Sticking of Drilling Pipes Monitoring and Early Warning Technology Based on Time-Series Analysis

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Abstract

capable of accurate and timely judgment pipe sticking accident type, to take proper remedial measures are particularly important. Being dead against the sticking of drilling pipes the workover drilling as an example, this paper studies the sticking of drilling pipes monitoring and early warning technology based on time-series analysis using the causes and charadteristics of sticking of drilling pipes. The judgment result of the monitoring and early warning system is consistent with the actual situation in the field, which verifies the reliability of the design scheme and provides effective help for taking the correct decryption mode.

Keywords

Workover Sticking; Sticking Early Warning; Time Series; Data Acquisition.

1. Introduction

On the basis of in-depth study of the mechanism of occurrence of sticking workover, sticking characterization parameters and characterization of the law, based on laboratory parameters of existing drilling instrument designed and developed a simulation system suitable for sticking workover process monitoring and early warning. The system uses the drilling instrument to complete other data acquisition, and uses the time series analysis modeling method to realize the intelligent warning of the workover drilling, provides the decision-making basis and the technical support for the field technical personnel, so as to make the countermeasures in time to avoid the workover Of the accident and the resulting accident, to ensure that the workover safety, fast.

2. The characterization of the occurrence of workover drill

String in the card can be divided into sand and dirt sticking, buckling sticking, sleeve sticking, blasting sticking, fall sticking, as shown in Figure 1-1.

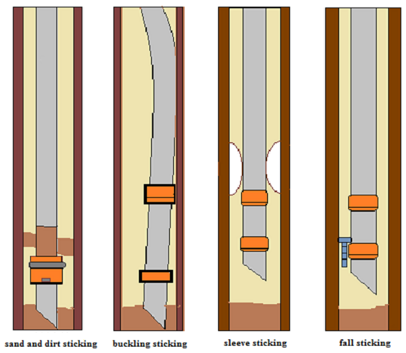


Figure 1-1. Sticking type

After the sticking accident occurred, no matter what the reasons are caused by the drill, the final result is the workover string or tool in the underground lost the ability to move freely, the most direct characterization that friction and torque is the increase parameters in undercut. Torque and friction can only utilize surface measurements and indirectly, this article select workover string friction parameter as an early warning. In order to avoid using downhole implemented in the measuring instrument to reduce development costs while achieving workover process of sticking the real-time early warning purposes, thus ensuring the workover work safely and quickly.

3. Establishment of friction random time-series analysis calculation model

Random time series model is divided into four types: AR, MA and ARMA models describe stationary time series, ARIMA model describes nonstationary time series.

The essence of ARIMA (p, d, q) model is the combination of ARMA (p, q) model and differential operation. Therefore, for the non-stationary sequence, in view of the strong ability of the differential operation to determine the information extraction, only the appropriate difference can be transformed into a smooth sequence, so as to carry out ARMA model fitting. The basic form is as follows:

In the ARIMA (p, d, q) model, the random sequence {Xt, t=0, 1,2……}satisfies the following equation:

$$\varphi(B)(1-B)^d X_t = \theta(B)\varepsilon_t \tag{1}$$

Where: B —— the delay operator, defined as $BX_t = X_{t-1}$ $B^k X_t = X_{t-k}$;

d ——differential order;

$\varphi(B)$ ——autoregressive coefficient polynomials $\varphi(B) = 1 - \varphi_1 B - \cdots - \varphi_P B^P$;

$\theta(B)$ ——moving average coefficient polynomials $\theta(B) = 1 - \theta_1 B - \cdots - \theta_q B^q$.

Establish friction random time series model, and predict its future value.When there is a significant increase in friction it could prejudge the moment Sticking accidents happen. The workover monitoring and early warning process is shown in Figure 2-1.

