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| **Title** |
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| **Abstract**：[Objective] The net buoyancy of the deep-sea self-holding intelligent buoy (DSIB) will change with depth due to pressure hull deformation in the deep submergence process. The net buoyancy changes affect the hovering performance of the DSIB. To make the DSIB have better resistance to the external disturbances caused by the net buoyancy and water resistance, a depth controller was proposed to improve the depth positioning based on the active disturbance rejection control (ADRC). [Method(detialed)] Firstly, a dynamic model was established based on the motion analysis of the DSIB. In addition, the extended state observer (ESO) and nonlinear state error feedback controller were designed based on the Lyapunov stability principle. Besides, semi-physical simulations for the depth control process were made by using the ADRC depth controller and traditional PID depth controller separately. [Result] The results of the semi-physical simulations indicate that the depth controller based on the ADRC can achieve the predefined depth under the external disturbances. Compared with the traditional PID depth controller, the overshoot of the ADRC depth controller is 1.74%, and the depth error is within 0.5%.[Conclusion] It has a better control capability to restrain the overshoot and shock caused by the external disturbances. The research of this control method has certain significance in improving the DSIB's intelligence under the depth-following task．  **Keywords**：deep-sea self-holding intelligent buoy (DSIB)；active disturbance rejection control (ADRC)； depth control；buoyancy change；pressure hull deformation |

**CLD number:** TP273

**0 Introduction**

In the actual chemical production process, the monitoring of product quality standards and environmental pollution has attracted increasing attention in recent years. However, effective control strategies are needed to achieve product quality control and implement environmental monitoring[1]. Therefore, it is particularly important to monitor the vital variables in the chemical process. But, under the existing technical conditions, they are difficult to measure directly or are not suitable for fast on-line measurement. They can only indirectly guarantee the quality requirements by controlling other measurable variables.

Data-driven soft sensor modeling method has been successfully applied[4-7], but now it faces some challenges, such as over-fitting, stability, robustness and complexity of learning process. In order to solve the above difficulties, such as neural network, fuzzy logic, support vector machine, wavelet analysis and non-linear filter, etc., have been used in soft sensor modeling research[8-16]. Neural network[11,14], support vector machines(SVM)[9,12] and other computational intelligence models are the main modeling tools.

**1 Text**

**1.1 Formulae**

If the N pairs of data (xl, yl) in the data set are given, and l=1, ..., N. The descriptor variable matrix and the response variable matrix are defined respectively as

 (1)

In order to facilitate the design of the controller, the variables are defined as

 (2)

where is the reference speed given by PMSM, and is the actual running speed of PMSM.

**The power balance constraint is**

** (3)**

**whereis load power at time t.**

**1.2 Figure**

The scheduling result of scenario 1 is shown in Fig .1.

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**Fig.1 Relationship between quadratic drag and linearized drag**



**Fig.2 Depth control curve under different controllers in relatively shallow water**

**1.3 Table**

Table 1 presents the non-dynamic parameters of the DSIB.

**Table 1 Non-dynamic parameters of DSIB**

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Value | Unit | Description |
| *M* | 52.39 | kg | Total mass of DSIB |
| *g* | 9.8 | m/s2 | Acceleration due to gravity |
| *V*f | 0.0504 | m3 | Volume of DSIB |
| *C*d-up | 0.77 |  | Drag coefficient as DSIB ascending |
| Cd-down | 0.7 |  | Drag coefficient as DSIB diving |
| *A* | 0.301 | m2 | Projected area of hull |
|  |  | kg/m3 | Seawater density at a set depth scope |
| *Q* |  | m3 | Hydraulic oil volume of external bladder |

**2**  **Conclusion**

In this study, a buoyancy-driven deep-sea intelligent float was the object of research interest. Based on the pressure hull deformation of the DSIB, the dynamic model of the DSIB was modeled. In order to realize depth control process from the initial depth to the target depth, a depth control strategy based on ADRC method was proposed. The stability of the designed ADRC depth controller was proved by Lyapunov stability principle. Finally, the designed depth controller was verified by the semi-physical test platform. The depth controller based on ADRC method has better response ability and anti-jamming effect in comparison to the PID algorithm. The designed depth controller provides a stable operation condition of the marine sensors carried by the DSIB, and ensures the high-precision data acquisition of the DSIB on the ocean environment observation of a target depth. Since ADRC depth controller has various parameters and complicated setting process, the optimization method of ADRC needs to be further studied. In addition, the designed depth controller can be applied to the actual experiments to further verify the effectiveness of the method.

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| **摘 要：[目的]** 深海自持式智能浮标在下潜过程中，随着深度增加将会引起浮标壳体形变，使得浮标的自身净浮力产生变化，而浮标净浮力的变化将会影响浮标的定深性能。为了使浮标在实际定深工作中更好地抵抗净浮力和水阻力所构成的外部干扰，提出基于自抗扰控制方法设计定深控制器以提高深度定位效果。[方法（详细）] 首先，通过分析浮标的运动过程，建立了动力学模型。然后，基于李雅普诺夫稳定性原理来设计扩张状态观测器和非线性状态误差反馈控制器。将所设计的自抗扰深度控制器与基于传统的PID方法的定深控制器进行了半实物仿真实验对比。 [结果] 仿真实验结果表明，基于自抗扰控制技术的深海智能浮标深度控制方法能够实现准确定深跟踪控制，同时，相比于传统PID控制器，自抗扰深度控制器的超调量为 1.74%，深度误差控制在 0.5%以内。[结论] 自抗扰深度控制方法能够更有效地抑制净浮力和水阻力共同干扰下所造成的超调和震颤等现象，具有更优的控制效果。该控制方法的研究对提高深海自持式智能浮标在进行深度跟踪任务时的智能性具有一定意义。（英文摘要包括目的、方法、结果、结论，方法阐述要详尽）  **关键词：**深海智能浮标；自抗扰技术；深度控制；浮力变化；耐压壳体形变  引用格式：WANG Yangmin, Author, Author, et al. A method of ... . Journal of Measurement Science and Instrumentation, 2021, 12: 00-00. |

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