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Modelling and Simulation on Shearer Self-adaptive Memory Cutting

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Abstract

Automation of shearer is the key point to realize the fully mechanized coal face. According to the complicated geological condition in our country, this paper built a shearer self-adaptive memory cutting model based on fuzzy control theory. This model contains shearer positioning system and fuzzy control system which can get the message of shearer's position and attitude at any point, trace the memorial cutting path automatically, judge whether the shearer cuts rocks based on fuzzy control theory and find the optimal scheme. The author simulated the working environment in laboratory and factory, did experiment to test whether the model can adapt complicated geological condition in the coal mine. The simulation results show that the model can realize the shearer memory cutting and discriminate the abnormal state, then adjust the drawing speed and drum height self-adaptively which can satisfy the control requirements under the complicated geological condition.

Keywords: shearer; fuzzy control; modelling; simulation

1. Control model of shearer self-adaptive memory cutting

For the shearer there are two important movements when it working: the horizontal reciprocating motion and the longitudinal direction of the rocker arm movements. The former corresponds to the speed of traction motor, and the latter corresponds to the telescopic amount of the height adjusting oil cylinder. So the mining machine control is mainly determined by the traction motor and the height adjusting oil cylinder. Conventional memory cutting technology requirements of shearer arm dropping immediately when cutting to the rock, so as to avoid the cutting motor blocking or cutting tooth fracture. As the electric power increases and the cutting tooth material improvement, it makes the shearer can be cut

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directly on the general hardness of rock. So in this scheme, the controller can not only identify whether or not cutting into the rock, but also able to determine whether to allow the direct cutting according to the coal mining machine of the sensing data. The control model of shearer self-adaptive memory cutting is shown in Fig.1, which can be divided into three stages: artificial teaching stage, the adaptive cutting stage and manual correction phase. Each stage is a relatively independent and interrelated.

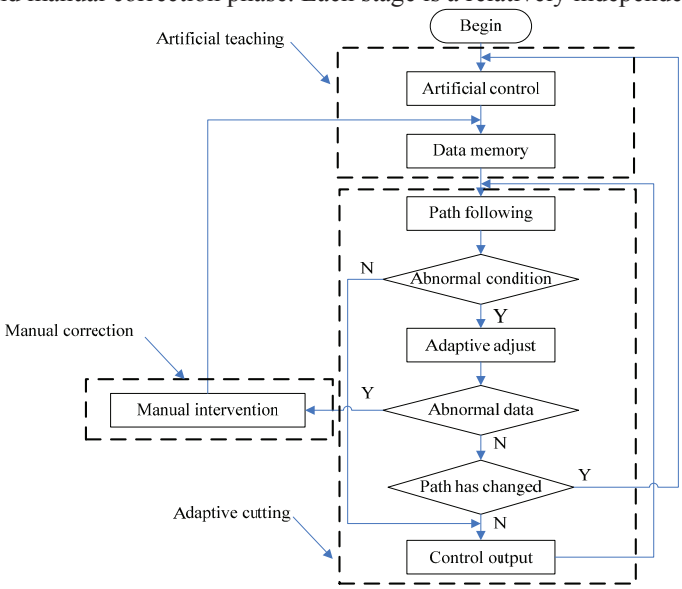

Fig.1. Control model of shearer self-adaptive memory cutting

2. Position and attitude model of shearer

Shearer position and attitude is the important information of self-adaptive memory cutting, and affect the mining machine control effect directly. Some scholars have proposed that we can use shaft encoders calculate the walking distance to locate the coal mining location, use displacement sensor get the high oil cylinder's expansion amount for attitude positioning. However, in this method as mentioned in reference [1] and [2], we can only get the relative value of the position and attitude rather than the absolute value of three-dimensional. Thus, the solution of shearer position and attitude positioning is the prerequisite and basis for achieving the adaptive cutting.