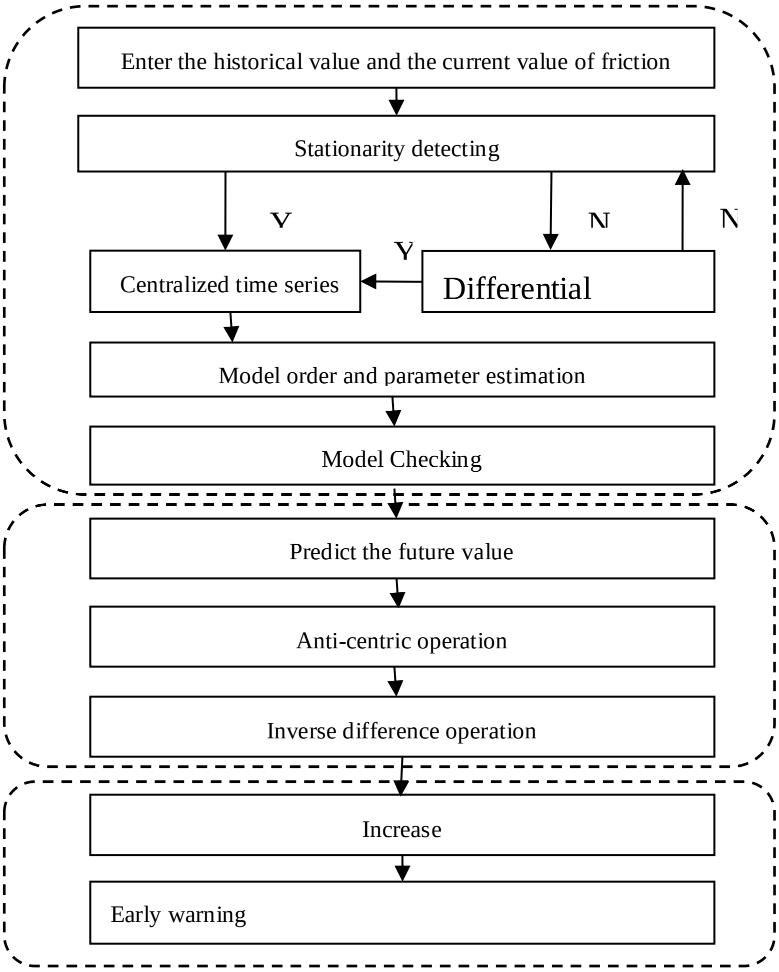
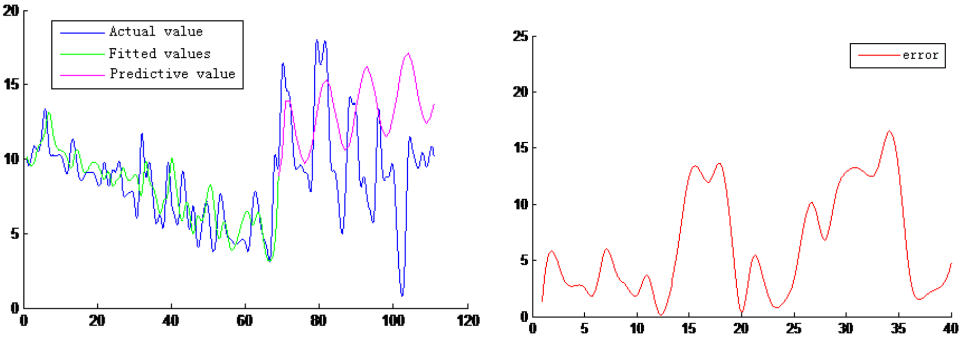


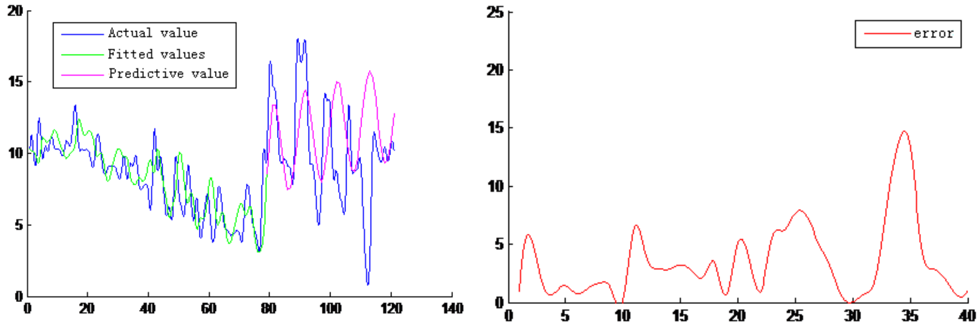
Figure 2-1. Workover monitoring and early warning flow chart

(1)The number of samples and the predicted value determining step

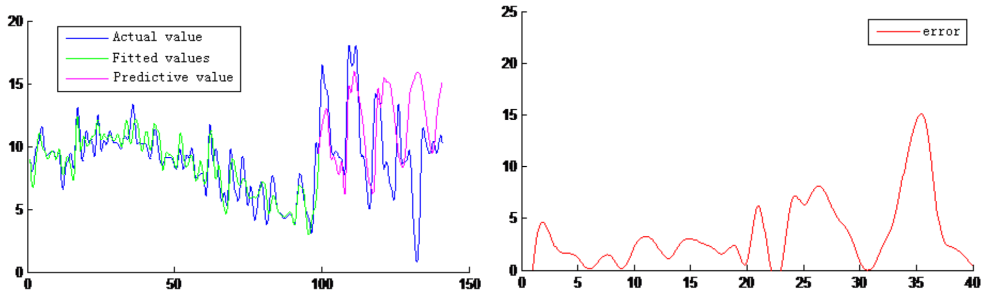
Taking the actual workover friction data of xx block x as the sample, the model number is 60, 80, 100, 120 to establish the model for prediction, the forecast step is 40,and prediction error as shown in Figure 2-2.



