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Development of a control strategy for a self-stop valve in production wells

Desarrollo de una estrategia de control para una válvula de autocierre en pozos de producción

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Abstract:

One of the primary challenges in automated oil wells is maintaining operational continuity during abrupt pressure fluctuations that cause unscheduled shutdowns. Traditional continuous PID control schemes fall short when process dynamics become highly variable, while advanced alternatives like Managed Pressure Drilling (MPD) remain expensive and complex to implement. This paper presents an event-based alternative using operational severity levels to control choke valves. The architecture combines PLC control, SCADA supervision, alarm escalation, and a progressive reopening strategy to manage critical events autonomously. During field testing, the system recorded 62 automatic interventions without plant shutdowns, achieving response times under 3 seconds and recovery rates above 90% during transient events. This shows that it is possible to stabilize the process and reduce operator dependence, but not eliminate it from the operation, through a practical solution that's easy to integrate into existing plants.

Keywords: event-based control, operational resilience, choke valves, automation, industrial automation, PLC control, SCADA systems, oil production systems, adaptive recovery.

Resumen:

Uno de los mayores retos en los pozos petroleros automatizados es mantener la continuidad de la operación frente a los cambios repentinos de presión que provocan paradas no programadas. Los esquemas tradicionales de control PID continuo se quedan cortos cuando el proceso se vuelve muy dinámico, mientras que alternativas avanzadas como la perforación con presión controlada (MPD) resultan costosas y difíciles de implementar por su complejidad técnica. En este artículo se presenta una alternativa basada en eventos y niveles de severidad operativa para operar válvulas de estrangulación (choke valves). El desarrollo combina controladores PLC, supervisión SCADA, escalamiento de alarmas y una reapertura gradual para controlar eventos críticos de forma autónoma. Durante las pruebas en campo, la arquitectura registró 62 intervenciones automáticas sin paros de planta, reaccionando en menos de 3 segundos y logrando una recuperación superior al 90 % en eventos transitorios. Esto demuestra que es posible estabilizar el proceso y reducir la dependencia del operador mas no eliminarlo de la operación mediante una solución práctica y fácil de integrar en plantas existentes.

Palabras clave: control basado en eventos, resiliencia operativa, automatización de válvulas de estrangulación, automatización industrial, control PLC, sistemas SCADA, sistemas de producción de petróleo, recuperación adaptativa.

INTRODUCTION

In the oil industry, automating production processes has become indispensable for keeping plants operating continuously, avoiding costly stoppages and reacting in time to process variations [1]–[3]. Implementing autonomous control schemes therefore helps make facilities more stable and less dependent on constant human supervision in day-to-day operations[1],[2].

Operational problem

Keeping wells producing without interruption is a complex task, especially when pressure surges or unexpected flow variations occur [4]–[10]. In these highly variable scenarios, conventional control systems may be unable to react in time, which ultimately leads to unplanned shutdowns, crude losses and the need for manual operator intervention[1],[2],[6],[8].

Problems such as overpressures, sudden changes in separator levels and the fluctuations inherent to multiphase flow are among the causes of operational instability in the field [6]–[10]. Besides wearing out equipment, these failures reduce continuity and affect overall productivity. For this reason, the sector increasingly seeks automated solutions that absorb these disturbances and reduce the need for manual maneuvers at the well [1]–[5].

State of the art

Most production systems in the industry operate through traditional PID loops designed to regulate pressure and flow rate continuously[13],[14]. Although they perform adequately in steady state, this type of control can show limitations when rapid transients, nonlinearities or abrupt changes arising from multiphase flow within the well occur[6],[13],[14].

Under severe process variations, conventional strategies may react with delay or show reduced performance, which can cause pressure oscillations and force field personnel to intervene manually[6],[13],[14]. This lack of rapid response increases the risk of shutdown-related stoppages, reducing system availability and complicating the restoration of operating conditions[1],[2], [8]–[10].

To address this, advanced technologies exist, such as managed pressure drilling (MPD) control, predictive schemes and intelligent algorithms that can damp disturbances and control critical process variables [15]–[21]. However, these alternatives may require additional infrastructure, more complex mathematical models and a high level of computation, which can hinder their adoption in conventional fields or facilities [17]–[21].

Under these conditions, event-based control is a practical option for managing discrete disturbances without continuously executing control actions [22]–[24]. By executing actions only when the variable exceeds certain thresholds or critical conditions, a rapid response can be achieved, with fewer control actions and without necessarily requiring the complexity of an advanced predictive model [22]–[24].

Scientific gap

Despite advances in the automation of oil facilities, the reviewed literature leaves a gap regarding how to integrate tiered severity classifications with gradual recovery mechanisms in real industrial infrastructures [1]–[24].

Most of the studies analyzed focus on continuous, predictive, robust, or adaptive control schemes to respond to abrupt changes and nonlinear phenomena of multiphase flow[6], [13]–[21]. This work therefore proposes a hybrid supervision architecture that combines event-based logic with adaptive reopening of the choke valve, contributing to the prevention of plant shutdowns without necessarily resorting to highly complex predictive models for field processing [22]–[26].

Contribution of the work

To address this problem, this work proposes an autonomous event-based control strategy that classifies faults by severity level in oil production systems. The system combines PLC logic, SCADA supervision, and a gradual recovery scheme to automatically regulate the opening of the choke valve in response to process variations.

The main contributions of this research are summarized below:

1. Design of an event-based control: A control logic was developed to respond automatically to transient disturbances in multiphase flows.

