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Structural response of Autoclave due to vibrations and optimisation of its supports by spring elements

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Abstract

This paper will present a novel approach to supporting a piece of process equipment subjected to long-term exploitation conditions, with the main goal of improving its reliability and safety. Optimising the supports of the process equipment (in this particular case, 16 autoclaves used for coal drying) began by measuring the load at the support points. It was followed by an analysis based on good engineering practice to develop a new technical solution. The old support solution represented a rigid connection between the autoclave envelope and the supporting structure. Meanwhile, the new approach introduced spring supports, thus providing flexible connections between the Autoclave and the structure. This flexibility ensures that the load on the vessel's shell is reduced significantly and that stress distribution at the support points is uniform. Simultaneously, the load distribution in the structure's support zone is significantly more favourable. The economic benefit of such an approach and a reflection on sustainability are also discussed.

Keywords

autoclave, structural response, supports, vibrations, spring elements;

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1. Introduction

Depending on its type and working parameters, pressure equipment can be exposed to different conditions during the in-service period. These exploitation conditions can lead to the most dangerous type of failure, i.e. brittle fracture, which results in significant material damages and down-time for the whole installation (Lancaster, 2005; Sedmak et al., 2009; Benac et al., 2016; Benac, 2002; Filipović et al., 2007). Both scientific and engineering practices provide an increasing number of probabilistic methods used for the assessment of failure and equipment (or material) reliability (Mastilovic et al., 2024; Popović et al., 2024; Kirin et al., 2020; Sedmak et al., 2023; Chavoshi et al., 2021; Ruggieri, 2024). These methods can, to a certain extent, predict a safe work life within a given time interval. It should be emphasised that it is necessary to recognise all risks for each of these probabilistic methods in order to adequately apply them (Horváth-Kálmán et al., 2023; Jovanović et al., 2023). Integrity and reliability assessment also includes classic engineering methods, such as non-destructive testing (Kurz et al., 2013; Jarić et al., 2024a, 2024b), which can provide insight into the current damage state but not what caused it. One of the major aspects to consider during downtime of pressure vessel equipment and during monitoring and reconstruction is the economic impact. Recently, all of these aspects were recognised, and all fit into a discipline of cognitive sustainability, representing an interdisciplinary approach that helps determine the sustainability of a proposed solution or process (Zöldy et al., 2022).

Damage to process equipment is often caused by a static load to which such equipment is subjected or by aggressive mediums, which may cause erosion and/or degradation of pressure vessel walls. This was the case with the coal drying Autoclave in question, which was the subject of numerous studies regarding its reconstruction and repairs, such as cases presented by Ilić and Radić (2003), Maneski et al. (2008) and Jovanović et al. (2022). Dynamic loading represents the second most dangerous cause of long-term damage to the material (Németh et al., 2020; Stosiak et al., 2022; Towoju et al., 2023; Leshchinskii et al., 2024; Sedmak et al., 2019; Di Nicola et al., 2024; John et al., 2024) is often less considered in overall structural response on pressure vessel equipment. Dynamic loading caused by vibrations in very "stiff" supports can lead to failure of the whole Autoclave, resulting in downtime, all for a rather "banal" reason – damage of the autoclave support, which (at first glance) does not play any role in the technological process of drying of coal. The fact that there are supports to keep the Autoclave in place and ensure its safe operation is often neglected.

As previously mentioned, the way this pressure equipment was supported could greatly impact its work life when it is subjected to variable load while having an inappropriate technical solution for its support. The original and initial solution for autoclave supports included a stiff connection between the vessels and the load-bearing steel structure. In this example, regarding these specific autoclaves, a very important fact was neglected during their design: autoclaves are equipment subjected to periodic filling and emptying (due to their use – coal drying). Since this represents dynamic loading, such equipment cannot be considered a classic pressure vessel (subjected to internal pressure and/or dilatations due to temperature changes). In this particular case, 16 autoclaves have suffered a significant number of failures while in use due to cracks occurring in the support zone of the Autoclave. This would then result in unplanned production downtimes and additional costs for repairs. All aforementioned factors affect the sustainability of the whole facility, which must guarantee a reliable, safe and constant process of coal drying.

In order to restore pressure equipment functionality, it is necessary to consider all the unfavourable effects that caused it to fail in the first place. Since a common cause of autoclave failure was through-thickness cracks in the support zone, it was concluded that the sole reason lies in the inadequate connection between the Autoclave and the load-bearing structure. Thus, there was a need to assess the overall structural response, with special attention devoted to dynamic loading caused by vibrations.

In order to reach proper conclusions about the cause, a static analysis was performed, along with measuring amplitudes (dynamic loading) during autoclave operation. The measurements and thorough analyses provided the solution that the fixed connection (typically used for pressure vessels) should be replaced with a flexible connection (spring supports), which can absorb impact loads caused by filling, emptying and inadequate operation of this equipment. In this way, favourable load distribution in pressure equipment walls and load-bearing structures can be achieved, resulting in less downtime for the whole facility and less need for repair. A techno-economic analysis along with a cost comparison of the traditional solution (which involves a repair welding procedure of fixed connections) and the new solution (that includes mounting of spring

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elements) of the Autoclave was conducted as well, with a purpose of direct indication of the economic and sustainable benefit of the new approach. A thorough analysis of the proposed support solution is offered. It should be emphasised that the analysis of spring supports and the overall structural response of autoclaves was conducted during their operating mode (i.e. under real exploitation conditions) due to time constraints for prototyping and the demands of the energy supply industry.

