III Congresso Brasileiro em Engenharia de Sistemas em Processos (PSEBR 2024)
29 a 31 de Julho de 2024, São Paulo-SP, Brasil.

From Theory towards Practice: A lab rig experimental study of Health-Aware Control for Subsea Oil Operations

Jose Matias[a,b*], Johannes Jäschke[b]

[a]*Department of Chemical Engineering, KU Leuven, Sint-Katelijne Waver, Belgium*
[b]*Department of Chemical Engineering, NTNU, Trondheim, Norway*
**jose.matias@kuleuven.be*

ABSTRACT

A natural trade-off exists between optimizing production levels and minimizing equipment degradation, as exemplified in oil wells. While maximizing oil extraction is desirable, increased throughput often accelerates equipment wear and tear. To address this trade-off, we advocate for the adoption of a health-aware controller (HAC) (Escobet et al., 2012). This controller integrates production optimization methods with equipment health monitoring in a receding horizon model predictive control approach. By incorporating system health considerations into its design, the controller aims to maximize economic performance while proactively preventing unexpected breakdowns. The objective is to avoid faults altogether rather than only reacting when a fault occurs.

This concept has been explored in prior research, such as by Verheyleweghen et al. (2018) and Bernardino et al. (2020), although predominantly in simulated environments. To assess the practicality of such a controller, we developed a laboratory-scale setup emulating a subsea oil well with a degrading choke valve. Then, we implemented a receding health-aware controller within this setup to illustrate its primary benefits and implementation challenges.

In our implementation, we utilized a rigorous first-principles model to capture the hydraulic behavior of the system, while employing a simplified surrogate model for predicting system degradation. Experimental findings indicate that, despite approximating the degradation dynamics, the receding horizon strategy, in conjunction with plant feedback, effectively balances the trade-off between economic performance with maintenance considerations, and yields good overall results. We further discuss how we combined the conflicting objectives of maximizing production and minimizing degradation, and also how we dealt with the different time scales between the economics and degradation in our experimental implementation.

.

Keywords: Health-aware controller; Prognostics and Health Management

References

Bernardino, L. F., Souza, A. F. F. D., Secchi, A. R., de Souza Jr, M. B., & Barros, A. (2020). Integration of Prognostics and Control of an Oil/CO2 Subsea Separation System. Processes, 8(2), 148.

Escobet, T., Puig, V., & Nejjari, F. (2012, July). Health aware control and model-based prognosis. In 2012 20th Mediterranean Conf. on Control & Automation (pp. 691-696).

Verheyleweghen, A., Gjøby, J. M., & Jäschke, J. (2018). Health-aware operation of a subsea compression system subject to degradation. In Computer Aided Chemical Engineering (Vol. 43, pp. 1021-1026). Elsevier.