2. Classification by severity: A tiered scheme was implemented that adjusts the actions on the choke valve according to the severity of the disturbance in real time.

3. Gradual recovery mechanism (Slow Recovery): A staged reopening strategy was designed to avoid pressure surges and prevent alarms from being reactivated after the fault is controlled.

4. Standard and industrial architecture: The solution was integrated on commercial hardware (PLC-HMI-SCADA), which facilitates its implementation through retrofit in existing facilities without changing the infrastructure.

5. Field validation: The system was tested in real operation, achieving response times of less than 3 seconds and automatic recovery above 90 %, and reducing plant shutdowns by more than 45 % compared with traditional control.

The figure shows how the reading of process variables, the PLC logic structured by severity, the SCADA/HMI supervision, and the gradual adjustment of the choke valve are integrated.

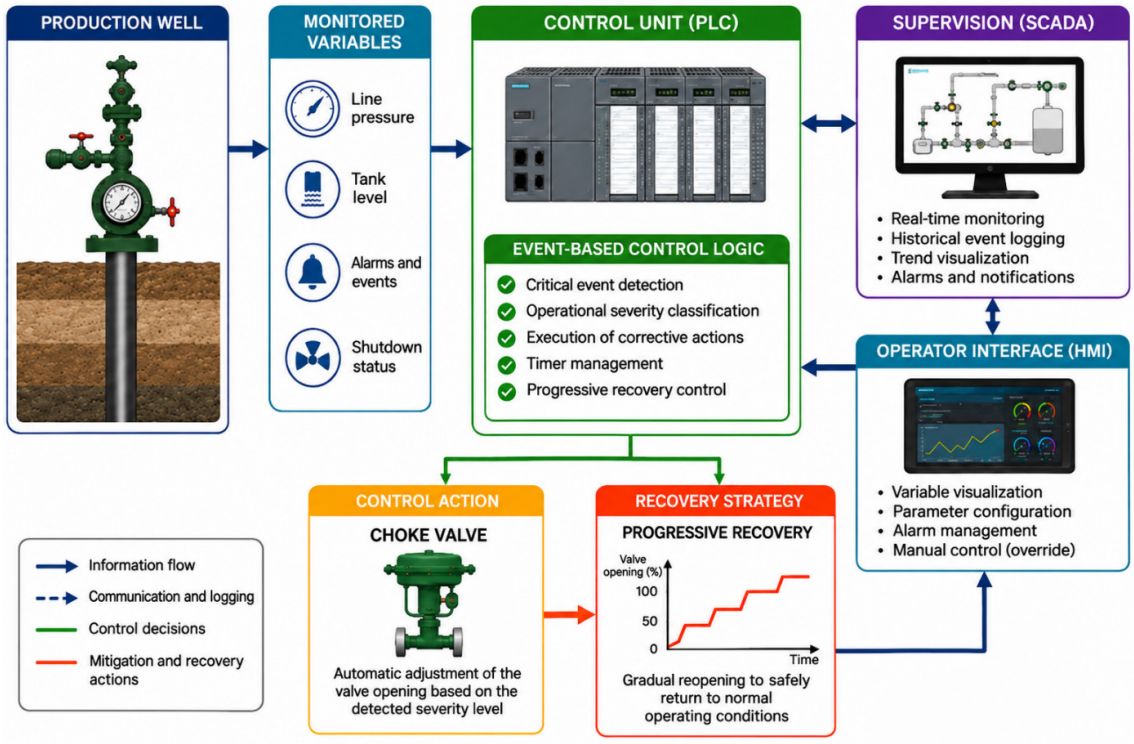


Fig. 1. *General scheme of the proposed control strategy to mitigate disturbances in production wells.*
Source: The author.

MATERIALS AND METHODS

The methodological development was structured from the perspective of industrial automation, with the aim of increasing operational stability and preventing unscheduled shutdowns in oil wells. The solution combines event-based logic, a ranking of alarms by severity and a progressive reopening of the choke valve, all built on a standard architecture of PLC, SCADA and HMI interface [27]–[30].

The design was conceived to operate in real field facilities, where it allows monitoring the key process variables and automatically actuating the choke valve according to the dynamics exhibited by the well.

System architecture

A modular architecture was chosen to facilitate installation of the system in wells that are already operating, without the need to drastically modify their infrastructure. The structure is organized hierarchically: it includes field instrumentation, the PLC controller, the SCADA supervision system and an HMI screen that allows interaction with the operator and real-time monitoring of the variables[29],[30].

The programmed logic continuously monitors the behavior of the well and automatically actuates the choke valve when it detects a critical condition, following the principle of event-conditioned actuation [22]–[24]. Because it is built with commonly used industrial components, the platform guarantees compatibility with standard automation environments and allows the solution to be scaled to other wells in the facility[29],[30].

Figure 2 shows the integration between instrument readings, classification by severity levels in the controller and the automatic mitigation and progressive reopening actions on the choke valve in response to transient events.

Monitored variables

The system continuously reads the key variables of the well to assess pressure stability, levels in the tanks/separators and

emergency shutdown states (shutdown). All these signals enter the PLC, where the algorithm processes the information to determine the process conditions and execute the corresponding response.