2. Load Measurements

The fixed connections of the autoclave supporting system exercise unfavourable stress on the shell around them. This state could initiate fatigue cracks, one of the problems observed during previous reconstruction. The technical solution for autoclave support suggested 20 years ago that fixed (rigid) elements proved to be inappropriate for long-term exposure to various loads imposed by working conditions (more about this problem basis can be found in Ilić and Radić (2003), Maneski et al. (2008) and Jovanović et al. (2022)). In order to find an appropriate solution for supporting the Autoclave, the whole analysis was preceded by load measurements in autoclaves subjected to real exploitation conditions. The proposed solution involves placing four spring-damping elements between the support feet of the Autoclave and the steel support (i.e. steel structure) around the Autoclave. The drawing of the Autoclave, its major elements, and the proposed technical support solution are presented in Fig. 1.

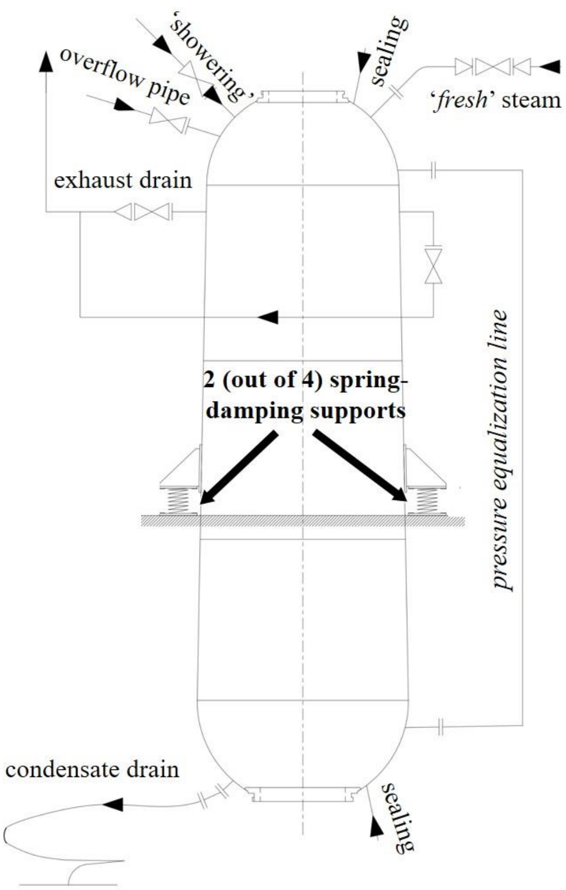

Figure 1. Illustration of the technical solution for Autoclave support with spring-damping supports

Both static and dynamic loads and their influence on overall structural integrity were analysed. Static load analysis was performed first. Magnitudes of static loads to which pressure equipment was subjected were:

- Empty Autoclave (with heat insulation and pipelines) – 410 kN;
- Autoclave filled with raw coal (lignite) – 745 kN;
- Autoclave with coal after drying – 580 kN;
- Autoclave with maximum load (e.g. during a hydro test) – 985 kN.

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Measuring dynamic loads during the exploitation of autoclaves was performed using the MEDA software package (version: R2016-1), made by IRIS (Wölfel Engineering). The measurement of dynamic loads in the original supports using a sensor made by the Wölfel Monitoring System model VS-1D. The layout of measuring locations before and after support replacement is shown in Fig. 2. Locations where sensors were installed on the original autoclave supports are shown in Fig. 3.

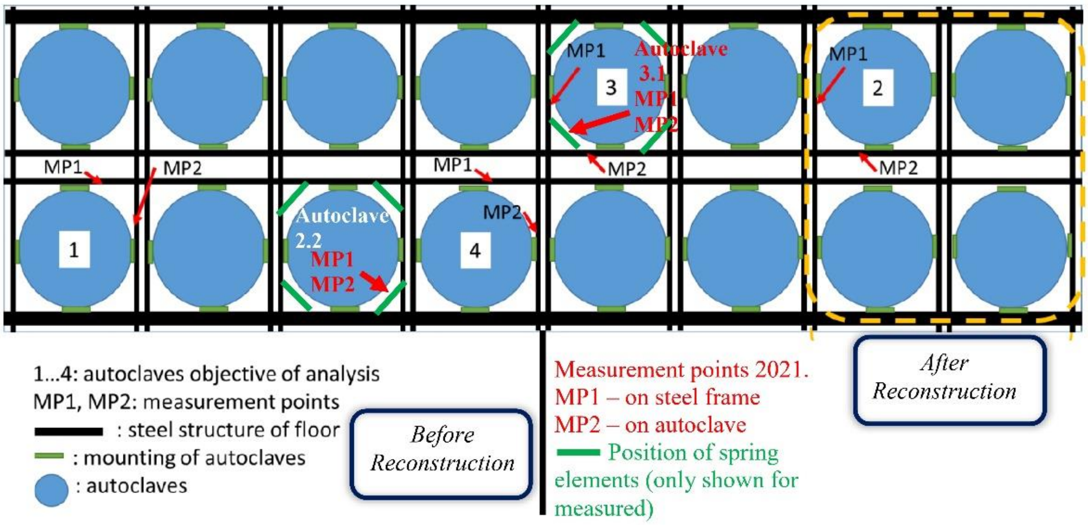

Figure 2. Layout of measurement elements (sensors)

