc. in real time. In this case, the visualization of bottlenecks is carried out: the screen provides the current values in comparison with their established limits in controlled processes. The data of well operation are processed and issued upon the request in the format required [13]. The user is supplied with the rich information by the opportunities the report generator allows to design reports in a standard format in different directions: changeable and daily production reports, reports on the production and delivery of hydrocarbon, injector volumes, status of wells, etc. The monitoring and the reports on the events, the data of which come from the distributed control system (DCS) and the sensor systems and security are carried out. The sequence of events that triggered the alarm are recorded and analyzed. A continuously verification of the safety valves on the potentially dangerous areas of gathering and initial treatment of oil and gas is executed and on its basis this [16] generates reports of any changes in their conditions are made up [12]. The monitoring and the analysis of all the equipment shut-downs directed out fixing all the reasons for shut-downs, the shut offs on the basis of restoration in the history of the process of all the actions that led to a shutoffs is conducted as highlighted in the process.

4. Tracking the Parameters

4.1 Functions of the Process Control

The function of the well monitor as shown in figure 4 is to keep track of the wells temperature, pressure and flow rate. If the temperature of a certain well is getting too high the system gives off an alarm notifying the user that a well is getting too hot, which can in turn prevent the well from shutting down. It also tells you which well is currently running and which one has been shut down [14].

Figure 4 Well Monitor

The well monitor is tailored to the functions of the advanced process control, which are a set of software and algorithmic tools for centralized management and the technical-economic optimization of complex systems. The advanced control includes three main concepts: Multi-coupling regulation, based on the model predictive control (MPC - Model Predictive Control). Virtual analyzers (inferential measurements) -empirical - neural network or regression - models that reflect the relationship of the immeasurable parameter and the indirect factor [15]. Technical and economic optimization in real time. Multi-coupling control unit (for example, a column with a coupled heat exchanger, process furnace, etc.) can be realized with a single multiply controller regulating the, PID control knobs that represent the basic automation system, or directly the actuators.

4.2 Reference Analysis

The amount of gas passing through the evaporation also affects the quality of gas treatment. When reducing the flow through the device (at a constant contact pressure) the linear gas velocity through the device decreases and consequently the velocity factor, which reducing the intensity of the mass transfer the coefficient of the testability of the nozzle and the deterioration of the dew point temperature [18]. Since the deposits of the field has long entered a stage of declining production and is characterized by high water invasion, the engineers, from the 25 C are still trying to find solutions for the effective modernization of the field gas treatment in order to adapt to the changed (and continues to change) field conditions. In reference analysis is given to the modernization of field options, all of them being associated with significant capital costs because they assume new construction and / or reconstruction of old facilities. Consequently, it is possible to implement the individual control based on the Programmable Logic Controller (PLC) system [20]. With regard to the use of such systems, the increased complexity of their operation is often compared with the processes of refining and petrochemicals, as well as by a large number of similar systems, therefore, even the introduction of this our tool, which is developed for specific facilities, is based on the technology of two-stage dehydration. As mentioned above, after the first stage the gas is considerably heated, which reduces the absorption efficiency of gas dehydration. In order to cool the gas after the first stage the air coolers (AC) are used. Since the gas at this stage of the preparation contains a fairly large amount of water, and a bank of tubes that pass through the air cooler cools unevenly because of the design features in the winter time the dehydration is probable. To combat it, the following method is used: the saturated DEG (PDEG) from absorbers with a mass concentration of about ~ 95% is injected into the pipeline after the separation process. The separating filters separate the treated NDEG (ONDEG), which [21] delivered for the regeneration. In this case the dehydration of gas flow with a minimum efficiency of 0.5 theoretical plates, allows to reach the hydrate less nature of AC. Thus, the application of this process scheme solves the problem of lowering the temperature of the gas contact - DEG through deeper gas cooling in the air coolers apparatus of the first stage (as partially dehydration gas) [19]. This can be achieved through the following approaches: 1. Implementing Virtual analyzers which data will serve as a basis for constructing multiply regulators and the optimization process, and will allow the operator to judge the flow process in real time. They have the following disadvantages [10]: a significant duration of one measurement cycle of about 10-15 minutes, a fast drift of readings which requires a constant maintenance of the device, the complexity of such services. The virtual analyzers of dew point temperature enable to improve the efficiency of data collection and to provide the necessary for the APC systems collection frequency measurements. Moreover, their readings can be reflect the drift of real measuring device reading. 2. The implementation of a multiply regulator gas dehydration plant for the purpose of stabilizing the absorption dehydration process, characterized by a multi connected, complex dynamics of flow, considerable inertia and fluctuations in raw material input flow rate and composition [9].