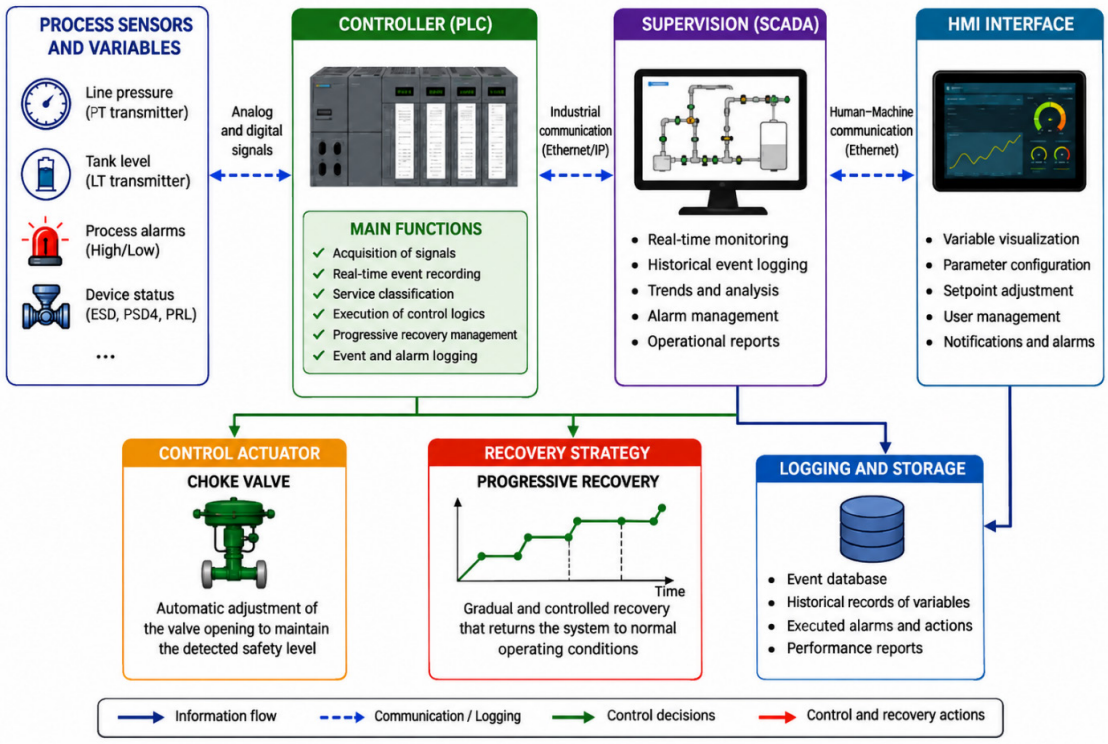


Fig. 2. *Functional structure of the proposed PLC/SCADA system.*
Source: The author

The monitored parameters include wellhead/line pressure, vessel level, the history of active alarms and abrupt variations in multiphase flow. The joint consideration of process variables and alarms provides information to detect anomalous behaviors and assign the severity level of the event in real time[27],[28]. By integrating these measurements into the control, the system responds to transients and minimizes the manual maneuvers the operator must perform in critical situations.

Table 1 summarizes the actions applied to the choke valve and the waiting times required to confirm the process condition.

Table 1: Monitoring parameters, severity levels and persistence times for the choke valve response logic.

Severity	Operational condition	Action applied	Persistence time
Level 1	Slight pressure variation	Moderate choke reduction	5 s
Level 2	Alarm persistence	Progressive reduction	10 s
Level 3	High criticality	Aggressive choke closure	15 s
Level 4	Shutdown risk	Maximum mitigation	20 s

Source: The author.

Severity model

The core of the strategy relies on a tiered model that classifies the severity of disturbances as they occur. The algorithm's response thus adjusts its aggressiveness depending on how critical the detected condition in the well is. The scheme contemplates four severity states. Each level triggers a specific movement in the choke valve, taking into account the persistence of the fault over time, the magnitude of the pressure peak and the overall impact on the facility.

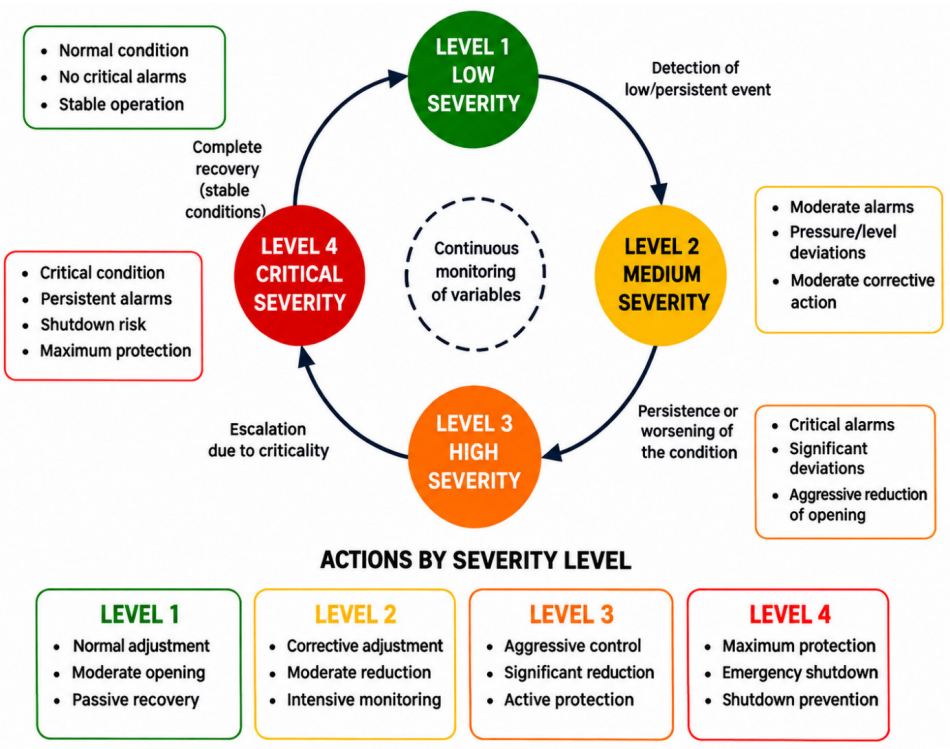
From the perspective of control theory, this structure can be represented as an event-driven hybrid dynamic system, by combining the continuous response of the process variables with discrete supervisory logic [22]–[26]. Thus, each level jump represents a state transition that modifies the opening or closing of the valve to contain the disturbance without destabilizing the plant[25],[26].