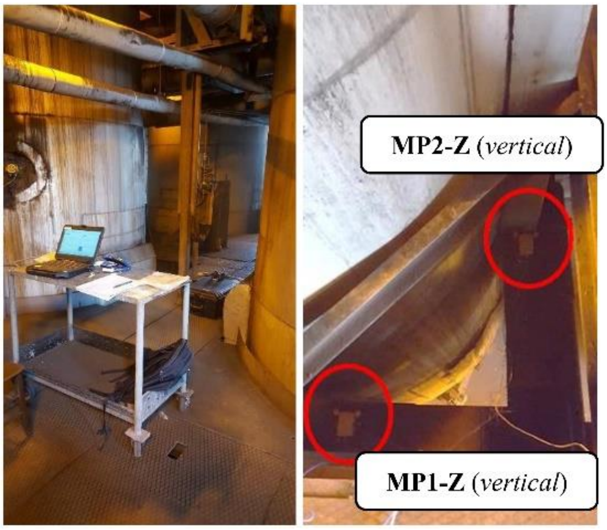

Figure 3. Location of installation of sensors on the original supports of the vessel

After autoclave reconstruction was completed, control measuring of new type supports was conducted, using measuring equipment by the same manufacturer as previously mentioned, along with post-processing of data using this software package. A sensor Piezoelectric accelerometer, S/N LW225020; LW225021 made by PCB model 356A16 was used to measure the dynamic load of new supports. Fig. 4 shows how sensors were installed and their locations for the new supports for two reconstructed autoclaves.

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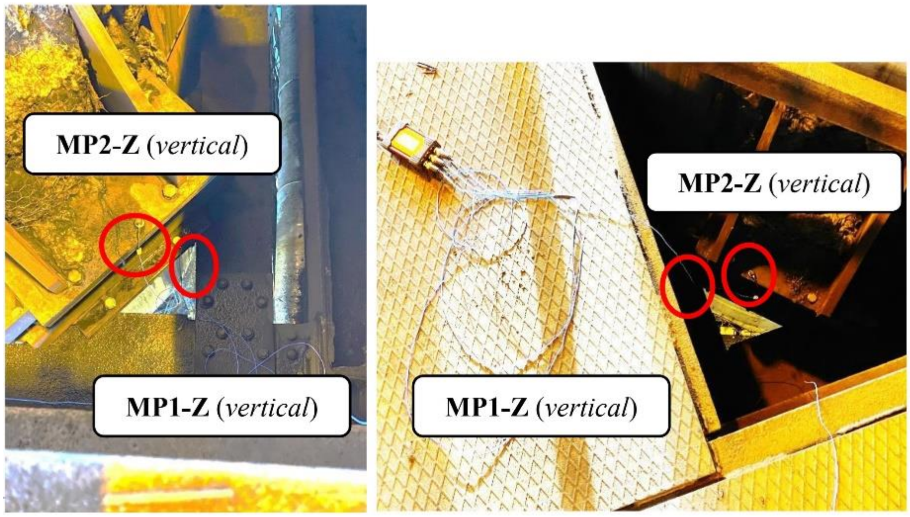

Figure 4. Locations of installation of sensors on the new type of vessel support

3. Analysis of results – vibration measurement

Firstly, vibration measurements were performed before the installation of spring elements on the supports. The results will be used to define spring elements for an improved mounting solution with optimised vibration characteristics during operation. The vibration level is analysed by calculating peak values and RMS values of the measured time series. Results are shown in Table 1.

