

## **Research Article**

### **Failure early warning model for Electrical Submersible Pump based on regression analysis**

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**Abstract:** Take 120 the Electrical Submersible Pump (ESP) well as the object of study, has constructed based on 6 commonly used target return early warning models, then to dives the Electrical Submersible Pump breakdown well to carry on the forecast analysis. The findings indicated the model has the good forecast effect, forecast the rate of accuracy achieves 92.5%, may carry on the breakdown early warning well for the oil field enterprise interior, and provides the daily management and the policy-making basis for the oil field enterprise system.

**Keywords:** Early warning; Dives the oil electric pump; Return model

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## **INTRODUCTION**

### **Issues raised**

Enters the mid and late part along with our country oil field mining, the water content increases, many oil fields have used massively dive the oil electric pump extraction. According to dives the oil electric pump unit to produce the characteristic, any part of any kind of breakdown will all affect the oil well the regular production. Unit's each breakdown all must raise machine the repair, a mine shaft work continues generally several days, the operation cost and the repair expense is quite high, because in addition the unit breakdown creates the production suspension, the underproduction, lost is more inestimable. Some extraction factory dives oil electric pump well altogether 430, accounts for the entire factory total number of wells 1/3, but the output accounts for the entire factory ultimate output 70%, thus it can be seen, dives the oil electric pump to hold the extremely important status in the crude oil production. The electric pump well running status mainly for the normal well, the breakdown well and stops the mechanical well, the normal well reduces for the breakdown well is gradually a process which proceeds in an orderly way, therefore may carry on the early warning using the oil well daily management target to the breakdown well[1]. Dives the oil electric pump well movement tendency using the data mining knowledge analysis, the establishment dives the oil electric pump breakdown well early warning model, performs in the production to prevent, has the very vital significance.

### **Oil production status of early warning research**

Since along with our country petroleum and the international trail connection, petroleum enterprise production condition question oneself after has aroused our country experts' interest, our country petroleum profession also started this aspect research.

In 1998, by Cai Fuan et al. undertook "the petroleum enterprise to produce the management condition monitor early warning method research" topics, has opened the research which Our country Petroleum Enterprise forewarned; In 2002 Wu Wensheng has established the oil resource appraisal target system and the standard in "our country oil resource safety evaluation and the early warning research", pointed out in 2010 before China's petroleum supplies are in highly the warning area. In February, 2003 by China Petroleum and Chemical Corporation Henan oil field subsidiary company academy of engineering Liu Yu, Tian Ze's research topic "the petroleum enterprise economic security and the early warning at the beginning of countermeasure searched" all is produces the management angle analysis from the petroleum enterprise to study the monitor early warning method[2]. In 2005 Xiao Jianhong published "Oil field Crude oil Mining Economies of scale Theory And Applied research" in a book has established the oil-field development scale of production early warning system, has explored the crude oil development enterprise's economies of scale early warning method[3]. In 2006 Fan Qiufang, gives a thought to the brilliance, basis petroleum enterprise's and so on Ma Yang production management characteristics, established the petroleum

enterprise to produce the management system monitor early warning target system, and the application weighted mean method constructed the petroleum enterprise in this foundation to produce the management quality synthetic evaluation early warning model[4]. Utilization forecast early warning theories and the present age computer technology and so on Chang Yanrong, has realized the forecast early warning software system, and to produces the condition unusual monitoring object to give reports to the police promptly processes. In 2007 Niu Qibin, Chen Daen uses the yellow early warning method, has constructed the oil gas enterprise economy early warning system target system, uses the target value, reasonable methods and so on economic limit and profession value determined forewarns the police to limit, and carries on the synthesis early warning, forecast the oil gas enterprise will future produce the management possible trend of development.

In summary, produces the early warning in the petroleum enterprise also mainly strongly in to produce the management to the petroleum enterprise the macroscopic monitor early warning aspect, to produces the microscopic equipment daily management early warning related literature to be very few, through the scene investigation and study, discovered forewarns in the crude oil production process also mainly is concentrates in to forewarns the target the dynamic monitoring aspect.

#### Contents of this article

Based on dives the oil electric pump may obtain the nature in our country oil field mining important status as well as the research data, this article research take dives the oil electric pump well as the object of study, has screened 120 achievement research sample, simultaneously, in profits from the predecessor research results fully in the foundation, after had determined reasonable sample and target, uses the method which the multi-dimensional return and the principal components analysis unifies to construct based on 7 commonly used target return early warning models, then to dives the oil electric pump breakdown well to carry on the forecast analysis. Causes the model establishment above the credible mathematical foundation, the early warning effect is more ideal, and the model is simple. May carry on the breakdown early warning well for the oil field enterprise interior, and provides the daily management and the policy-making basis for the oil field enterprise system.