$S(t+1) = f(S(t),\ P(t),\ L(t),\ A(t))$ where $S(t)$ represents the operational severity status, $P(t)$ corresponds to the system's pressure variables, $L(t)$ represents the separator level conditions and $A(t)$ the set of active alarms at the evaluation moment. This formulation allows modeling the system's dynamic evolution as a discrete process monitored by operational events [25].

$u(t) = K_S{*}S(t)$ where $u(t)$ represents the control action applied to the choke valve and k_s corresponds to the mitigation factor

associated with the detected severity level. Under this architecture, the valve opening does not depend on a conventional continuous response, but rather on a hierarchical proportional logic based on operational criticality.

$E_C = P > P_{\max},\ L > L_{\max},\ A = 1$. Critical events are triggered by simultaneously evaluating the pressure, level, and operational alarms of the well. This logic allows discrete decisions to automatically monitor the process, following an event-driven action plan [22]–[25]. In fact, this hybrid approach allows conceptualizing Autoshock 1.0 architecture as an event-oriented system capable of responding to sudden changes in multiphase flow. Thus, the shift from one severity level to another works as a progressive mitigation mechanism aimed at stabilizing the plant without causing sudden closures or pressure surges.



Source: The author.

The algorithm is seen to process the field alarms, evaluate the persistence times and switch between the four severity levels to adjust the opening of the valve.

The model adjusts its states dynamically by measuring pressure, level and active alarms in real time. Depending on the level reached, the logic applies a given action to the choke valve, grading the response according to how strong and persistent the event is. In addition, the algorithm includes a safe-return sequence to restore normal operation once the fault has been overcome.

When the severity is low, the valve makes minor corrections to stabilize the process without altering the flow. If the condition worsens, the system closes the valve more aggressively to contain the pressure peak, preventing emergency shutdowns from being triggered and keeping the well online.

In table 2, the structure shows how the logic moves from one stage to another by evaluating the duration of the alarms and the degree of disturbance in the process, executing the closing or progressive reopening of the valve as appropriate.

Table 2: Hierarchical classification of the four operational severity levels defined in the algorithm.

Level	Severity	Description	Typical conditions	Action on choke valve
1	Low	Normal operating condition without critical alarms.	Pressure and level within range. No significant deviations.	Normal adjustment: moderate increases/decreases.
2	Mean	Moderate deviations requiring corrective action.	Minor or persistent alarms. Moderate pressure/level variations.	Moderate reduction in opening.
3	High	Critical conditions with risk of operational impact.	Active critical alarms. Significant deviations. Worsening trend.	Significant reduction in opening. Active protection.
4	Critical	Critical condition with high risk of shutdown.	Persistent critical alarms. Overpressure / Overlevel. Imminent risk of shutdown.	Emergency closure (0 % opening). Maximum protection.

Source: The author

Recovery strategy

Once the critical event is under control, the system activates a gradual recovery phase to bring the well back to its normal parameters without re-triggering the field alarms. Rather than opening the valve all at once, the algorithm increases the opening in stages, which dampens flow peaks and keeps the line pressure stable.

This automatic reopening is managed through adjustable timers in the PLC, which verify that the variables remain within safe ranges before taking the next step. In this way, the system adjusts the recovery rate according to the actual response of the well, protecting continuous production against complex transients.

Unlike traditional strategies that reopen abruptly, the Slow Recovery method acts as a buffer between the fault state and normal operation. This smooth transition prevents secondary pressure oscillations, prevents alarm recurrence, and stabilizes the process throughout the transient.

$V(t+1) = V(t) + \Delta V$ where $V(t)$ represents the percentage of opening of the valve choke and ΔV corresponds to the progressive increment applied during the recovery stage. This logic seeks to prevent sudden pressure surges and reduce the secondary fluctuations that can occur when opening the valve rapidly [8], [9].

Simplified dynamic model of the system

$$\frac{dP(t)}{dt} = -k_1\left(P(t) - P_{ref}\right) - k_2 u(t)$$

where $P(t)$ represents the system pressure, P_{ref} corresponds to the operating reference pressurel, $u(t)$ is the control action applied to the choke valve and k_1, k_2 represent dynamic constants associated with the hydraulic behavior of the process.

This formulation allows the process to be modeled through simplified first-order dynamics under the supervision of a hybrid event-based control[17], [22]–[26]. With this approach, the action on the valve directly alters the transient pressure response to sudden changes in multiphase flow.