Table 1 Analysis of operational vibrations

Measurement No.	Date	Time	Autoclave No.	Process	MP1-Z RMS [mm/s]	MP1-Z peak value [mm/s]	MP2-Z RMS [mm/s]	MP2-Z peak value [mm/s]
1	23. July	13:13	1	Loading	0.3	6.6	0.4	8.3
2	23. July	13:19	1	Drying	0.1	1.0	0.1	1.3
3	23. July	13:25	1	Drying	0.1	1.3	0.1	1.3
4	23. July	13:30	1	Drying	0.1	0.7	0.1	0.5
5	23. July	13:36	1	Drying	0.1	0.8	0.1	0.6
6	23. July	13:42	1	Drying	0.1	0.8	0.1	0.9
7	23. July	13:53	1	Drying	0.2	2.9	0.2	2.8
8	23. July	14:03	1	Drying	0.4	26.7	0.5	25.1
9	23. July	14:14	1	Drying	0.1	0.3	0.1	0.3
10	23. July	14:25	1	Drying	0.1	0.3	0.1	0.3
11	23. July	14:36	1	Drying	0.1	0.6	0.1	0.7
12	23. July	14:47	1	Drying	0.1	0.7	0.1	0.5
13	23. July	14:58	1	Drying	0.2	4.5	0.2	5.0
14	23. July	15:09	1	Drying	0.1	0.4	0.1	0.4
15	23. July	15:20	1	Drying	0.1	1.1	0.1	1.2
16	23. July	15:31	1	Unloading	1.3	30.9	1.1	25.7
17	23. July	15:42	1	Loading	0.4	5.0	0.4	8.5
1	24. July	09:26	2	Not in operation	0.5	1.1	0.1	0.6
2	24. July	09:39	2	Not in operation	0.6	1.1	0.1	0.5
3	24. July	10:23	3	Unloading	0.8	44.6	1.0	40.1
4	24. July	10:34	3	Loading	0.4	9.0	0.4	4.6
5	24. July	10:44	3	Drying	0.1	1.3	0.1	1.1
6	24. July	11:23	4	Drying	0.1	0.7	0.1	0.6
7	24. July	11:35	4	Drying	0.2	1	0.1	0.8
8	24. July	11:46	4	Drying	0.2	0.8	0.2	0.9
9	24. July	11:57	4	Unloading	2.0	44.5	1.8	56.9
10	24. July	12:07	4	Loading	6.3	0.3	0.4	8.9

The highest vibration amplitudes are observed during unloading. The loading process shows higher values, too, whereas the drying process shows very low values.

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The time series of an unloading process is shown in Fig. 5. and 6. Unloading shows vibrations with a typical shape of impulse loads as excitation. A series of excitations with impulses every 4 seconds follows a sequence without excitation.

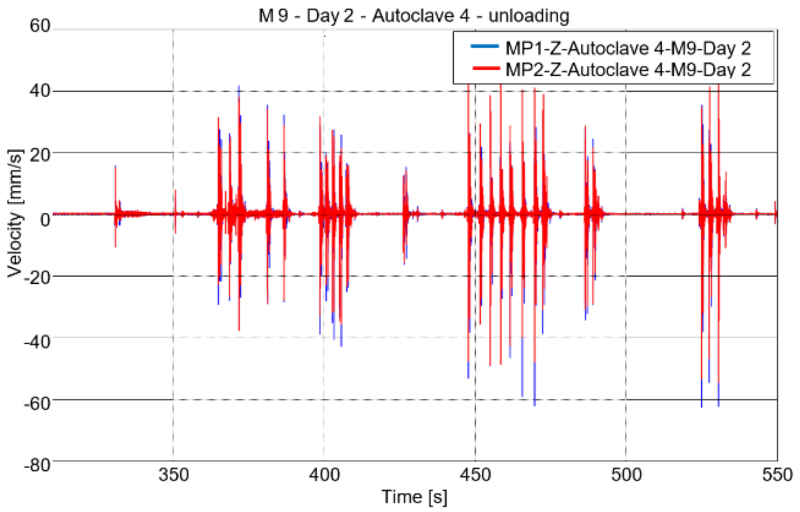

Figure 5. Time series of unloading

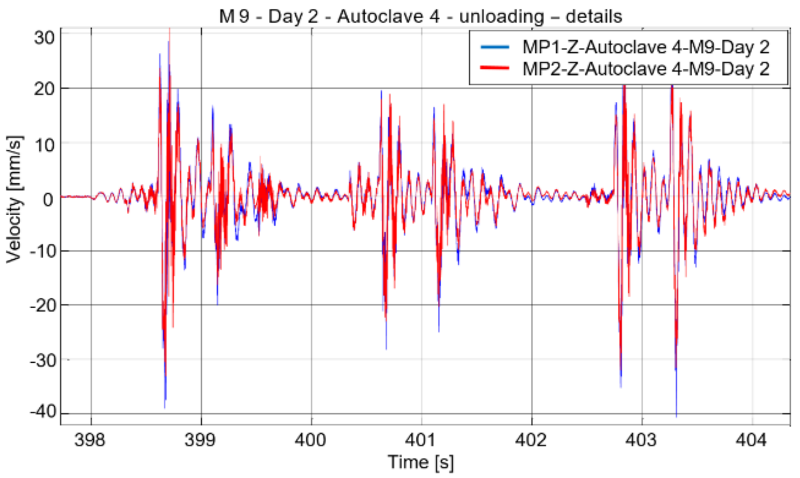

Figure 6. Time series of unloading – details

In order to analyse vibrations in the frequency domain, the measured time series have been transformed by Fast Fourier Transformation (FFT). The loading and unloading process results in impulse loads on the vessels and the connected floor. A structure which is excited by impulses responds in its natural frequencies. Therefore, the measured frequency peaks show the structure's natural frequency, which is the objective of this analysis. The results of an unloading process are shown in Fig. 7. Two natural frequencies are identified at around 5 Hz and 11 Hz.

