Economic comparison of concrete and stainless steel molten salt tanks for CSP applications over the 2015–2025 period

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Abstract:

Advances in concentrating solar power (CSP) plants are crucial for their broader deployment. Increasing operating temperatures represents one of the most effective strategies to achieve further cost reductions and performance gains. In this context, the development of key components—such as molten salt storage tanks—is essential to support these improvements. This study evaluates a novel molten salt tank based on refractory concrete against a conventional design made of 347H stainless steel over the period 2015–2025. The cost evolution of refractory concrete and stainless steel was analyzed to estimate the corresponding TES tank costs in 2015 and 2025. Results indicate that, although the concrete-based tank was more expensive in 2015, the trend reversed by 2025, with the stainless-steel solution becoming approximately 11% more costly. Furthermore, an assessment of the producer price indices for both materials shows that concrete followed a more stable trend, whereas stainless steel experienced greater intra- and inter-annual variability.

Keywords:

Concrete, CSP plants, Economic analysis, Molten salts, Stainless steel.

1. Introduction

Concentrating solar power (CSP) plants represent one of the most advanced renewable technologies for converting heat into electricity, as they can deliver stable and dispatchable power at the multi-megawatt scale when integrated with thermal energy storage (TES) systems [1]. The continued development and cost reduction of CSP technologies depend strongly on the possibility of increasing the operating temperatures of heat-transfer fluids (HTFs). Raising these temperatures is a practical and near-term strategy for enhancing overall plant performance and improving economic competitiveness. At the same time, operating at higher temperatures creates new challenges, especially regarding the materials and design approaches used for TES tanks, which must maintain full compatibility with high-temperature molten salts over long periods of operation. For this reason, the selection of materials for both storage tanks and associated piping systems is critical for enabling the next generation of CSP installations [1]. Within this context, the present study evaluates the economic feasibility of a novel multilayer tank configuration designed for molten salt TES. The proposed concept consists of three primary layers: an internal metallic liner, an intermediate layer of refractory concrete, and an external structural concrete shell. Collectively, these layers fulfil the key requirements for molten-salt containment, namely ensuring chemical compatibility (metallic liner), providing adequate thermal insulation (refractory concrete), and maintaining long-term mechanical stability (structural concrete).

The study conducts an economic comparison with more conventional TES tank designs fabricated from high-temperature-resistant stainless steel alloys, with particular emphasis on stainless steel grade 347H. The analysis accounts for both material and structural costs, incorporating historical price data from 2015 to 2025 and extending the comparison to projected costs for the concrete-based solution over the coming decade. In addition, the study examines the stainless steel supply chain, highlighting the geographic distribution of raw material extraction sites. The results suggest that stainless-steel prices are highly influenced by geopolitical and socio-economic factors concentrated in a limited number of regions, thereby introducing greater uncertainty for project planning compared to concrete-based solutions that rely on widely available and more evenly distributed materials [2].

2. Methods

The system analysed in this study consists of a molten salt TES tank integrated within a tower-type CSP plant. The tank is designed to store 22,500 tons of molten salts and adopts a cylindrical geometry with a diameter of 40 m and a height of 14 m. Under the specified tower configuration, the TES system delivers a storage capacity of 2.36 GWh and operates within a temperature range of 285 °C to 565 °C. Two design alternatives are considered: a conventional configuration primarily based on grade 347H stainless steel, and an innovative multilayer concept employing refractory concrete, which is shown in Figure 1.

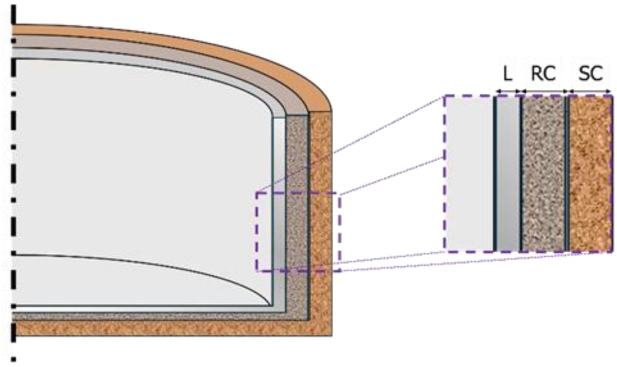

Figure 1. *Novel refractory concrete-based molten salts tank configuration. L: metallic liner, RC: refractory concrete, SC: structural concrete [2].*

The material cost evaluation of the concrete-based TES tank was performed by considering the different constituents of the refractory concrete, their relative proportions, and their unit costs, as provided by specialized suppliers for the years 2015 and 2025. In contrast, the cost of stainless steel was estimated by combining the base price of grade 304 with the alloy surcharge corresponding to grade 347. The alloy surcharge represents an industry-standard pricing mechanism used to capture the additional cost associated with alloying elements relative to a base grade. In this analysis, surcharge data for grade 347 were used in place of grade 347H, assuming a negligible price difference due to their limited compositional variation, primarily related to carbon content. Beyond the comparison of absolute material costs, particular attention was given to their price evolution over the period from 2015 to 2025, in order to identify which material exhibits greater stability and is therefore more suitable for practical applications due to enhanced cost predictability. This assessment was conducted using the producer price index (PPI) for stainless steel and cement, the principal components of the respective tank configurations. The PPI represents the average change over time in the selling prices received by domestic producers for their output.