In terms of operational stability, the strategy is designed to drive the system toward a safe operating zone, provided that the algorithm's response is proportional to the magnitude of the event and that changes between severity levels do not occur too rapidly. Under this criterion, the architecture seeks to preserve stable behavior during transitions between the different operational states, following the general principles of hybrid systems[26]. However, the formal stability of the system by analytical methods is an aspect that must be evaluated in future work.

Likewise, the combination of progressive reopening with hierarchical mitigation rules seeks to reduce oscillations caused by abrupt valve movements[8],[9]. This facilitates smooth transitions between fault states and favors the return of the well to a safe operating state.

RESULTS

Experimental environment

The Autochoque 1.0 system was validated on an industrial platform with PLC, SCADA and field instrumentation, aimed at detecting and mitigating disturbances due to changes in pressure, level and transient well dynamics. The test allowed the severity classification logic and the automatic response at the choke valve to be evaluated.

The experimental setup included pressure and level sensors, analog/digital input and output modules, an EtherNet/IP industrial network and the SCADA screen for real-time supervision, trend logging and alarm management. The severity hierarchy, mitigation routines and progressive reopening sequence were programmed in the controller.

During field testing, line pressure, choke valve position, alarm activation and fault times were continuously recorded. The system responded to process deviations by applying progressive closures and activating staged protections.

The gradual recovery routine, in turn, was executed only when the process variables remained stable during the validation time programmed in the PLC, which prevented abrupt openings that could destabilize the line again.

Operational performance of the system

The results confirmed that the Autochoque 1.0 strategy responds autonomously to process transients, reducing the need for manual maneuvers by the operator and maintaining stability at critical operating points. During the testing phase, the platform recorded 62 automatic interventions in response to disturbances without a single emergency shutdown being triggered. Likewise, the algorithm responded in less than 3 s to pressure peaks and achieved an automatic recovery rate above 90 % against variations in multiphase flow.

Figure 4 illustrates the time response of line pressure, choke valve position and the severity level determined by the PLC. The trend shows how the algorithm detects the disturbance in time, applies a staged closure to contain the overpressure and executes progressive reopening until the flow stabilizes.

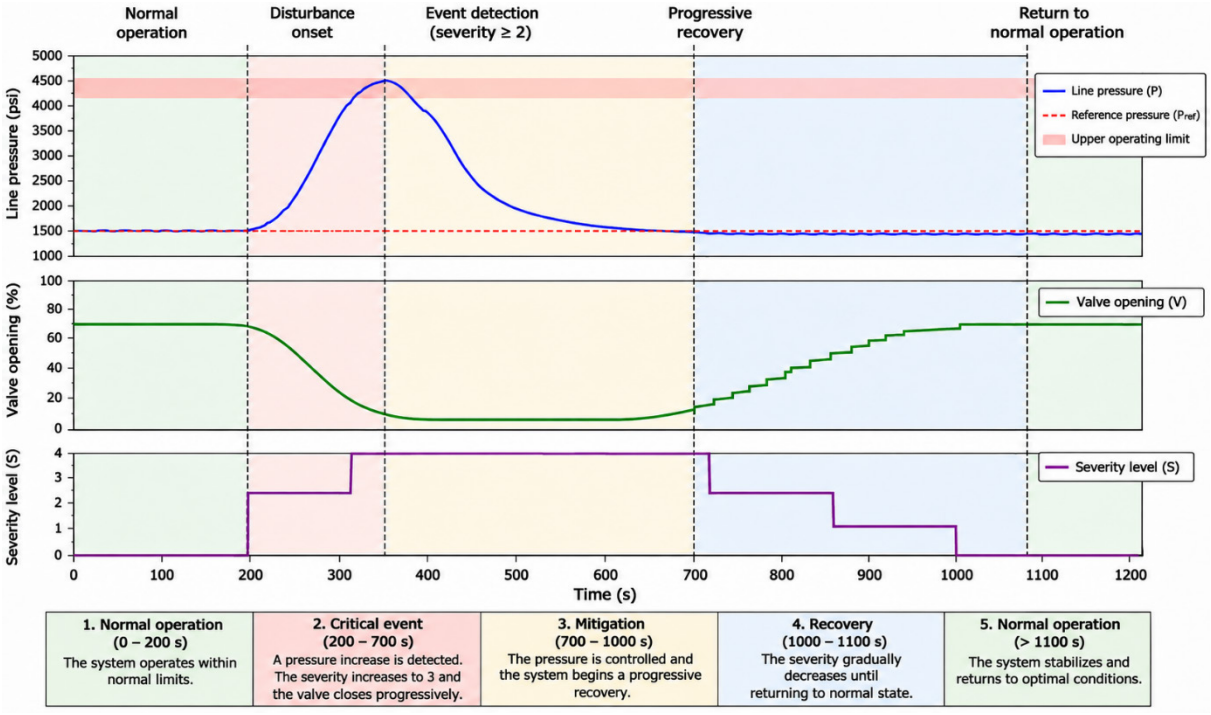


Fig. 4. *Dynamic response of the Autochoque 1.0 system.*
Source: The author.

Plant tests demonstrate that the system improves operational availability compared with traditional manual control, especially in highly variable transients where the operator's reaction time is insufficient.

In the event of abnormal pressure rises or persistent alarms, the controller responds according to the fault level. Under medium severity conditions, it applies moderate closures to the choke valve, whereas in critical events it activates faster closures to prevent shutdown tripping.