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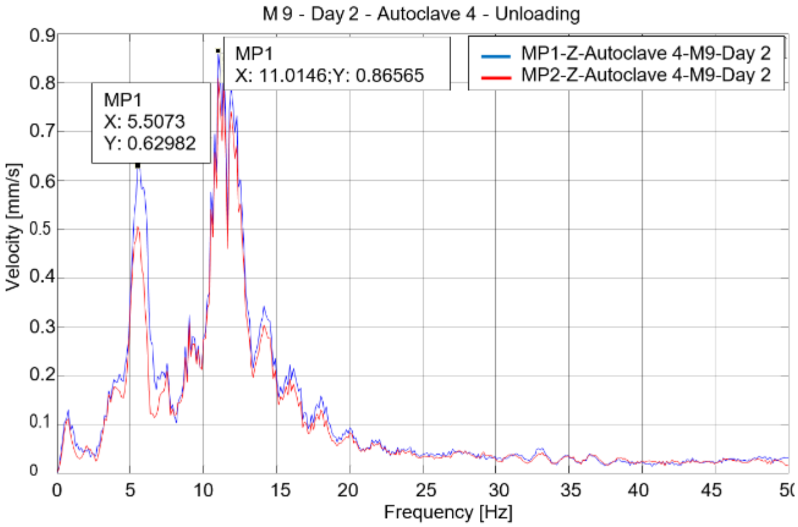
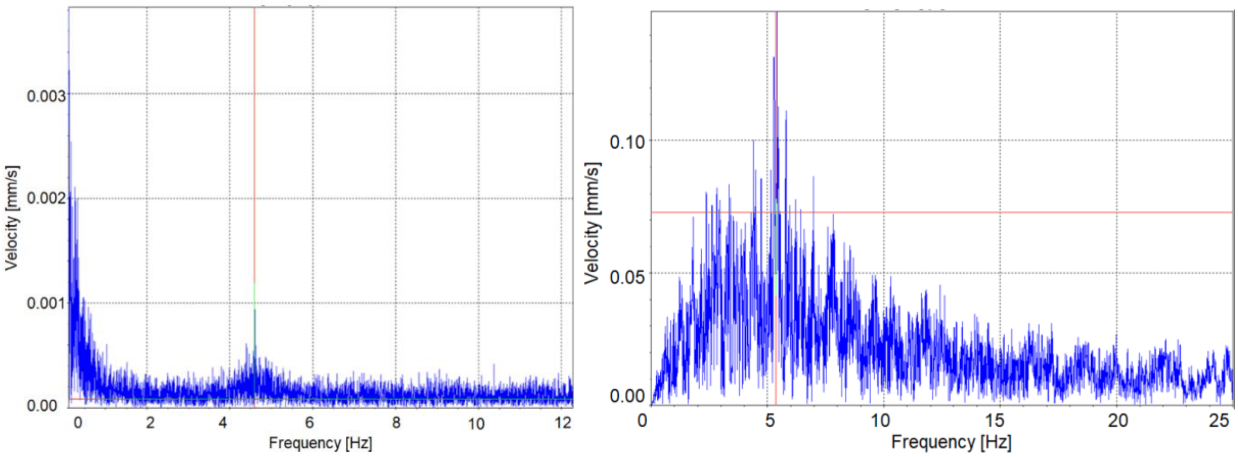


Figure 7. Dominant frequency during the unloading process

Then, vibration measurements were taken after the reconstruction, i.e. installation of the spring elements on the supports. The objective was to compare the results before and after installing spring elements and to show the optimised vibration characteristics during operation. The measured time of the aforementioned FFT has transformed the series to analyse vibrations in the frequency domain. The natural frequency of the autoclaves was calculated to be 4.6 Hz (empty Autoclave) and 3.4 Hz (fully loaded). Measured frequencies range from 4.0 to 4.6 Hz (full) and 4.9 to 5.3 Hz (empty). Whether the "full" load corresponds to the theoretical maximum values could not be detected. However, the deviations are within limits and do not produce any negative effects on the operation (Fig. 8):



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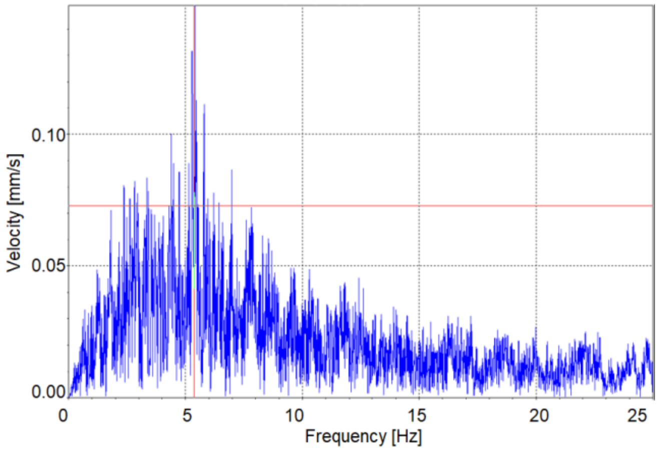

c)

Figure 8. a) Autoclave 3.1, full, dominant peak at 4.5 Hz; b) Autoclave 3.1, full, dominant frequency 4.6 Hz; c) Autoclave 3.1, empty, dominant frequency 5.3Hz

The structural response due to the dynamic behaviour of the autoclaves was significantly improved by the installation of the spring elements, which can be observed from the comparison diagram shown in Fig. 9. The vibration level within the steel beams is significantly lower than before. The peak values in the beams could be reduced from around 40 mm/s to 4 mm/s. As a result, the dynamic forces could be reduced as desired. The measured displacement amplitudes at the measured "worst" load cases, i.e. unloading, are below the predicted ones.

