Advances in Intelligent Systems Research, volume 165
International Conference on Modeling, Simulation, Optimization and Numerical Techniques (SMONT 2019)

Development and Application of Online Simulation System for Western Products Oil Pipeline

Zhijun Zhang[1], Yulei Xu[1], Wang Di[1], Yunlei Zhang[1], Peijun Zhai[1], Yanquan Wang[1] and Xiaowei Wang[2]
[1]PetroChina Oil & Gas Pipeline Control Center; No.9 Dong zhi men bei da jie, DongCheng District Beijing, 100007; China
[2]Commissioning Operation Company of China Petroleum Pipeline Engineering Co, Ltd; Huaxin Road 9, Langfang City, Hebei Province China

Abstract—**Based on software SIM of ATMOS from UK, the online simulation system of western products oil pipeline has been developed which embodies seven modules and provides a platform for the operation of long distance pipeline transportation. It could modulate the running state of any point along the pipeline at any time interval, including both steady state and transient state, and improves the efficiency and safety of the whole pipeline system to make it more reasonable, economical and optimize the operation. Meanwhile, it provides a reference for the development of online simulation system.**

Keywords—western products oil pipeline; online simulation; system structure; development; application

I. INTRODUCTION

Western products oil pipeline initiates from Urumqi at Xinjiang province and travels to the east end in Lanzhou at Gansu province, with a total length of 1842.3 km and a design capacity of moving 1000 tons of oil per year. During operation, dispatchers may encounter various of emergency situations, which requires a fast feedback from the real time pipeline transportation system for related parameters and predictable situations, so that the running state of the pipeline could be optimized or modified if necessary. To establish a reliable and multi-functional online simulation system for oil transportation could benefit the management and operation of the long distance pipeline, tracking the running history, indicating the real time state as well as predicting upcoming situations, which could reduce energy consumption and level up long distance dispatching advantage.

II. STRUCTURE OF ONLINE SIMULATION SYSTEM FOR OIL PIPELINES

Online simulation system of western products oil pipeline consists of seven modules, which is divided into two categories, basic modules and auxiliary modules respectively, based on the features and importance of each module. The basic modules include real time simulation, tracking modules of different batches and pigging, trend prediction, batch plan, scheme optimization. Meanwhile, auxiliary modules are composed of simulation training, leakage detection as well as locating module.

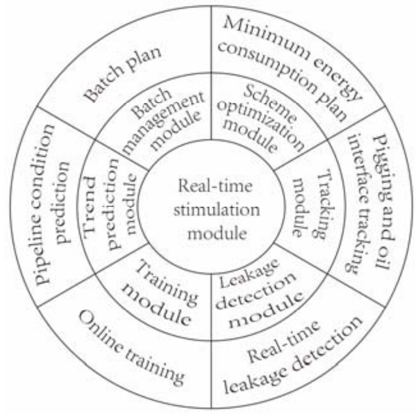

FIGURE I. FUNCTION DIAGRAM OF ON-LINE SIMULATION SYSTEM FOR OIL PIPELINE

The structure of online simulation system for western products oil pipeline is seen in fig.2, of which the modules are installed in three servers, two workstations for simulators and four dispatching workstations for dispatchers.

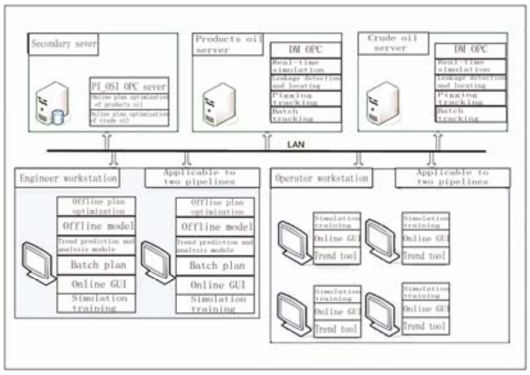

FIGURE II. STRUCTURE OF ONLINE SIMULATION SYSTEM

The mutual data paths among each module are shown in fig.3. The main source of real time data comes from center data base PI, which transfers detailed parameters of two pipelines to the online simulation system, like pressure, flow rate, temperature, density and so on. The preprocessing algorithm is applied to deal with the rationality of real time relational data from center data base, and correct the wrong values, which would take the gradient of real time data, compensation factors and time labels into consideration. For the data that could not go through the rationality treatment would be filtrated out.