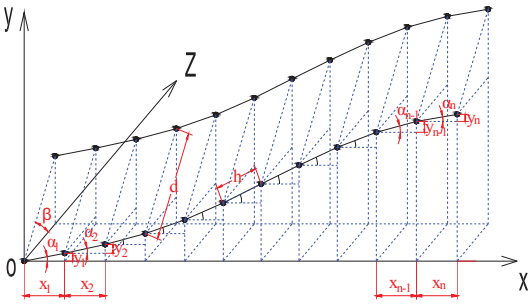

Fig.2. Model of shearer position

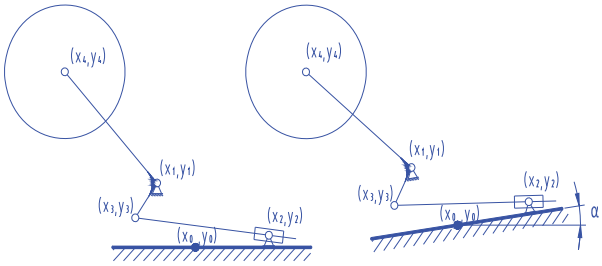

Fig.3. Model of shearer attitude

The most intuitive way to determine the position of shearer body is to get its coordinates in 3D space, and this requires solving the following problems: Select a fixed point on the shearer as a feature point for the location positioning; defined three-dimensional coordinate system; derived calculation formula of feature point's coordinates. Fig.2 shows the model of shearer position. The solid line is the arrangement of the scraper conveyor; solid dots are the hinge point of each section between the scraper conveyors.

In the case of only considering the coal mining machine horizontal angle, we can get the X axis and Y axis according to key point coordinates of a drum. Fig.3 shows the projection of the shearer hydraulic system schematic diagram of mechanism in XY plane. Fig.3 have a total of five points(0-4), the coordinates of the number i point is (x_i,y_i), that the line segment between points 2 and 3 is protrusion length of the cylinder, thick solid line is shearer body, Point 0 is the feature points used in location positioning. In Fig.3, left figure is the body's level attitude, right figure is the body attitude forwarding angle α.

3. Simulation of shearer self-adaptive memory cutting

Shearer self-adaptive memory cutting is the key point of shearer control, which contains path tracking and adaptive adjustment. Path tracking refers to that we can recover the coal mining process with manual data recorded when the operation as much as possible under the premise of the normal working state, Adaptive adjustment refers to that we can determine the shearer operating state in the process of path tracking, and take appropriate measures to adjust shearer to normal working condition depending on the situation.

3.1. Simulation of path tracking

In order to verify the practical effect of the path tracking strategy, the group developed a experiment platform of shearers memory cutting. Fig.4 shows that the platform has the same control as real shearer, and can simulate the working process. Author had a path tracking test results based on the platform of the shearer. Experimental curve from the path tracking shown in Fig.5, solid line portion is the path memory, and its solid points are memory points, including conventional point and critical point, dashed part is the actual operation path. The results show that: the path tracking strategy can be effectively tracked by the memory of the cutting path, but the inflection point in the path are still some lag, which was mainly due to that the response of height adjusting oil cylinder to the command control has a certain latency.

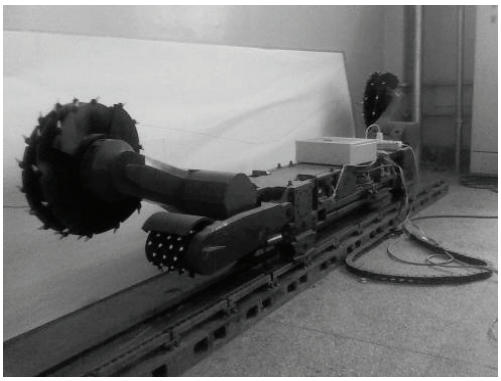

Fig.4. Experimental platform of memory cutting

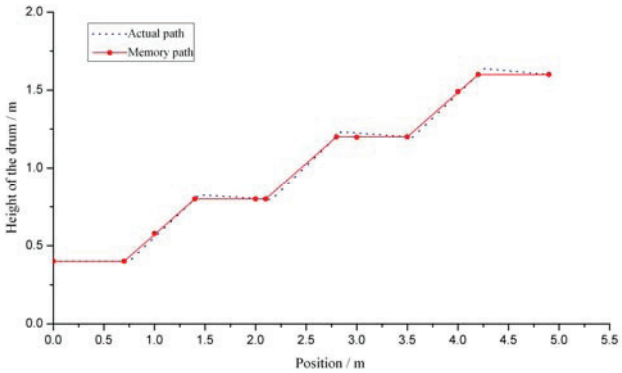

Fig.5. Path tracing curve of the shearer

3.2. Simulation of adaptive adjustment

Because of the judgment of state about shearer whether is abnormal mainly from production experience it is difficult to establish mathematical model of shearer, so this paper adopts fuzzy control method to realize shearer's self-adaptive regulation strategies. Concept of fuzzy control was firstly proposed by L.A.Zadeh professor at University of California. Its basic idea is to describe the operator's control experience with a language and variables having vague meaning. The control rules and corresponding fuzzy reasoning are constituted by a set of conditional statement. Finally we get accurate control variable through fuzzy decision. Fuzzy control as mentioned in references [3-6] has the following characteristics: there is no need to establish mathematical model of controlled object, just master knowledge, experience and data of operators or concerned expert; it has strong robustness especially apply to control of nonlinear time-varying and delay system; we describe the system not with numerical but fuzzy variable of language allowing it's easy to achieve man-machine interaction with natural language for operators. Combined with the specific circumstances, the input of the fuzzy control system including: cutting motor current and vibration amplitude of rocker arm. The universe of discourse of cutting motor current C is [0,2]; the universe of discourse of vibration amplitude of rocker arm V is [0,3]; the universe of discourse of output of fuzzy control. Theirs fuzzy subsets are {NB, NM, ZO, PM, PB} corresponding to "negative big", "negative medium", "zero", "positive medium", "positive big". The system's fuzzy control rules are shown in table1. The value of each fuzzy subset in C, V, O is determined by combining the experience of both operators and manufacturers.