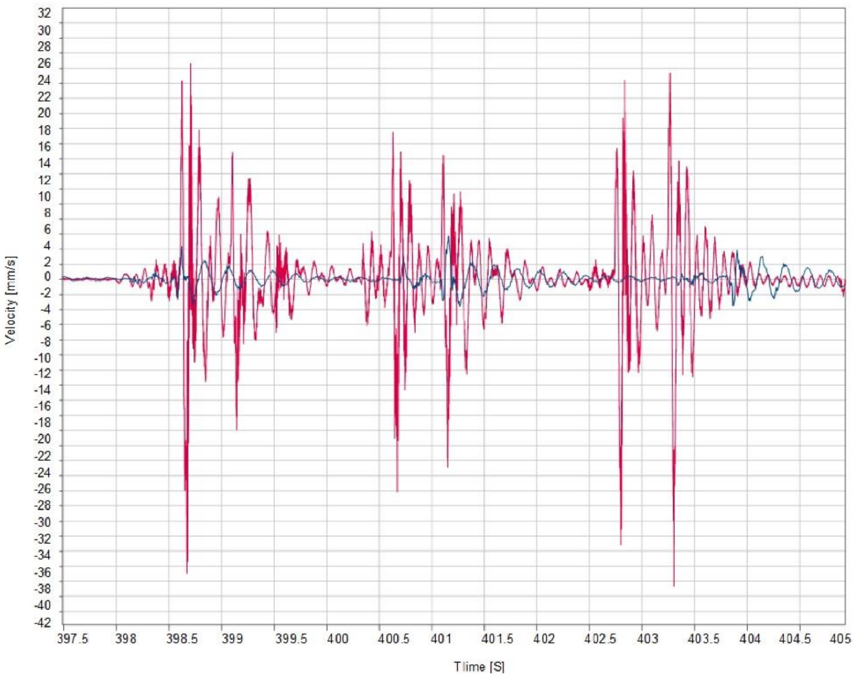

Figure 9. Red line – unloading autoclave MP1 (steelwork, without spring elements); blue line – unloading Autoclave 3.1 MP1 (steelwork with spring elements)

The obtained results of vibration measurement proved that the mounting of proposed spring element supports leads to a decrease in dynamic impacts on the supporting structure and relative displacement between the supporting structure and the Autoclave itself. Indirectly, this will decrease the likelihood of cracks appearing on the autoclave shell and, most importantly, on welded joints. Applying this type of spring-damping support will solve the problem related to high-impact forces and loads during loading/unloading of the Autoclave, which will compensate for radial dilatation as well.

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5. Techno-economic analysis and sustainability feature of novel approach

From an engineering point of view, the advantages of the novel approach are obvious; however, economic aspects and compliance with them must also be checked. Economic features of both approaches for 16 autoclaves in the form of techno-economic analysis, with a thorough list of activities, along with a direct comparison of their costs, are presented in Table 2. As can be seen, the new approach demands introducing some new activities compared to the traditional repair process. Activates such as the development of technical documentation, material procurement, manufacturing and delivery of the autoclave bottom lid, flanged ring, and middle and bottom sections of the autoclave shell, procurement and delivery of spring supports for the Autoclave with reinforced load-bearing steel structure for pressure equipment represent the basis of the newly proposed solution for autoclave reconstruction speaking in terms of economy. However, the overall sustainability aspect shows the superiority of the new solution in the long run, primarily in the final factor – the downtime costs due to failure or maintenance. To repair 16 autoclaves in total, which has to be performed every second year (shown by engineering practice in this particular case), 30 days of downtime is required. Taking a daily working capacity of 153 t/per autoclave, severe financial losses are observed compared to losses caused by reconstruction using spring damping elements. From the sustainability perspective, the novel approach for supporting is the better solution, as it requires less additional maintenance work and reduces downtime over the Autoclave's design life.

