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Distributed Real-time Computing and Application of Chemical Pipeline Network Based on Hadoop

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The author carries out a study on distributed real-time computing and application of chemical pipeline network based on Hadoop. Firstly, the initial value setting is done by setting the linearized initial value. Secondly, the distributed computing framework Hadoop is used to perform the pipeline network graph theory computing. Then the distributed pipeline network based on B/S is used to build the distributed simulation platform of chemical pipeline network. The result of the simulation can be calculated in unit time. The pipeline network running on this system can achieve the purpose of being real-time and stable and is worthy of promotion and application.

1. Introduction

At present, the computing model shows a trend of complexity with the development of the chemical industry. In general, different pipeline networks are responsible for the connection of various equipments on site to build a large-scale chemical pipeline network. According to domestic and foreign literatures, the time-delay simulation model is widely used in the design of fluid pipeline networks. Under normal circumstances, the training of workers can rely on the complex system model of the chemical industry, which is conducive to the construction and improvement of the chemical pipeline network. On the other hand, enterprises can use the system for simulation tests, timely monitoring and troubleshooting. It can be said that the production and maintenance of large-scale equipment in the petrochemical industry is inseparable from the chemical pipeline network system. The rapid development of simulation technology has continuously improved the computing of chemical unit equipment. A large amount of data shows that the error between the computing result of the simulation computing model of the petrochemical unit equipment and the actual value is within a reasonable range, which can basically reflect the actual situation. The real-time nature of the simulated computing of the pipeline network is a factor that must be considered by the relevant personnel, because it can be quickly used for students to learn the content of full-scale simulation.
Considering the real-time and complexity of pipeline network computing, in this paper, the author studies the distributed real-time computing and application of chemical pipeline network based on Hadoop. The initial value setting is completed mainly through the method of linearized initial value setting. Secondly, Hadoop is used to calculate the pipeline network graph theory. Then the distributed network based on B/S is used to construct the distributed simulation platform for chemical pipeline networks.

2. Literature review

In the present work, we focus on the development and application of Lyapunov-based economic model predictive control designs to a catalytic alkylation of benzene process network, which consists of four continuously stirred tank reactors and a flash separator. We initially propose a new economic measure for the entire process network which accounts for a broad set of economic considerations on the process operation including reaction conversion, separation quality and energy efficiency. Then, a sequential distributed economic model predictive control design method, suitable for large-scale process networks, is proposed and its closed-loop stability properties are established. Using the proposed method, economic, distributed as well

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as centralized, model predictive control systems are designed and are implemented on the process to drive the closed-loop system state close to the economically optimal steady-state (Chen et al., 2012).

Natural gas pipeline engineering calculation involves multiple specialties, complex content, complicated analysis process and multiple application levels. In the paper, following the theories and methods of modern gas pipeline engineering analysis, according to the current domestic and international norms and standards, and depending on the application requirements and characteristics of engineering technology and management personnel, the latest computer, network, communication technology and smart mobile devices were combined with the advanced system integration and development technologies to realize the integration of gas pipeline engineering analysis methods. Finally, a set of integrated calculation and application software system was established for natural gas pipeline engineering, which serves for multi-platforms, multi-specialties and multi-systems. Furthermore, integrated application platforms of natural gas pipeline engineering calculation were built for different systems. Practical applications show that this integrated application platform works in the way that engineers are accustomed to and provides corresponding operation functions. It provides universal and convenient tools for the central dispatch, daily management and on-site operation of the natural gas pipeline system for all levels of professional and technical personnel. No need for re-development makes it able to improve work quality and efficiency (Gao et al., 2015).

The steam flow in geothermal pipeline networks is more complex than that in any other system since the pressure, temperature and flow rate of fluid in geothermal wells are controlled by nature. Additionally, the large distance among wells and their topographic settings in a geothermal field also complicate the steam flow in the pipeline networks. There are two fundamental aspects to be considered for the simulation of steam transport in a geothermal pipeline network: internal consistency in the thermodynamic data of water, and appropriate algorithm. The input data for steam flow simulations are the thermodynamic properties of water; therefore, both the aspects are interrelated and the simulation results are highly influenced by the water properties (Verma, 2013).

Hydrogen pipeline network operation is important for balancing the hydrogen producing and consuming unit onsite. To make the operation efficient and stable, this article presents a mathematical program which incorporates equilibrium constraints for scheduling of hydrogen pipeline network between hydrogen producing and consuming units within a refinery. The developed model not only handles the multi-component and non-ideal nature of the hydrogen pipeline network, but also allows flow reversals and flow transitions inside the pipeline. A real refinery case study shows that the optimal schedule of pipeline storage could stabilize the hydrogen production, which improves the efficiency of the system. Operating safety is also ensured by the pressure constraints.