Table 1. Fuzzy control rules of adaptive adjustment

O \ C / V	NB	NM	ZO	PM	PB
NB	PB	PB	PB	PB	NB
NM	PB	PM	PM	NM	NB
ZO	PB	PM	ZO	NM	NB
PM	PB	NM	NM	NM	NB
PB	NB	NB	NB	NB	NB

The authors have done the test on a simulation experiment table in Xi'an Coal mining Machinery Co., Ltd. As shown in Fig.5 this experiment table can simulate shearer working parameters at different loads. Cutting motor current and vibration amplitude of rocker arm are simulating by this system during the experiment, and then we put them into the fuzzy controller. Fuzzy controller control the traction speed of shearer based on fuzzy judgment rules. As shown in Fig.6 when cutting motor current and vibration amplitude of rocker arm are rapidly increasing the speed of traction motor is reduced controlled by fuzzy controller; with the reduction in traction speed cutting motor current and vibration amplitude of rocker arm are decreased; when the value of cutting motor current and vibration amplitude of rocker arm tend to be normal fuzzy controller no longer reduce the speed of traction motor, at this time the value of traction speed is tend to stabilized.

Fig.5. Experimental platform of shearer adaptive adjustment

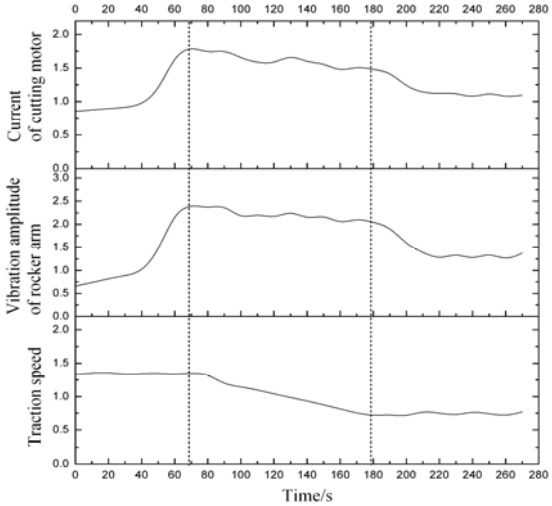

Fig.6. Effect of shearer adaptive adjustment

4. Conclusion

Memory cutting has been proven the most effectively for shearer's automatic control. In China geological conditions is very complex and coal-rock interface change rapidly so depending only on memory cutting technology is not applicable. In order to solve this problem, the author put forward a shearer self-adaptive memory cutting model based on fuzzy control theory, which contains the position model, attitude model and the fuzzy control model. At present, the path tracking was tested in experimental platform constituted by 1:6 prototype model of MG900/2210-WD AC electric haulage shearer. And the author has demonstrated the feasibility of the path tracking strategy and conducted a self-adaptive test on shearer's working parameters simulation experiment table in Xi'an Coal mining Machinery Co., Ltd. Next there will be a field experiment in coalface and further improvement will be done on this model according to the results.

References

[1] F. Xinqiu, H. Jie, Z. Bin, et al., Self-positioning system of the shearer in unmanned workface. Journal of Xi'an University of Science and Technology, 28 (2), 2008, p. 349-353.

[2] X. Huguo, "Principle and application of shearer position monitoring device," Mining & Processing Equipment, 38(11), 2007, p. 25-27.

[3] C. Kaiyuan, Z. Lei, Fuzzy reasoning as a control problem, Fuzzy Systems, 16 (3), 2008, p. 600-614.

[4] Laurent Foulloy, Sylvie Galichet, Fuzzy control with fuzzy inputs, Fuzzy Systems, 11 (4), , 2003, p. 437-449.

[5] Rodolfo E. Haber, Jose R. Alique, Fuzzy logic-based torque control system for milling process optimization, Systems Man and Cybernetics, 37 (5), 2007, p. 941-950.

[6] H.K. Lam, L.D. Seneviratne, Tracking control of sampled-data fuzzy-model-based control systems, Control Theory and Applications, 3 (1), 2009, p. 56-57.