Table 2. Techno-economic analysis of both approaches used for Autoclave restoring functionality

#	Activities	Autoclave reconstruction (by using the newly proposed spring supports)	Repairing of existing autoclaves (by repairing of existing supports)	Notes
		Cost (EUR)		
1	Development of technical documentation – design documentation and project supervision	137,000.00	0.00	*Not needed for repairs*
2	Development of the repair report and proposal of solution for repairs of damage that had occurred	0.00	40,000.00	*Necessary for any and all repairs, statistically speaking, failures like this occur once per year, per Autoclave.*
3	Material procurement, manufacturing and delivery of the autoclave bottom lid, flanged ring, and middle and bottom sections of the autoclave shell	928,000.00	0.00	*Procurement of new equipment not required for repairs*
4	Procurement and delivery of spring supports for the Autoclave with reinforced load-bearing steel structure for pressure equipment	160,000.00	0.00	*A new solution, as required by the reconstruction*
5	Procurement and delivery of remaining pipes, sheets and equipment, as per project	80,000.00	0.00	*During repairs, there is no need for these replacements*
6	Cost of a Notified Body for pressure equipment engagement regarding manufacturing, installation and final inspections, along with making a non-conformity evaluation report	96,000.00	0.00	*The scope of NDT engagement is smaller during repairs since reconstruction is much more complex regarding monitoring.*
7	Cost of a Notified Body for pressure equipment engagement regarding equipment repairs and issuing all of the necessary documentation	0.00	64,000.00	
8	Manufacturing of temporary support structure for the Autoclave	1,440,000.00	880,000.00	*These activities are identical for repair and reconstruction, although repairs involve significantly fewer work hours on locksmithing and welding activities during installation.*
9	Installation work, including non-destructive testing of welded joints			
10	Cold test			
11	Development of technical and certification documentation			
12	Insulation of the bottom part of the Autoclave			
13	Preparation for finishing works			
14	Costs of downtime due to failure	14,688,000.00	146,880,000.00	*Downtime costs for 40 years (design work life)* • *Reconstruction – 60 days downtime over 40 years* • *Repairs – 30 days downtime every second year* *Daily capacity of 153 t/per autoclave; coal price of 100 EUR/t*
	Total	**17,529,000.00**	**147,864,000.00**	

** Techno-economic analysis refers to 16 autoclaves in total, which represents the number in a facility for coal production in this particular case*

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4. Conclusion

The application of a novel approach for decreasing dynamic influence on autoclave supports showed improved results in terms of structural response. From this analysis, the following conclusions can be drawn:

- Installed spring elements on supports caused the vibration level within the steel beams to decrease. The final measurements showed that the loads were up to 10 times less than the original rigid connection. The displacement amplitudes at the measured "worst" load cases – unloading – are below the predicted ones. This suggests that replacing fixed (rigid) supports with new ones further improved the integrity of the Autoclave by ensuring support flexibility, providing a favourable stress state in the autoclave shell, and reducing the likelihood of crack formation.
- With this new method, the problem of the occurrence of cracks in the area of the supports on the autoclave casing was solved. In addition, the dynamic load transferred to the object's structure was also reduced.
- The novel approach for autoclave support proposed here offers a sustainable solution applicable to pressure vessel equipment, requiring less additional maintenance and reducing downtime. This results in a more favourable economic outcome than the traditional method involving classic repairs.

Still, some suggestions by the authors of this paper for further work related to autoclave monitoring and the use of risk assessment methods to quantify further the improvements in the reliability of the newly reconstructed Autoclave or assess failure probabilities, which would serve as another indicator of reconstruction quality.

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References

Benac, D. J. (2002). Failure analysis and life assessment of structural components and equipment. *In ASM International eBooks,* 227–242. DOI: https://doi.org/nmw8

Benac, D. J., Cherolis, N., Wood, D. (2016). Managing cold temperature and brittle fracture hazards in pressure vessels. *Journal of Failure Analysis and Prevention*. 16(1), 55–66. DOI: https://doi.org/nmw7

Chavoshi, S. Z., Bradford, R., Booker, J. (2021). A validated approach for probabilistic structural integrity design code implementation. *Engineering Fracture Mechanics*. 257, 108028. DOI: https://doi.org/nmxc

Di Nicola, F., Lonardi, G., Fantuzzi, N., Luciano, R. (2024). Structural integrity assessment of an offshore platform using RB-FEA. *International Journal of Structural Integrity*. DOI: https://doi.org/nmxm

Filipović, N., Gerić, K., Sedmak, S. (2007). Loading Condition Effect on the Fracture of Welded Thin-walled Storage Tank. *Structural Integrity and Life*. 7(1), 21–28.

Horváth-Kálmán, E., Elek, B. (2023). Risks and the management of construction in the environment of nuclear facilities. *Acta Technica Jaurinensis*. 16(4), 143–151. DOI: https://doi.org/nmxd

Ilić, V., Radić, N. S. (2003). Redesign and damage repair experience related to manufacturing requirements for new "bidons". *Zavarivanje I Zavarene Konstrukcije*. 48(4), 211–214. URL: https://scindeks-clanci.ceon.rs/data/pdf/0354-7965/2003/0354-79650304211I.pdf

Jarić, M., Budimir, N., Petronić, S., Sedmak, S., Vitas. N. (2024a). Analysis of remediation of manifold line damaged by longitudinal crack in the piping elbow of oil and gas well collector. *Structural Integrity and Life*. 24(1), 111–115. DOI: https://doi.org/nmxg

Jarić, M., Petronić, S., Čolić, K., Opačić, M., Svetel, I. (2024b). Analysis of service problems of caustic tanks installed in oil and gas plants. *Structural Integrity and Life*. 24(1), 117–123. DOI: https://doi.org/nmxf

John, E., Boxall, J., Collins, R., Bowman, E., Susmel, L. (2024). Fatigue failure analysis of grey cast iron water pipes accounting for fatigue strength variation. *Engineering Failure Analysis*. 165, 108762. DOI: https://doi.org/nmxn

Jovanović, A., Đorđević, B., Jeremić, L., Milovanović, N.,Smoljanić, T. (2022). Integrity assessment of autoclaves after reconstruction. *Structural Integrity and Life*. 22(3), 347–352.

