New Energy Vehicle Acceleration Control Simulation Based on Active Disturbance Rejection Control Technoloty

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***Abstract* — In order to solve the contradiction between fast response and overshoot in new energy vehicle acceleration control, in this article, we use MATLAB to design the ADRC controller for vehicle acceleration and carry out comparative simulation experiment with PI controller, and the simulation results show that ADRC controller has the advantages of slighter overshoot, stronger and higher accuracy in vehicle acceleration control.**

Keywords - ponent; New Energy Vehicle; Acceleration Control; ADRC

I. INTRODUCTION

Active disturbance rejection control (ADRC) is a control technology proposed by Professor Han Jingqing in the late 1980s. By absorbing the core idea of PID control and combining the achievement of modern control theory, ADRC technology has been proved to be of great practical value. Moreover, it does not depend on the accurate mathematical model of the controlled object, so it is regarded as novel practical digital control technology.

With the increasingly prominent environmental issues, the auto industry is playing a key role in environmental protection. In new energy vehicle, electricity is used as energy source, which be transformed from hydro, wind, solar, biomass and other renewable energy, so it could not only reduce the consumption of fossil energy, but also reduce emissions of harmful substances. However, to a certain extent, the development of automatic control technology has restricted the popularization of new energy vehicles. For acceleration control of new energy vehicles, there is contradiction between fast response and overshoot. Here we use MATLAB to design the ADRC controller for vehicle acceleration and carry out comparative simulation experiment with PI controller, and the simulation results show that ADRC controller has the advantages of slighter overshoot, stronger and higher accuracy in vehicle acceleration control.

II. ACTIVE DISTURBANCE REJECTION CONTROLLER DESIGH

A. *ADRC Controller Structure*

Active disturbance rejection controller is composed of tracking differentiator (TD), extended state observer (ESO) and nonlinear state error feedback (NLSEF). Functions of the three parts are:

1) TD arranges the transition process to realize the fast non-overshoot tracking of the system input signal, and extract its differential signal.

2) ESO can estimate the state and uncertain disturbance of the system, and take the uncertainty of the system's own model as the internal disturbance, and regard the combined effects of internal and external disturbances as the general disturbance.

3) NLSEF determines the nonlinear combination of the error between the transition process and the state estimation, and compensate for the general disturbance of the system.

ADRC not only compensates the system internal parameters and the disturbance of the model, but also suppresses the external disturbance, with strong robustness and achievability. A typical structure of ADRC controller is shown in Figure 1:

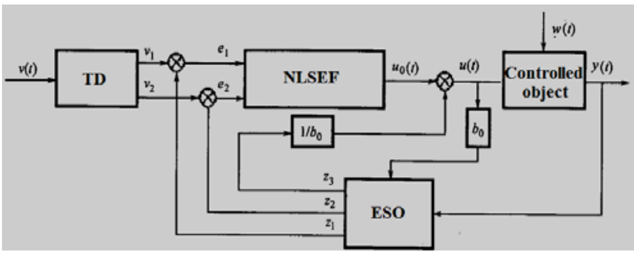

Figure 1. Typical structure of ADRC controller.

In Figure 1, *w(t)* is unknown disturbances; *u(t)* is control amount; *x* is system state variable, which is directly measurable or indirectly measurable.

B. *ADRC Controller Simulation Model*

MATLAB provides a convenient graphical programming for control system. Here we use MATLAB to build vehicle acceleration controller simulation model, and generate dynamic link library file to encapsulate the corresponding application into separate ADRC module library. The internal structure of ADRC controller simulation model is shown in Figure 2:

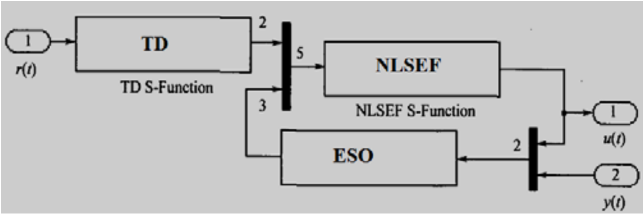

Figure 2. Internal structure of ADRC controller simulation model.