The tests confirmed that the level-based logic manages to filter minor disturbances from severe faults. This prevents the system from overreacting to transient changes and avoids unnecessary total shutdowns.

Continuous monitoring of the key variables stabilized the operation against abrupt pressure variations and the multiphase flow slugs typical of the line.

Finally, progressive reopening allowed the well to be returned to its normal parameters through valve position steps. This strategy reduced the recurrence of critical alarms and eliminated pressure oscillations during production.

When comparing the Autochoque 1.0 architecture with manual operation or conventional PID control, the proposed strategy showed greater flexibility to manage transients and adapt to the variability observed during the tests. This behavior is consistent with studies that have reported advantages of automatic choke control and advanced strategies under variable operating conditions[1],[2],[6],[13],[14].

Comparative analysis

Manual control depends directly on the operator's judgment and reaction time, and may therefore show variability in the response to a fault. Traditional PID loops, for their part, may show degraded performance when operating under nonlinearities, abrupt pressure changes and significant variations in the operating point[13],[14]. These limitations have motivated the development of robust, predictive and adaptive strategies for pressure control applications using choke valves [15]–[21].

By contrast, the hybrid logic of the algorithm combines the severity hierarchy with continuous monitoring, executing differentiated actions according to the severity of the event. This staged response improves preventive mitigation and prevents a minor disturbance from escalating to a full well shutdown.

Table 3 compares the manual operation, PID control and Autochoque 1.0 architecture schemes, taking into account the behavior observed during field tests and the background reported in the literature for automatic and advanced choke valve control[1],[2], [13]–[21].

Table 3: Comparison of control strategies: Manual vs PID vs Autochoque 1.0.

Criterion	Manual	Conventional PID	Autochoque 1.0 (Proposed)
Response time	High (variable)	Medium (s–min)	Low (< 3 s)
Operational shutdown	Frequent	Moderate	Reduced (>45% reduction)
Automatic recovery	Low	Medium	High (>90% recovery)
Operator intervention	High	Medium	Low (autonomous)
Operational stability	Low	Medium	High
Adaptability to disturbances	Low	Medium	High (severity levels)
Prevention of critical events	Low	Medium	High (progressive mitigation)
Progressive recovery (Slow Recovery)	Not applicable	Limited or not implemented	Yes (gradual increments)
Dependence on advanced infrastructure	No	Medium	Low (standard PLC/SCADA)
Compatibility with existing facilities	Yes	Medium	High (retrofit strategy)
Implementation complexity	Low	Medium	Medium
Implementation cost	Low	High (models, infrastructure)	Medium (standard infrastructure)
Production continuity	Low	Medium	High (greater availability)
Working capacity under multiple conditions	Low	Medium	High (transient events)

Source: The author

Likewise, progressive reopening offers an advantage over abrupt opening, since it allows the process variables to be stabilized before bringing the well back to its normal production condition. This behavior is consistent with the use of the choke as an active element to mitigate multiphase flow oscillations reported in other studies[8],[9].

From the point of view of applied control, the ability to differentiate minor disturbances from failure conditions of greater severity is a distinctive feature of the proposed strategy compared with a conventional PID loop. This feature is especially relevant in multiphase flows, where nonlinearities and high operational variability may occur [6]–[10],[17].

Progressive recovery dynamics

The Slow Recovery phase remained stable while restoring production after the critical events were controlled. The algorithm applied opening steps to the valve only when pressure and level stayed within safe limits during the validation times in the PLC.

This criterion eliminated alarm recurrences and avoided the fluctuations that abrupt openings usually cause. The adaptive logic reduced oscillations in the line, protecting flow continuity during the reopening transient.

Overall, the tests show that integrating supervised recovery routines is an effective alternative for increasing resilience in wells with multiphase flow, where critical events and pressure variations are recurrent.

DISCUSSION

The results confirm that Autochoque 1.0 is an effective alternative for mitigating critical failures in multiphase oil systems under the evaluated conditions. Unlike traditional PID control or manual operation, the architecture integrates hybrid supervision by severity and a Slow Recovery routine focused on protecting process stability. The use of choke valves as active elements for regulation and disturbance mitigation has shown favorable results in production applications and multiphase systems[1], [4]–[9].

The level-based hierarchy differentiated minor transients from higher-severity failure conditions, avoiding excessive PLC responses and helping to prevent unscheduled shutdowns. This response capability is especially relevant in multiphase lines, where nonlinearities and abrupt flow changes may occur [6]–[10],[17].

From the perspective of automatic control, the algorithm acts as an event-oriented supervision system by combining continuous process variables with discrete transitions associated with severity conditions [22]–[26]. This feature provides a response different from that of conventional PID loops, which act continuously and may show performance limitations under significant changes in the operating point and nonlinear dynamics[13],[14]. In this sense, Autochoque 1.0 does not necessarily seek to replace the existing continuous control, but rather to incorporate a supervision layer to respond to critical operational events.

Progressive reopening, in turn, showed favorable behavior compared with abrupt opening. Applying staged increments with validation in the PLC made it possible to reduce pressure oscillations and the recurrence of critical alarms during production restoration. This result is consistent with research in multiphase systems showing that controlled manipulation of the choke opening directly influences the amplitude of pressure fluctuations and can be used as a stabilization mechanism[8],[9].

A key advantage for the industry is that the algorithm runs on standard PLC/SCADA platforms[29],[30]. This allows it to be installed on existing infrastructure through retrofit strategies, without necessarily requiring the incorporation of more complex predictive control platforms. This feature can facilitate its application in existing facilities with infrastructure or processing capacity constraints.