Jovanović, A., Bakić, G., Golubović, T., Kirin, S., Sedmak, A. (2023). Integrity and Risk Assessment of Reconstructed Steam Line. *Structural Integrity and Life*. 23(3), 367–371.

Kirin, S., Sedmak, A., Zaidi, R., Grbović, A., Šarkočević, Ž. (2020). Comparison of experimental, numerical and analytical risk assessment of oil drilling rig welded pipe based on fracture mechanics parameters. *Engineering Failure Analysis*. 114, 104600. DOI: https://doi.org/nmxb

Kurz, J. H., Jüngert, A., Dugan, S., Dobmann, G., Boller, C. (2013). Reliability considerations of NDT by probability of detection (POD) determination using ultrasound phased array. *Engineering Failure Analysis*. 35, 609–617. DOI: https://doi.org/f5mxkh

Lancaster, J. (2005). Engineering Catastrophes. In: Causes and Effects of Major Accidents. 3rd edition. Woodhead Publishing. ISBN 978-1-84569-016-8.

https://doi.org/10.55343/CogSust.130

Leshchinskii, L., Ivanov, V., Lavrova, E., Il'yaschenko, D., Verkhoturova, E.V. (2024). Fracture resistance of the deposited metal under dynamic and cyclic loading. *Structural Integrity and Life*. 24(2), 187–192. DOI: 10.69644/ivk-2024-02-0187

Maneski, T., Milošević-Mitić, V., Anđelić, N., Milović, L. (2008). Overhaul and reconstruction of an autoclave. *Structural Integrity and Life*. 8(3), 171-180.

Mastilovic, S., Djordjevic, B., Sedmak, A., Kirin, S. (2024). Data-driven prediction of fracture toughness size effect in ductile-to-brittle transition using Two-Step-Scaling procedure. *Engineering Fracture Mechanics*, 307, 110339. DOI: https://doi.org/nmw9

Németh, A., Major, Z., Fischer, S. (2020). FEM modelling Possibilities of glued Insulated rail joints for CWR tracks. *Acta Technica Jaurinensis*. 13(1), 42–84. DOI: https://doi.org/nmxh

Popović, I., Đorđević, M., Skerlić, J., Čamagić, I., Kirin, S. (2024). Determining the Reliability Function of the Thermal Power System in Power Plant' Nikola Tesla, Block B1' Using The Weibull Distribution. *Structural Integrity and Life*. 24(2), 145–149. DOI: 10.69644/ivk-2024-02-0145

Ruggieri, C. (2024). A probabilistic model to predict specimen geometry effects on fracture toughness in ferritic-pearlitic steels. *Engineering Fracture Mechanics*, 110493. DOI: https://doi.org/nmts

Sedmak A., Grbović A., Zaidi R., Kirin S., Vitas N., Golubović T., Vučetić I. (2023). Numerical, Analytical and Experimental Determination of Remaining Life of A Pipe With an Axial Crack. *Structural Integrity and Life*. 23(3), 239–244. URL: http://divk.inovacionicentar.rs/ivk/ivk23/239-IVK3-2023-AS-AG-RZ-SK-NV-TG-IV.pdf

Sedmak, S., Grabulov, V., Momčilović, D. (2009). Chronology of Lost Structural Integrity Initiated from Manufacturing Defects in Welded Structures. *Structural Integrity and Life*. 9(1), 39–50. URL: http://divk.inovacionicentar.rs/ivk/ivk09/039-IVK1-2009-SS-VG-DM.pdf

Sedmak, S., Burzić, Z., Perković, S., Jovičić, R., Aranđelović, M., Radović, L., Ilić, N. (2019). Influence of welded joint microstructures on fatigue behaviour of specimens with a notch in the heat affected zone. *Engineering Failure Analysis*. 106, 104162. DOI: https://doi.org/nmxk

Stosiak, M., Karpenko, M., Deptuła, A. (2022). Coincidence of pressure pulsations with excitation of mechanical vibrations of hydraulic system components: An experimental study. *Cognitive Sustainability*. 1(2). DOI: https://doi.org/gr2bdn

Towoju, O., Enochoghene, S., Adeyemi, J. (2023). Structural Integrity of Turbine Stator Blades Using Different Super Alloys with Internal Cooling at Fluid Temperature Range of 600 K – 700 K. *Acta Technica Jaurinensis*. 16(4), 152–157. DOI: https://doi.org/nmxj

Zoldy, M., Szalmane Csete, M., Kolozsi, P. P., Bordas, P., & Torok, A. (2022). Cognitive Sustainability. Cognitive Sustainability. 1(1). DOI: https://doi.org/10.55343/cogsust.7