These descriptors are object related properties used to describe each image component. Embedded machine vision systems demand a robust performance and power efficiency as well as minimum area utilization, depending on the deployed application. In the proposed architecture, the hardware modules for component labeling and feature calculation run in parallel (Malik et al., 2014). There are many considerations in these design problems, involving various constraints, decisions and the associated costs for the construction, operation, maintenance, etc., of the system. The present approach proposes a systematic search for optimal and near-optimal solutions. The search is based on stochastic optimisation and assumes that the same information and simulation tools as in the case of design by trial and error are available (Marcoulaki et al., 2012).

It gains its efficiency by expressing a small probability event as a product of a sequence of intermediate events with larger conditional probabilities. Reliability of a buried flexible steel pipe with time-dependent failure modes, namely, corrosion induced deflection, buckling, wall thrust and bending stress has been assessed in this study. The analysis indicates that corrosion induced excessive deflection is the most critical failure event whereas buckling is the least susceptible during the whole service life of the pipe. The study also shows that SS is robust method to estimate the reliability of buried pipelines and it is more efficient than MCS, especially in small failure probability prediction (Kong, 2014).

Energy-awareness is an important criterion for many mobile appliances such as (smart)phones and handhelds. It is also indispensable for electronic controller units in cars for example. Unfortunately, low energy consumption and high- computing power exclude each other. With the proposed methods of space-sharing, adaptive and selective clocking and software-first design, both goals can be reached simultaneously. Space-sharing is an alternative to time-sharing for multi-task controllers in real-time systems that significantly simplifies task scheduling. With space-sharing, there is no need for worst-case execution-time analysis. Furthermore, adaptive and selective clocking, together with a software-first design reduce the controller's energy consumption to the absolute minimum. The results described herein were achieved by a set of measurements made at a single-chip multiprocessor system called MPSoC1 that implements space-sharing on one FPGA and by a second system in software-first design called MPSoC2 that implements adaptive and selective clocking (Aust, 2012).

In the pipeline network of geothermal power plant, the steam flows from high to low pressure and heat flows from high to low temperature. There is a decrease in the temperature and pressure of steam along the pipeline, even when there is no heat loss, which is associated with the expansion of steam during its flow. Additionally, the algorithm presented here is constrained for the simulation of steam transport by the limitations of internal consistency in the thermodynamic properties of water. The energy balance at any point in the pipeline network validates the functionality of the present algorithm for steam transport in geothermal pipeline networks (Li et al., 2014).

The results show that the proposed petrochemical pipeline network real-time calculation strategy architecture based on Hadoop can effectively solve the problems introduced above, thus real-time calculation of petrochemical pipeline network could be successfully achieved. Thus, the workload not only is reduced, but also the effectiveness of the predicted results is fundamentally promoted and the security risks in network operation management are excluded. The software can facilitate the management of the pipeline network operations and avoid the blindness of production scheduling, and this provides a theoretical expert guidance for the scientific management of gas transportation pipeline network.

3. Methodology

In the initial value setting, if the method is too complicated and requires a lot of computing time, there is no practical significance for setting the initial value. Therefore, when the structure of the pipeline network is not complicated, the initial value can be set by a simple method. This not only reduces the computing time when the initial value is set, but also allows the initially set value to be closer to the true value, the number of iterations is less, the time is less and the linearized initial value is set. In fact, the method is to use the principle of linear superposition. Firstly, the relationship between pressure and flow is simplified and linearized. After that, the principle of linear superposition can be applied to it and corresponding parameters can be obtained through experiments and the related methods can be verified.

The most typical and commonly used formula of pressure and flow of fluid is Fanning equation, as shown below:

$$\Delta p_f = \lambda \frac{l \rho u_m^2}{d 2} \tag{1}$$

In the Fanning equation, ∆pf refers to the pressure drop of a fluid flowing over a distance. The unit of this variable is Pa, λ is the so-called coefficient of friction. The coefficient is not the same for different materials. l is the length of pipe section, the international unit is m, d is the inner diameter of pipe section, ρ is the density of fluid, the unit can be kg/m3 and the last parameter is um, which represents the average flow rate.

The friction coefficient λ can be obtained from the standard tables formed by previous experiments in different materials. The second is to use some empirical formulas to calculate the friction coefficient values. There are some very classic and commonly used formulas, such as the Hazen-Williams formula, Colebrook-White formula, Chevirov formula and so on.

The tandem structure is a very simple structure in the pipeline network. Its characteristic is that the flow through each pipeline is the same and it is the same as the total flow. This is obvious and there is one point for each segment. Pressure loss and total pressure loss, these characteristics can be obtained according to the law of conservation of mass and conservation of energy, series structure is very common, it is also very important to clarify its characteristics.