However, the system depends on precise instrumentation calibration and manual adjustment of thresholds according to the well. In addition, the tests were conducted under specific field conditions and the dynamic model used a simplified first-order approximation. Therefore, future work should include advanced multiphase models, formal stability tests and adaptive self-tuning mechanisms[17],[20],[21],[26].

As a later development, we consider integrating predictive algorithms for the automatic adaptation of severities, the dynamic adjustment of parameters and the early detection of production failures[16],[18],[20],[21]. These tools could complement the event-based logic, maintaining the proposed supervisory architecture and allowing its parameters to be adjusted according to the dynamic evolution of the process.

CONCLUSIONS

The Autochoque 1.0 strategy consolidated an autonomous scheme for mitigation and operational recovery, reducing the occurrence of critical events during complex transients in multiphase wells.

The architecture integrated severity-based supervision, staggered closures in the choke valve and the Slow Recovery routine, preserving process stability and preventing trips due to shutdown.

The hybrid event-based logic proved superior to manual and conventional PID control by filtering out minor fluctuations from persistent failures, improving flow continuity and reducing human intervention.

Direct implementation on standard PLC/SCADA confirms its technical and economic feasibility, offering a low-cost alternative for modernizing production infrastructure in mature fields.

This development lays the foundation for incorporating predictive algorithms, adaptive schemes and artificial intelligence applied to autonomous control in wells and production facilities in the future.

In industrial terms, the results confirm that Autochoque 1.0 increases operational resilience and optimizes the uptime of production systems subjected to severe disturbances.

REFERENCES

[1] P. Kittilsen, K. Fjalestad, I. L. Sperle, and R. Aasheim, “Robust Automatic Well Choke Control – Physical Constraint Based Operation,” *IFAC-PapersOnLine*, vol. 49, no. 7, pp. 296–301, 2016. https://doi.org/10.1016/j.ifacol.2016.07.308

[2] P. Kittilsen, K. Fjalestad, and R. Aasheim, “Stabilized and Increased Well Production Using Automatic Choke Control,” in Abu Dhabi International Petroleum Exhibition and Conference (ADIPEC), Abu Dhabi, UAE, 2014, SPE-171859-MS. https://doi.org/10.2118/171859-MS

[3] F. C. Diehl, T. O. Machado, T. K. Anzai, C. S. Almeida, C. A. Moreira, G. A. Nery, M. C. M. M. Campos, M. Farenzena, and J. O. Trierweiler, “10% increase in oil production through a field applied APC in a Petrobras ultra-deepwater well,” *Control Engineering Practice*, vol. 91, Art. no. 104108, 2019. https://doi.org/10.1016/j.conengprac.2019.104108

[4] A. Plucenio, M. Campos, and A. F. Teixeira, “New Developments in the Control of Fluid Dynamics of Wells and Risers in Oil Production Systems,” *IFAC-PapersOnLine*, vol. 48, no. 6, pp. 97–103, 2015. https://doi.org/10.1016/j.ifacol.2015.08.016

[5] M. Campos, T. Takahashi, F. Ashikawa, S. Simões, A. Stender, and O. Meien, “Advanced Anti-slug Control for Offshore Production Plants,” *IFAC-PapersOnLine*, vol. 48, no. 6, pp. 83–88, 2015. https://doi.org/10.1016/j.ifacol.2015.08.014

[6] E. Jahanshahi, S. Skogestad, and A. H. Helgesen, “Controllability analysis of severe slugging in well-pipeline-riser systems,” *IFAC Proceedings Volumes*, vol. 45, no. 8, pp. 101–108, 2012. https://doi.org/10.3182/20120531-2-NO-4020.00014

[7] G. A. de Andrade and D. J. Pagano, “Boundary control for stabilization of slugging oscillations,” *IFAC-PapersOnLine*, vol. 48, no. 6, pp. 77–82, 2015. https://doi.org/10.1016/j.ifacol.2015.08.013

[8] X. Zhao, Q. Xu, J. Fu, Y. Chang, Q. Wu, and L. Guo, “Study on eliminating severe slugging by manual and automatic choking in long pipeline-riser system,” *Chemical Engineering Science*, vol. 292, Art. no. 119978, 2024. https://doi.org/10.1016/j.ces.2024.119978

[9] V. Banjara, C. Avila, D. Murugavel, and E. Pereyra, “Severe slugging mitigation by utilizing the active use of choke control valve,” *Applied Ocean Research*, vol. 158, Art. no. 104547, 2025. https://doi.org/10.1016/j.apor.2025.104547

[10] J. Chen, L. Dai, L. Xu, L. Zhou, P. Li, and S. Zou, “Optimization of Installation Position of Choke Valve for Severe Slugging Control on FPSO Units in Offshore Oilfield,” *Processes*, vol. 14, no. 7, Art. no. 1164, 2026. https://doi.org/10.3390/pr14071164

[11] M. Leporini, A. Terenzi, and B. Marchetti, “Improvement of a multiphase flow model for wellhead chokes under critical and subcritical conditions using field data,” *Journal of Petroleum Exploration and Production Technology*, vol. 11, pp. 1487–1503, 2021. https://doi.org/10.1007/s13202-021-01114-4