The parameters would be processed through real time module SIM. Then hydraulic lines and variation curves of each data could be drawn by TREND, so that reasonable prediction could be made. Moreover, real time SIM is also able to calculate and track the position of pig location.

Meanwhile, the real time data from PI would also be transferred to leakage detector module. By comparing the history of flow rate, the judgment of leakage situation could be determined. Also, based on the density and flow rate of the pipeline from PI, the position of different batches could be monitored and to help with batch plans. In order to guarantee reliability of each plan, the data would also go through optimization module to have hydraulic check before the final decision is made.

The data curves of each module are shown by graphical user interface, also known as GUI, which could be directly used by dispatchers for online simulation.

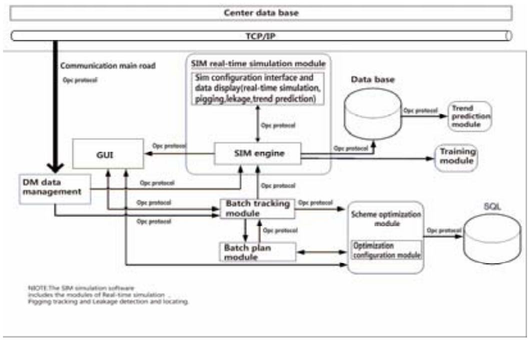

FIGURE III. DATA AND INFORMATION INTERACTION DIAGRAMS OF VARIOUS SYSTEMS

III. Analysis of Modules of Online Simulation System for Oil Pipelines

The real-time module of the online simulation system of western products oil pipeline adopts the maximum similarity algorithm as the data calibration method, which improves the accuracy of real-time simulation calculation.

The unique online status evaluator(MLSE) would evaluate the online instruments, and intelligently calibrate the precision. By setting the weight coefficient, namely increasing it of high-precision instrument while lowering that of low-precision instrument, the accuracy and stability of calculation for the online simulation system would be enhanced. By learning and comparing other parameters of the pipeline, the maximum similarity algorithm would be able to adjust the results to a reasonable level based on the respective error range of each instrument. For instance, the tolerance of instrument with low precision would be widen in the configuration. The method makes the real-time simulation module one of the most stable and accurate online simulation system, especially for the massive pipeline system involved with instruments.

User interface (Online GUI) provides a direct access for the functions of each module of the online simulation system, including the data curves of real-time model, results of batch tracking and optimum module as well as leakage detection. And it could be installed on different workstations to share the real-time data and functions within the same network segment.

For instance, the batch tracking module calculates the position of oil interface on 23rd,july 2012 based on the online simulation system. By comparing the result, it matches the real time of arrival of the subsequent batch and proves to be feasible in real practice.

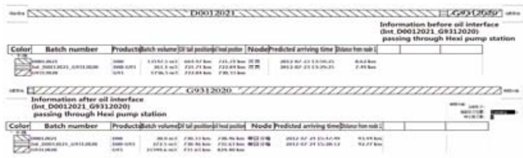

FIGURE IV. FIELD TEST RESULT DIAGRAM OF BATCH TRACKING FOR WESTERN PRODUCT OIL PIPELINE

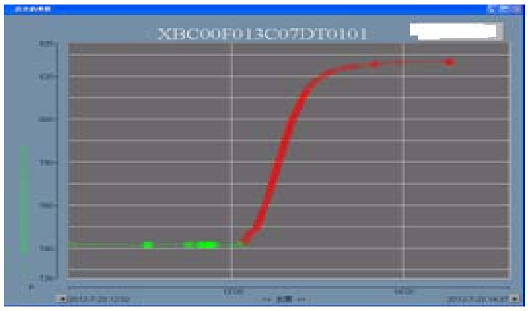

FIGURE V. REAL ARRIVAL RESULT CHART OF PRODUCT PIPELINE BATCHES

As for the pigging tracking, a pig was launched at Xinjing station at 15:27 on 17th july 2012. According to the final report, it indicates that the pig arrived at downstream station Xinpu at 6:45 on 18th july, 2012.