The parallel structure is also a very common structure in the pipeline network. The pressure and flow of the parallel structure have their own characteristics. The total flow rate is equal to the flow rate of each branch, the total pressure loss and the pressure on each pipe segment. The losses are the same. These characteristics are all derived from the laws of conservation of mass and conservation of energy. This parallel structure is also often used in petrochemical pipeline networks, as shown in Figure 1.

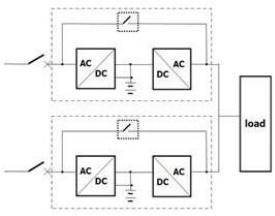

Figure 1: Parallel Structure Diagram

The applicable situation for branch pipelines is that in the petrochemical field, such pipelines will be used when the main pipeline needs to transport materials in multiple directions or in multiple spaces. In pipelines that are connected in series or parallel, there is a pipeline structure with one inlet and one outlet, but the branch pipelines or the combined pipelines are multiple outlets or multiple inlets. In the linear system theory, this problem will be introduced into the stacking. The principle to solve this problem is because the formula proposed is a nonlinear relationship, but the superposition principle can only be used in a linear system, so we need to propose a linearized treatment of this formula. We need to understand that the purpose is to reduce the computing time, to reduce the number of iterations of computing, if too late to introduce too complex methods to make the computing time is too long, it will outweigh the benefits. So the simplest method is to use a tangent instead of a curve near the working point to linearize the flow pressure of the pipeline.
The multi-conductor pipeline is a kind of complicated pipeline and the structure of multiple entrances and multiple exits may be more complicated. If such a structure is simply using the principle of linear superposition to set the initial value, it may not be compared. In the case of preparation, once this happens, in the petrochemical system, the initial value is set so as not to diverge the results, reduce the number of iterations and reduce the computing time. If this happens, the initial value will be lost. The meaning of the computing is no different from setting 1 directly. So a more suitable method is used to set the initial value
About using tangents to replace curves. One input is x and the output is y. The relationship between them is y?= f(x). X and y may be functions related to t, but at the same time they are nonlinear. If at this time you want to use the tangent near the working point instead of the curve, suppose some point S(x0,y0) is the working point, then there will be y0=f(x0). Therefore, it is very important to carry out a good estimation of working point, then the following formula can be obtained:

$$y = f(x_0) + f'(x) \bullet (x - x_0) \tag{2}$$

Pipeline network simulation distributed platform, on this platform allows students to carry out simulation training in class, but also for the training of workers or for the construction of this system with pipeline network structure play a role in guiding or testing. In order to provide more convenient simulation services, the B/S system is used. This can avoid the problem of having to install programs on each computer and it is also conducive to collecting large amounts of data. It is more effective for building such projects, as shown in Fig. 2. When the user accesses the platform for simulation service or simulation training, the user's request first goes to the Nginx server where the target reflexive proxy server acts and then Nginx distributes the request load balancing, if it is a picture or a small file. Requests may be to build a static server that specializes in handling such small files. This can be done using the open source distributed file system fastdfs. At the same time, this distributed file system can be easily extended horizontally.

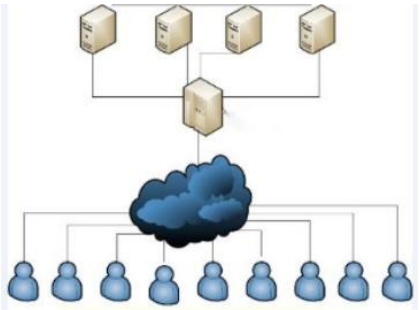

Figure 2: Distributed server diagram

4. Results and discussion

4.1 Double distillation tower group pipeline network

The process is relatively simple - through the branch pipeline, it feeds material to the rectifying columns T-001 and T-002, and there is a corresponding valve port in the pipe, the function of which is to adjust flow. This is a relatively simple pipeline network real-time computing system.
As shown in Figure 3, the upstream outlet has a skin force of 25 MPa and the feed pressure is 0.1 MPa. What needs to be done at the beginning is to build various computational models. Because the pipeline network distributed real-time computing system uses a WYSIWYG (what you see is what you get) way, the text drags the corresponding model onto the interface and connects it to each graph. The program will create the Core Agent corresponding to the computing and the corresponding NodeAgent, as well as the Agent of the fitting

and create it with the corresponding knowledge base. Lastly, these models should be stored. The next step is to open the dialog box of each component and then set the parameters of the relevant properties.