[12] S. A. Alarifi, “Workflow to predict wellhead choke performance during multiphase flow using machine learning,” *Journal of Petroleum Science and Engineering*, vol. 214, Art. no. 110563, 2022. https://doi.org/10.1016/j.petrol.2022.110563

[13] G. Nygaard and G. Nævdal, “Nonlinear model predictive control scheme for stabilizing annulus pressure during oil well drilling,” *Journal of Process Control*, vol. 16, no. 7, pp. 719–732, 2006. https://doi.org/10.1016/j.jprocont.2006.01.002

[14] L. A. Carlsen, G. Nygaard, and M. Nikolaou, "Evaluation of control methods for drilling operations with unexpected gas influx," *Journal of Process Control*, vol. 23, no. 3, pp. 306–316, 2013. https://doi.org/10.1016/j.jprocont.2012.12.003

[15] D. G. Reitsma and Y. Couturier, "New Choke Controller for Managed Pressure Drilling," *IFAC Proceedings Volumes*, vol. 45, no. 8, pp. 223–230, 2012. https://doi.org/10.3182/20120531-2-NO-4020.00049

[16] U. J. F. Aarsnes, B. Açıkmeşe, A. Ambrus, and O. M. Aamo, "Robust controller design for automated kick handling in managed pressure drilling," *Journal of Process Control*, vol. 47, pp. 46–57, 2016. https://doi.org/10.1016/j.jprocont.2016.09.001

[17] U. J. F. Aarsnes, T. Flåtten, and O. M. Aamo, "Review of two-phase flow models for control and estimation," *Annual Reviews in Control*, vol. 42, pp. 50–62, 2016. https://doi.org/10.1016/j.arcontrol.2016.06.001

[18] J. Park, C. Price, D. Pixton, M. Aghito, R. Nybø, K. Bjørkevoll, and J. D. Hedengren, "Model predictive control and estimation of managed pressure drilling using a real-time high fidelity flow model," *ISA Transactions*, vol. 105, pp. 256–268, 2020. https://doi.org/10.1016/j.isatra.2020.05.035

[19] O. Erge, Q. Gu, D. Chen, and E. van Oort, "MPD choke control considering the thixotropic gelation behavior of drilling fluids," *Journal of Petroleum Science and Engineering*, vol. 208, Art. no. 109793, 2022. https://doi.org/10.1016/j.petrol.2021.109793

[20] S. Naderi Lordejani, B. Besselink, W. H. A. Schilders, and N. van de Wouw, "Model complexity reduction and controller design for managed pressure drilling automation," *Journal of Process Control*, vol. 122, pp. 69–83, 2023. https://doi.org/10.1016/j.jprocont.2022.11.012

[21] Z. Li, N. Hovakimyan, and G.-O. Kaasa, "Bottom hole pressure estimation and adaptive control in managed pressure drilling system," *International Journal of Adaptive Control and Signal Processing*, vol. 31, no. 4, pp. 545–561, 2017. https://doi.org/10.1002/acs.2672

[22] P. Tabuada, "Event-Triggered Real-Time Scheduling of Stabilizing Control Tasks," *IEEE Transactions on Automatic Control*, vol. 52, no. 9, pp. 1680–1685, 2007. https://doi.org/10.1109/TAC.2007.904277

[23] W. P. M. H. Heemels, K. H. Johansson, and P. Tabuada, "An introduction to event-triggered and self-triggered control," in Proc. 51st IEEE Conference on Decision and Control (CDC), 2012, pp. 3270–3285. https://doi.org/10.1109/CDC.2012.6425820

[24] W. P. M. H. Heemels and M. C. F. Donkers, "Model-based periodic event-triggered control for linear systems," *Automatica*, vol. 49, no. 3, pp. 698–711, 2013. https://doi.org/10.1016/j.automatica.2012.11.025

[25] P. J. Ramadge and W. M. Wonham, "Supervisory Control of a Class of Discrete Event Processes," *SIAM Journal on Control and Optimization*, vol. 25, no. 1, pp. 206–230, 1987. https://doi.org/10.1137/0325013

[26] M. S. Branicky, "Multiple Lyapunov functions and other analysis tools for switched and hybrid systems," *IEEE Transactions on Automatic Control*, vol. 43, no. 4, pp. 475–482, 1998. https://doi.org/10.1109/9.664150

[27] P. Goel, A. Datta, and M. S. Mannan, "Industrial alarm systems: Challenges and opportunities," *Journal of Loss Prevention in the Process Industries*, vol. 50, pp. 23–36, 2017. https://doi.org/10.1016/j.jlp.2017.09.001

[28] F. E. Mustafa, I. Ahmed, A. Basit, U.-E.-H. Alvi, S. H. Malik, A. Mahmood, and P. R. Ali, "A review on effective alarm management systems for industrial process control: Barriers and opportunities," *International Journal of Critical Infrastructure Protection*, vol. 41, Art. no. 100599, 2023. https://doi.org/10.1016/j.ijcip.2023.100599

[29] F. J. Folgado, D. Calderón, I. González, and A. J. Calderón, "Review of Industry 4.0 from the Perspective of Automation and Supervision Systems: Definitions, Architectures and Recent Trends," *Electronics*, vol. 13, no. 4, Art. no. 782, 2024. https://doi.org/10.3390/electronics13040782

[30] G. Yadav and K. Paul, "Architecture and security of SCADA systems: A review," *International Journal of Critical Infrastructure Protection*, vol. 34, Art. no. 100433, 2021. https://doi.org/10.1016/j.ijcip.2021.100433

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