#### THE REGRESSION ANALYSIS AND FAILURE EARLY WARNING MODEL FOR ESP

##### The Regression Analysis

The Regression Analysis is studies between two variables or many variables the causal relation statistical method, mainly is hoped whether between the discussion data has one kind of specific relations. Its

basic thought is, in the correlation analysis foundation, to has the correlational dependence two or between the many variables the quantity change general relations carries on the determination, establishes an appropriate mathematical model, in order to infers another unknown quantity from a known quantity. The regression analysis mainly manifests in following several points:

1. Regression analysis research variable has division of by explanatory variable and the explanatory variable.
2. In regression analysis by the explanatory variable is the random variable, but explanatory variable right and wrong stochastic, a regression analysis important goal is through the explanatory variable which assigns forecasts by the explanatory variable.
3. Regression analysis may through a mathematical expression determine between the variable is connected concrete form. The return model general form is:

$$Y = F(X) + \varepsilon$$

In which:  $Y$  Is the dependent variable,  $X$  is the independent variable,  $\varepsilon$  is the random error.

The general situation, has one independent variable and  $k$  dependent variable, the dependent variable value may decompose is two parts: A part is by the independent variable influence, namely expression for independent variable function, in which function form known, but contains some unknown parameters; Another part is because other had not been considered factor and random influence, namely random error. When function form for unknown parameter linear function, calls the linearity regression analysis model; When function form for unknown parameter nonlinear function, is called the non-linear regression analysis model. When the independent variable integer is bigger than is called the multi-dimensional return, when the dependent variable integer is more than one is called the multiple regressions[5].

Regression analysis step:

1. Basis forecast goal, definite independent variable and dependent variable;
2. Establishment return forecast model  
Carries on the computation based on the independent variable and the dependent variable history statistical data, establishes the regression analysis equation in this foundation, namely regression analysis forecast model;
3. Carries on the correlation analysis;
4. Examination return forecast model, the computation forecasts the error

Return forecast model whether available in actual forecast, is decided in to returns the forecast model the examination and to forecasts erroneous the computation. the regression equation only then through each kind of examination, also the forecast error is

small, can carry on the regression equation as the forecast model the forecast;

5. Calculates and determines the forecast value

Using the return forecast model computation forecast value, and carries on the generalized analysis to the forecast value, determines the final forecast value.

### Failure early warning model for ESP

The electric pump well running status dives the oil electric pump system efficiency test result and the fundamental research all indicated that, dives the oil electric pump well system efficiency and the oil well flowing tubing head pressure, the flowing casing pressure, the well fluid, the working fluid level, and the gas oil ratio and so on many factors concerns. Therefore, dives the oil electric pump well system efficiency is a function of many variables. Dives the oil electric pump extraction system failure type because dives the oil electric pump work particularity, dives the oil pump, the separator, the protector, the electrical machinery and the electric cable all works in the mine shaft. Factor and so on subsurface temperature, mine shaft pressure, depth of plunger, actuating medium changes can affect the unit the working efficiency. Therefore, in dives in the oil electric pump well production movement process, always inevitably appears like this or such breakdown, enables the electric pump the normal work, affects its oil pumping effect and the equipment revolution life.

Dives the breakdown which the oil electric pump well appears to be possible to divide into [1]: One, when appears the breakdown, the electric pump unit can revolve, this includes three kind of common breakdowns: ①The pumpage low or is equal to the zero. ②The running current is high. ③The running current is not balanced. Two, when appears the breakdown, dives the oil electric pump unit not to be able to revolve, also includes three kind of breakdowns: ①The unit cannot start the revolution. ②Overload engine off. ③Owes carries the engine off. Dived oil electric pump these breakdowns to be able through to analyze in its production movement process frequently each kind of production parameter to obtain discovered in anticipation, thus avoided some like burning the pump and so on the significant accident to send the matter, reduced the economic loss and lengthens the operation hours.