4.3 Storage Accuracy

This functions of the controller can also be controlling the angle of attack of the blades of the air coolers for the uniform cooling of the bank of tubes at the entrance to the dehydrate shop [8]. To implement this punition the measurement results of the dew point temperature should be delivered to the regulator entrance after the first dehydration stage. They can be prepared with the corresponding virtual analyzer. 3. The implementation of a multi-connected array controller of separation. There is a problem of generating plug flow in gas gathering systems which leads to a drastic removal of large amounts of fluid in parallel separators separation unit that cannot cope with this problem. 4. The implementation of a multiple regulator of the plugging control [4].

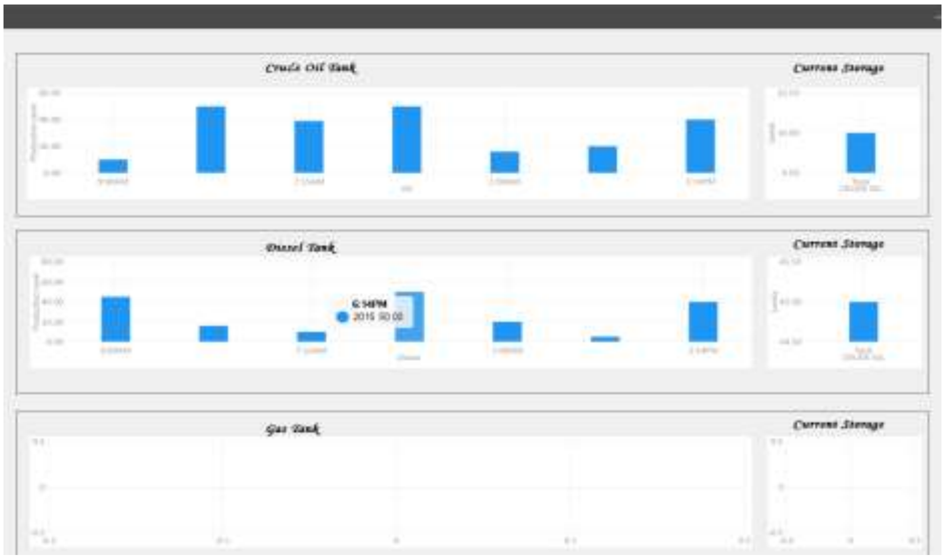


Figure 5 Tank/Storage Monitor

This system enables to conduct the flow in the pipe in the desired mode and to avoid plugging. The function of the tank monitor as shown in figure 5 is to give you accurate reading of the fluid storage tank levels at every point in time. Since the fluids collected from the wells are being sent for storage, it is important to know what quantity of fluid are available at every point in time. If the tank is full the system ought to let the user know. The equipment monitoring section generally will give the status of the equipment's used at the oilfield. If a certain part of the well is getting bad the system should alert the user in order to prevent further damage [5].

5 Conclusions and Future Work

Smart oil field applications capture the behavior of the oil field on the pc, the trend in this research is a data gathering system of the oil and gas companies' assets throughout the assets' outline lifecycles, which includes visualization of field data, and analysis at all levels real time. The software is domain specific i.e. specific to Smart Field Oil and Gas Flow Station Operations. The software is a language similar to any programming language where in this case code generation and optimization and crude syntactic bottlenecks will not be necessary rather, interpretation through a parser (Translation Engine) will enable any stakeholder in the domain to easily manipulate data in the Smart Field without being encumbered with high technology acquisition to get a desired job done on the Smart Field.). The functional components will be interacting with the smart field specifications for operation and control through user input. Further work is detailed to incorporate industry recommendations with a principal business interest in the oil and gas industry. The focus of this research is about how data can be gathered in a typical oil and gas smart field and related experts in the oil and gas industry whose primary line of business is tied to the field of pipeline mechanisms.

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