III. VEHICLE ACCELERATION CONTROL SIMULATION

Based on the principle of ADRC, we design the ADRC controller for new energy vehicle acceleration, and create a simulation model by MATLAB. In addition, in order to further analyze the performance of ADRC controller, we also carry out simulation of vehicle acceleration PI controller, and make comparative analysis of the two simulation results.

A. ADRC Acceleration Controller Simulation

First of all, consider the relatively simple case, that is, the speed of electric vehicle is maintained within a certain range. Within this range, the rotary mass coefficient of the vehicle is maintained at 1.02.

In order to verify the ability of ADRC controller to restrain disturbance, we exert perturbation at steady state and observe the dynamics of the system. In the simulation experiment, as the given expected acceleration is step signal of 0.1 in amplitude, a gate signal of 2 in amplitude appears at 4s~6s (output reaches a stable value at 4s), while the amplitudes are 0 at other times, as show in Figure 3:

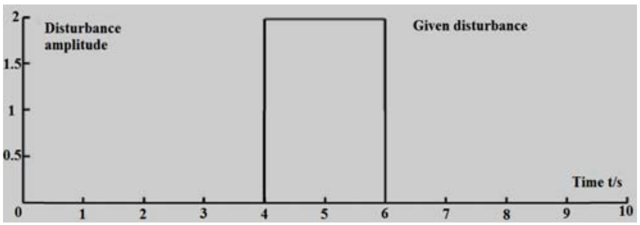

Figure 3. Interference signal.

The simulation result of the ADRC controller is shown as Figure 4:

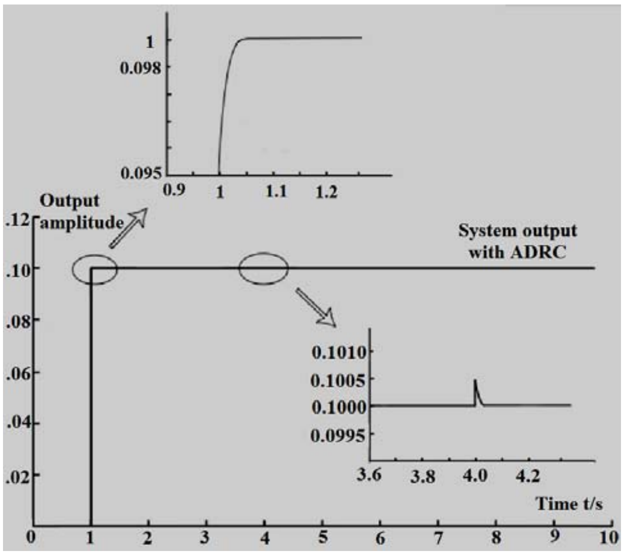

Figure 4. System output with ADRC controller of 0.1 in amplitude.

We can see from the simulation result that: the system output rise time is 0.025s, without overshoot; fluctuation of 0.0005 in amplitude appears at 4s and 6s, but it callbacks after 0.03s. The simulation result suggests that when the system is disturbed in steady state, the ADRC controller can quickly play a role of disturbance suppression.

Similarly, we also carry out another group of simulation when the speed change range is large, and the given expected acceleration is step signal of 1 in amplitude at this time.

Since the vehicle rotating mass coefficient varies with the change of the vehicle speed, conforming to the formula as follow:

$$\delta = \begin{cases} K_1 & (v(t) \le x_1) \\ K_2 & (x_1 < v(t) \le x_2) \\ K_3 & (x_2 < v(t) \le x_3) \\ K_4 & (x_3 < v(t) \le x_4) \\ K_5 & (x_4 < v(t)) \end{cases} \quad (1)$$

In the formula, $x_1 \sim x_4$ are constants, and their values in simulation are as follow:

$$\delta = \begin{cases} 10 & (v(t) \le 1) \\ 8 & (1 < v(t) \le 3) \\ 6 & (x_2 < v(t) \le x_3) \\ 1.02 & (x_3 < v(t) \le x_4) \\ 0.02 & (x_4 < v(t)) \end{cases} \quad (2)$$

Now, the system output with ADRC controller is shown as Figure 5:

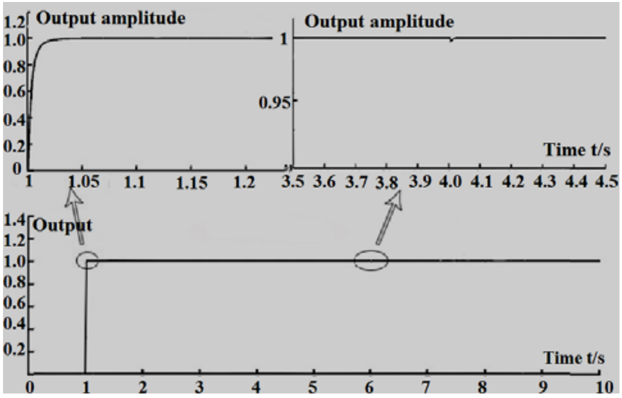

Figure 5. System output with ADRC controller of 1 in amplitude.

B. *PI Acceleration Controller Simulation*

To make the comparison more reasonable, simulation conditions of PI controller are set as the same as that of ADRC controller, and adjust the parameters until system output dynamic performance of the two controllers are the same. Then the system output with PI controller is shown as figure 6:

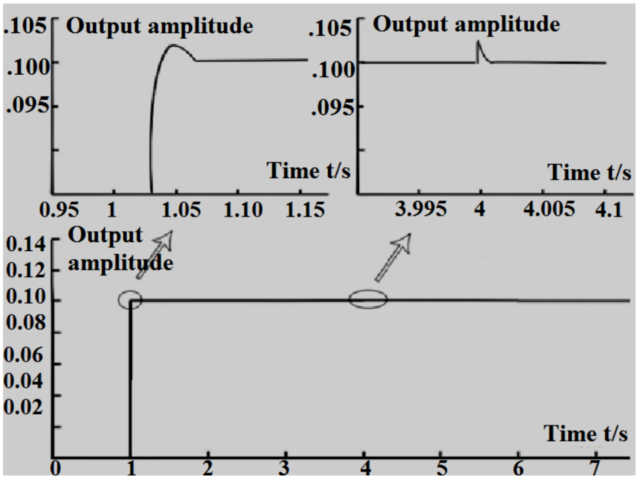

Figure 6. System output with PI controller of 0.1 in amplitude.

The simulation results show that under same simulation conditions, the system recovery time with PI controller is longer than that with ADRC controller when it is disturbed.

The main performance indicators of PID control system output are: the rise time is 0.03s, with slight overshoot of 0.2%; fluctuation appears at 4s~4.3s, and the wave peak value varies from 0.003 to 0.0023, and drops to 0 at 4.3s; the amplitude changes by 0.005 at 6s, and callbacks to the steady state after 0.3s.

In controller system, it not only needs god disturbance rejection performance, but also needs good system dynamic performance. So we consider adjusting the PI parameters until its disturbance rejection performance is equivalent to that of ADRC controller, and then observe its dynamic performance. However, the simulation results show that, increasing the P value of PI controller can shorten the adjusting time, but still unable to achieve the effect of the ADRC controller. Moreover, when the P value goes beyond a certain value, the system will become unstable, and once the adjusting time is shorten, system dynamic performance will be worse, and overshoot will be large and even cause shocks.

C. *Comparative Analysis*

Repeatedly change system input and disturbance, and compare the system output of ADRC controller and PID controller, and then we can conclude as follow:

1) ADRC controller has faster convergence rate and stronger disturbance rejection ability. At the same dynamic performance, ADRC controller can eliminate the influence of disturbance to the system in a shorter time, while the adjustment process of PID controller is much slower than ADRC controller.

2) ADRC controller mediate the conflict between the response speed and overshoot in PID controller, and with the same adjustment time, ADRC controller would not cause overshoot (or the overshoot is slight), but PID controller is likely to cause large overshoot.

III. Conclusion

In this article, we build a simulation model for new energy vehicle acceleration using MATLAB, and then make comparative analysis on the system dynamic performance and the disturbance rejection ability respectively with ADRC controller and PID controller. The simulation results and comparative analysis suggest that, comparing to PID controller, ADRC controller has the advantages of slighter overshoot, stronger and higher accuracy. Therefore, utilizing ADRC controller to control the acceleration of new energy vehicles could effectively improve the acceleration performance.

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