Dives the oil electric pump well operating mode analysis key production parameter in to dive in the oil electric pump well production process, must obtain the essential data material includes: The daily production liquid volume, produces the spirit, the well fluid direct reflection oil well produces the fluid ability, with the pump fixed displacement contrast, may know the pump the displacement efficiency. The liquid volume suddenly increase or reduces all needs further to analyze the reason. The flowing tubing head pressure, the back

pressure may reflect the oil deposit drives the oil ability as well as oil line unobstructed. Watery, sandy, through sample chemical examination analysis crude oil watery and sandy. The working fluid level, tests the oil well working fluid level curve using the depth recorder, and calculates sets out the liquid level depth. Through the working fluid level can reflect the oil well supplies the fluid ability. The electric current, the voltage, record the electrical machinery running current, the voltage, understands the electric pump unit the running status.

### RESULTS AND DISCUSSION

This article according to dives the oil electric pump well production movement management reality, selects 11 oil well daily management target to take the early warning target, as studies the sample take some oil field some extraction factory 120 electric pump well, conducts the early warning research to the breakdown well.

#### The study sample and the selected indicators

Because dives the oil electric pump work particularity, dives the oil pump, the separator, the protector, the electrical machinery and the electric cable all works in the mine shaft. The normal temperature well subsurface temperature in 40-50°C, the high temperature well subsurface temperature is generally highest may achieve 180°C; The mine shaft pressure is 2-12MPa, the external environment pressure is big, is generally 10-50MPa; The depth of plunger may be 500-3000m; Actuating medium besides crude oil, but also has the water, the natural gas, the granulated substance, filthily, even also possibly has the cement blocks. Therefore, because because the above working conditions particularity, simultaneously transports, the construction and the management and so on the human factor influence, dives the oil electric pump breakdown comprehensive probability to be high.

Responded the electric pump unit running status the target mainly for reflected the oil well produces the fluid ability the daily production liquid volume; Reflected the oil deposit drives the oil ability as well as oil line unobstructed the flowing tubing head pressure, the back pressure; Responds the crude oil basic condition the watery, sandy; Recording electrical machinery targets and so on running status electric current, voltage.

This article take some oil field some extraction factory from January, 2010 to September, 2013 electric pump well production data as a sample, the initial selection is used the most frequent efficiency, the head pressure, the casing pressure, the back pressure, the daily oil, the watery and so on 11 targets took the research variable, the concrete target name and the variable code see Table 1.

**Table-1: Variable Code**

NO.	NAME	CODE	NO.	NAME	CODE
1	Efficiency	BX	7	Daily oil	RCYL
2	head pressure	YY	8	Day water	RCSL
3	Casing pressure	TY	9	Sample watery	QYHS
4	Back pressure	HY	10	watery	HS
5	Electric current	SXDL	11	Concentration	CCYND
6	Daily Liquid	RCYL1			

**Filter indicators**

Excessively are many as a result of the initial selection target, has some not to have the remarkable separating capacity target, will be able to cause the model to appear the deviation, therefore will first have to reject the partial significance not big target; At the same time, between various targets possibly can have the reciprocity, the direct use can reduce the model the forecast result. This article uses the method which

returns gradually to the dependent variable to carry on screening, selects to the well fluid influence obviously decides the upward electric current, the back pressure, the flowing casing pressure, the flowing tubing head pressure and so on 7 dependent variable, and by this construction return model.

**Regression model**

**Table -2: Coefficient<sup>a</sup>**

model	Non-standardized coefficients		standardized coefficients	t	Sig.	95.0% Confidence interval of B		Collinearity Statistics	
	B	standardized error				down	up	Tolerance	VIF
(Constant)	-4.362	.163		-26.725	.000	-4.682	-4.042		
TY	4.995	.461	.398	10.846	.000	4.091	5.898	.158	6.336
BX	.052	.002	.406	22.969	.000	.048	.057	.682	1.466
CCYND	.001	.000	.118	6.725	.000	.000	.001	.689	1.452
YY	-6.003	.491	-.680	-12.229	.000	-6.966	-5.040	.069	14.526
HY	7.603	.737	.777	10.320	.000	6.157	9.048	.038	26.644
SXDL	.009	.004	.042	2.020	.044	.000	.018	.484	2.066

a: the dependent variable /RCYL

**Regression model:**

$$Y = 0.777X_1 + 0.398X_2 - 0.680X_3 + 0.042X_5 + 0.406X_6 + 0.118X_7$$

where: Y:RCYL X1:HY; X2:TY; X3:YY; X5:SXDL; X6:BX; X7:CCYND

So-called goodness of fit, is refers to the sample observed value to gather around the sample return line the close degree, also has reflected the regression

equation to by the explanatory variable explanation degree. The judgment return model goodness of fit most commonly used target is may definitely the coefficient.