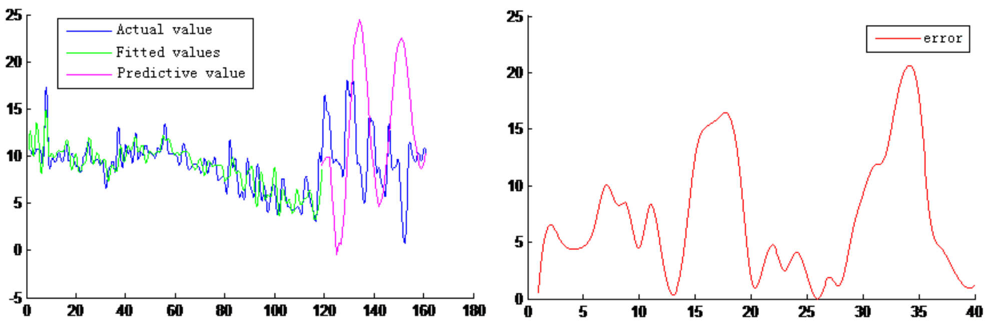
(a) The number of samples is 60



(b) The number of samples is 80



(c) The number of samples is 100



(d) The number of samples is 120

Through the analysis of Figure 2-2 we know

①Model predicts the number of samples to establish the same error as the prediction steps increases appears increasing trend;

② The prediction error decreases first and then increases with the increase of the number of samples, and the prediction error is the smallest when the number of samples is 100.

Therefore, the system selects the modeling of the number of samples is 100, while more accurate prediction steps 20 steps before, so the system selects the predicted value in steps of 20.

(2)Establish a friction time series model and predict future values

In this paper, the stationary detection method using the unit root test (ADF test), using simulation software that comes adftest function to smooth processing, it calls the method as follows:

[h, p, stat, cValue,reg] = adftest(Y);

If the friction time series is not smooth, it needs to be a difference operation, simulation software for the differential function diff, call format is:

Y=diff(X,n);

After the time series of friction are smooth and centered, the order and parameter estimation of the model are carried out and the selection of the optimal model is realized by using the AIC criterion and BIC criterion. Firstly, the highest order of the model is framed by using the Box-Jenkins method by using the intercepting and trailing judgment formulas of ACF and PACF. From low to high order to fit the model, and with the maximum likelihood estimation parameters, get a number of models.

In the simulation software using garchset to specify the model structure, garchfit to achieve the maximum likelihood of the model parameters estimation, aicbic calculation of smooth sequence AIC value and BIC value. Call the following format

Spec = garchset(param1,val1,param2,val2,...);

[Coeff,Errors,LLF,Innovations,Sigmas]= garchfit(Spec,Y);

[aic,bic] = aicbic(LLF,numParam,numObs);

When the optimal friction time series model is selected, the adaptability test of the friction time series model is used. If the model is not adaptable, it is necessary to change the order of the model, change the rule to use the minimum BIC value, If not then use AIC second small, BIC second small, and so on, and from the previous step to start again.

In the simulation software using the function chi2gof to achieve the test, the call format is:

[h,p,stats]= chi2gof(x,Name,Value)

In this system, the method of smooth linear minimum mean square is used to predict the future value of friction. Is set to the value of the future time of the smooth sequence Y, then the calculation is made:

$$E[(Y_{k+m} - \hat{Y}_k(m))^2] = \min$$

In the simulation software using the function garchpred to achieve the future value of the forecast, the call format:

[sigmaForecast,x_Forecast] = garchpred(coeffX,Y,n)

The predictive value obtained at this time is only the predicted value of the stationary time series of the centralization and differential processing, and the inverse friction value and the anti-centering operation are needed to obtain the future friction value. The anti-centering operation adds the original average to the predicted value value. Anti-differential operation, according to the differential operation can be obtained, the following are given 1 and 2 times the recovery formula. The recovery formula for the difference is:

$$X_t = X_1 + \sum_{j=1}^{t-1} W_{j+1} = X_k + \sum_{j=1}^{t-k} W_{j+k}, \quad t > k \geq 1 \tag{2}$$

Difference 2 times the recovery formula is:

$$X_t = X_2 + (t-2)(X_2 - X_1) + \sum_{j=1}^{t-2} (t-j-1)W_{j+2}$$
$$= X_k + (t-k)(X_k - X_{k-1}) + \sum_{j=1}^{t-k} (t-j-k+1)W_{j+k}, \quad t>k\geq 2 \tag{3}$$

Where w_i is the predicted value, x_t is the predicted future value of friction.