The result of online simulation is shown in fig.6 and proves to be accurate by comparing real arrival time of pig on site.

As for the optimization module, the real time data is imported as initial condition to take it as an off-line calculation with different boundary conditions, such as whether the pump is in back up condition. Then optimum goals could be set to activate the process, like the lowest energy consumption or total cost based on the pragmatic use for electric cost on site.

The leakage detection and positioning is part of online simulation, which could calculate the flow rate and pressure along the pipeline and monitor even 5% leakage within ten minutes based on the adjusted alert of three limits on detecting spots. When it happens, the warnings would be activated on GUI to dispatchers, such as 1)leakage alerts;2)rate of leakage;3) position;4)total quantity.

IV. Conclusion

This paper establishes online simulation system which is applicable to oil transportation pipelines. By applying maximum similarity algorithm and increasing the weight factor of high-precision instruments, the accuracy of real-time calculation of the online simulation system could be improved, which is better than pressure-pressure algorithm. As for the optimum plan, it both considers crude oil pipelines and products oil pipelines. Based on real-time calculation, the leakage detection module and locating module are developed, which could efficiently distinguish potential leakage (up to 5% leakage) from normal transportation condition. When putting into real practice for oil transportation, the model of online simulation system proves to be feasible.

ACKNOWLEDGEMENT

Fund Project: PetroChina Beijing Oil and Gas Control Center Project "On-line simulation system development project of oil pipeline", CPM11-TP03-DKZX01.

REFERENCES

[1] Ouyang Zhongbin, Wu Changchun, Ai Muyang. Pipeline simulation technology and its application [J]. Oil and gas storage and transportation, 2004 (08): 1-5+59-60.

[2] Wang Bin, Shao Xiao, Xu Zhicheng, on-line simulation of "white box" of product pipeline network [J]. Oil and gas storage and transportation, 2014, 33 (6): 669-671.

[3] Chen Guoqun, Zheng Jianguo, Liu Jianjun, Peng Shibiao, Present Situation and Prospect of Oil and Gas Pipeline Network Simulation Technology [J]. Oil and Gas Storage and Transportation, 2014, 5-15

[4] Modeling mechanism of on-line and off-line simulation for Li Yingdong, Xu Hui, Liu Chunyang, Dong Ping Province [J]. Oil and gas storage and transportation, 2011, 30 (3): 170-172.

[5] Ji Zhongli, Deng Zhian, Zhao Huijun. Pumps and Compressors [M]. Beijing: Petroleum Industry Press, 2008.

[6] Liu Lianghong, Zhou Xinggui, Yongqiwei. Analysis of two kinds of control theory according to transportation volume or intensity-long distance pipeline [J]. Journal of Chemical Engineering, 1996, 47 (3): 267-272.

[7] Li Yingdong, Xu Hui, Liu Chunyang, et al. Modeling mechanism of online and offline simulation [J]. Oil and gas storage and transportation, 2011, 30 (3): 170-172.

[8] Li Yi, Ren Ying, Zhou Hao, et al. Digitalization of safety supervision in oil and gas engineering enterprises and its application --- Taking Chuanqing Drilling Engineering Company of PetroChina as an example [J]. Natural Gas Industry, 2012, 32 (3): 109-112.

[9] Wang Yonghong, Li Xiaoping, Gong Jing. Application and Prospect of Long-distance Pipeline Online Simulation System [J]. Oil and Gas Storage and Transportation, 2011, 30 (2): 90-94.

[10] Zeng Duoli, Deng Songsheng, Liu Lingli. Oil product pipeline transportation technology [M]. Beijing: Petroleum Industry Press, 2002.