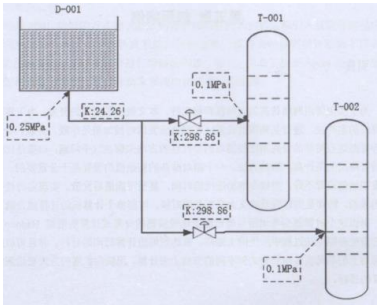

Figure 3: Schematic diagram of the process flow of double distillation towers

If the inlet valve in front of the T-002 is opened to 30%, then the coefficient of the pipe resistance of the branch of the branch pipe will be from 298.66 to 760 and the system will change accordingly. As shown in Figure 4, it shows the temperature and pressure curve of the second plate at the top of T-002.

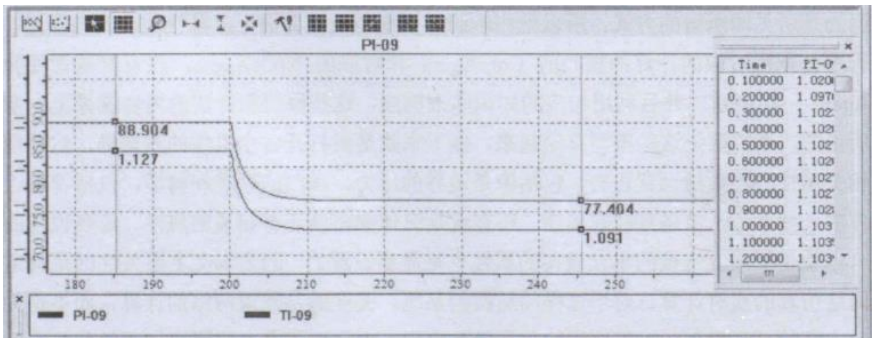

Figure 4: The temperature and pressure curve of the second plate at the top of the tower

4.2 Pipeline simulation of distillation towers

Figure 5 shows the temperature profile of the second plate on the top of the tower. The following value is the steady state value, where curve 1 is the tower T3011, the value is 88.916 degrees Celsius and curve 2 is the tower T30121.The value is 82.788 degrees Celsius, curve 3 is tower T302, it represents the value is 91.153 degrees Celsius, curve 4 is tower T303, it represents the value is 93.60, curve 5 is tower T305, the value is 87.329, where curve 6 is T06 and it The value is 94.197 degrees Celsius and the last one is Tower T302, whose value is 93.569 degrees Celsius. It can be seen that the simulations of all towers are working well.

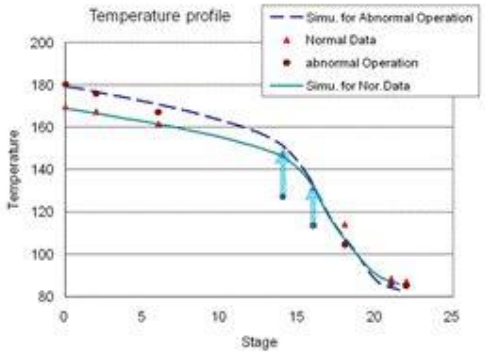

Figure 5: Temperature run curve of the second plate at the top of each tower

Introducing some interference to the system, that is, perturbation, the resulting graph is shown in Figure 6. It is also very stable quickly. Therefore, we use the method described in this paper to build a distributed pipeline network system to achieve real-time computing and Stability is no problem and can meet related needs.

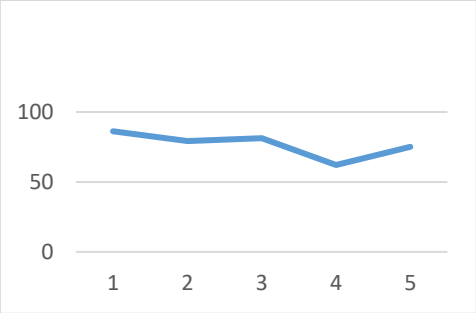

Figure 6: The fluctuation curve of distributed official website system under disturbance conditions

5. Conclusions

In this paper, the author studies the distributed real-time computing and application of chemical pipeline network based on Hadoop. The initial value setting is completed mainly through the method of linearized initial value setting. Secondly, Hadoop is used to calculate the pipeline network graph theory. Then the distributed network based on B/S is used to construct the distributed simulation platform for chemical pipeline networks. The results of this study show that the simulation results can be calculated in unit time. From the experimental results, the pipeline network running on this system can achieve the purpose of real-time and stability.

As the author's knowledge is limited, this experiment has the following deficiencies: First of all, it may be difficult for the method setting the initial value proposed in this paper to deal with the complex actual situation. In the future research, it may be necessary to establish a systematic and sound method to calibrate the parameters with a large number of tests. Secondly, in this paper, the author does not improve special matrices with large columns but few rows. Therefore, special matrix processing methods are needed in the future research work.

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