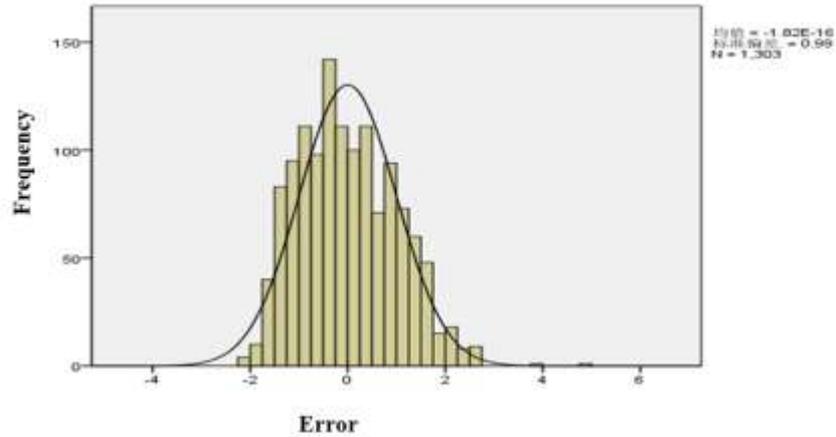


Fig-1: Histogram

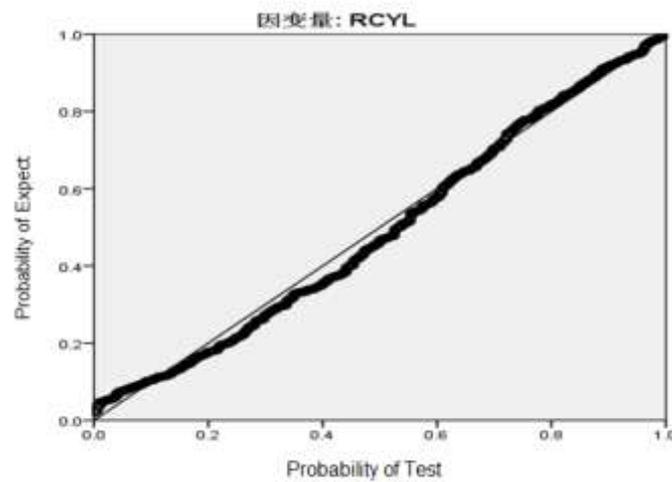


Fig-2: P-P of Standardized Error

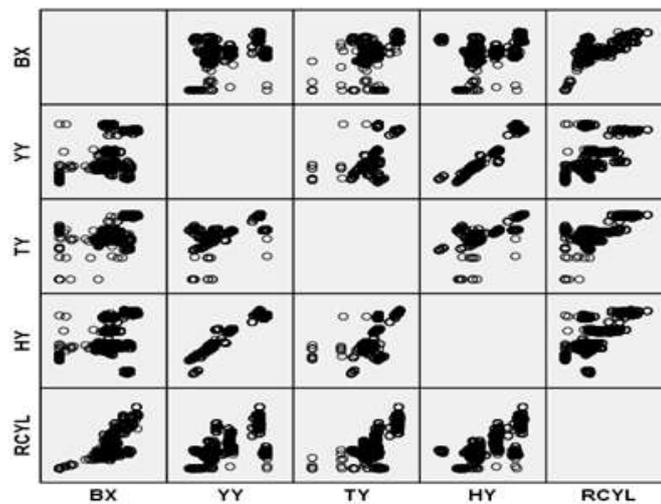


Fig-3: Variable Collinearity

**CONCLUSION**

This article uses the data comes from, the modelling has the strong forecast ability, distinguishable ability reaches as high as 92.5%, the result is ideal. And in the forecast target choice process

may discover profit ability, the cash current capacity, debt redemption ability and the growth ability four kind of financial norms to distinguished the enterprise credit risk effect is remarkable. However this article also has very many deficiencies, first the service data completely

for Gansu Province's small and medium-sized enterprise, when carries on the analysis to other local small and medium-sized enterprise, the model perhaps can have certain limitation; Next this article has only studied 6 early warning targets, includes all financial norm and the non-financial norm by no means, moreover as a result of the collection material way limit, regarding very has may affect the enterprise credit condition the target not to integrate the research. Regarding above question, waits for in later research work to be able to continue to discuss.

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