3. Case Analysis

The time series model is established by taking the friction data of the actual workover in xx block x well, and the partial friction data are shown in Table 3-1. The timing diagram is shown in Figure 3-1:

Table 3-1. Actual workover data for xx area x wells

Intake tubing length (m)	Friction (KN)
1041	8.43
1042	8.47
1043	9.78
1044	8.19
1045	9.22
1046	9.15
1047	9.78
1048	7.79
1049	7.57
1050	7.78
1051	7.34

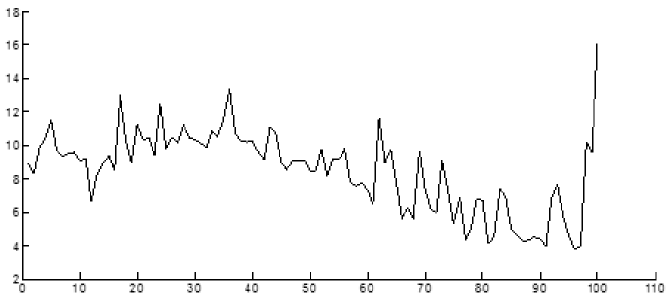


Figure 3-1. Timing diagram

The sequence of the sequence is shown in Fig. 3-2, and the sequence sequence is shown in Fig.3-2. After the sequence is not smooth, the sequence is not smooth and the sequence is smooth.

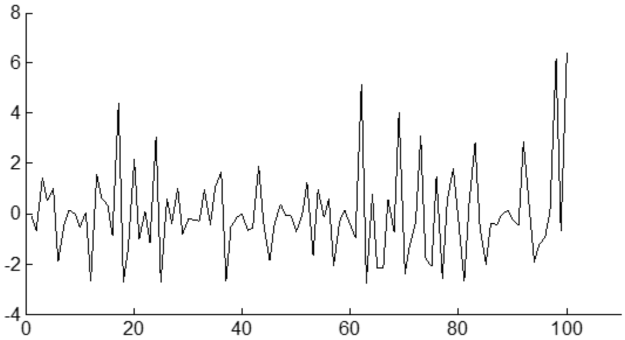


Figure 3-2. Timing diagram after preprocessing

Use the AIC criteria and the BIC criteria to get the model:

$$M_t = -1.034M_{t-1} - 0.8269M_{t-2} + \varepsilon_t + 0.6106\varepsilon_{t-1} + 0.3717\varepsilon_{t-2} - 0.5441\varepsilon_{t-3} \quad (4)$$

The fitness of the model was detected by h = 0, and the p value was 0.8113 significantly greater than 0.05. Therefore, it can be considered that the residual model of the fitting model belongs to the pure random sequence, that is, the fitting model is effective. And the predicted value, the predicted value and the actual value are shown in Figure 3-3. The prediction error is shown in Figure 3-4.

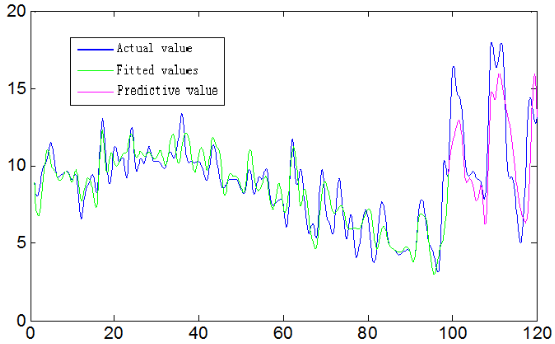


Figure 3-3. Fit value, predicted value, and actual value

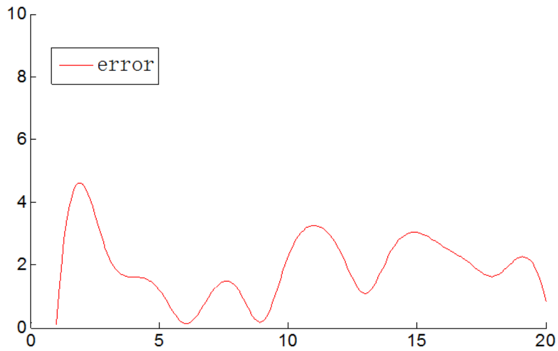


Figure 3-4. Predictive error

4. Conclusion

In this paper, the friction calculation model is established to provide the basic parameters for the monitoring and early warning of workover drilling. At the same time, according to the characterization and regularity of the workover drill, the time series analysis is used as the mathematical analysis method Based on the establishment of the workover drill early warning model, to achieve the workover during the card drill early warning, and then before the occurrence of the card drill to take appropriate measures to avoid the stuck. The future value of the friction time series model is analyzed, and if the future value is significantly increased, it is necessary to judge the occurrence of the accident and the warning.

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