3. Results

Figure 2 presents a comparison between the costs of conventional (stainless steel) and innovative (concrete-based) molten salt tanks for the years 2015 and 2025. While the refractory-based configuration was initially more costly in 2015, updated projections indicate that the traditional stainless steel solution becomes the more expensive option by 2025.

Furthermore, Figure 3 illustrates that both short-term (intra-year) and long-term (inter-year) price fluctuations are significantly more pronounced for stainless steel than for cement over the analysed decade. This finding underscores the lower volatility of the concrete-based solution in both short- and long-term cost projections [2].

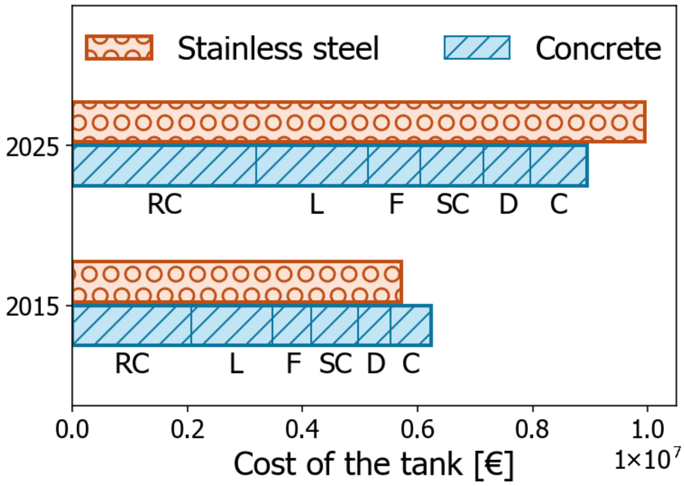

Figure 2. *Comparison between the estimated costs of the conventional (stainless steel) and the novel (concrete) molten salts tanks. RC: refractory concrete, L: stainless steel liner, F: foundation, SC: structural concrete, D: drying, C: stainless steel cover [2].*

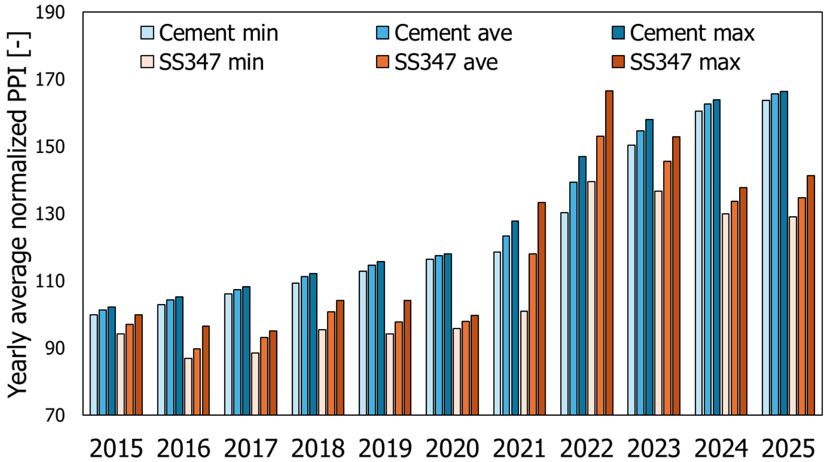

Figure 3*. Comparison of the average, maximum and minimum PPI of each year in the decade 2015–2025 for the cement and the stainless steel [2].*

4. Outcomes

This study presents an economic comparison of two molten salt tank concepts with equivalent thermo–chemical–mechanical performance for CSP applications over the period 2015–2025. A novel configuration integrating refractory concrete, structural concrete, and a metallic liner is evaluated against a conventional design based on stainless steel grade 347H. Results indicate that, although the concrete-based solution was more expensive in 2015, by 2025 the trend reverses, with the stainless steel design becoming approximately 11% more costly. This shift underscores the increasing economic attractiveness of alternative materials under changing market conditions. Finally, the producer price indices (PPIs) of stainless steel and cement were examined to assess cost predictability between 2015 and 2025. The analysis shows that: (i) the PPI for concrete remained comparatively stable throughout the decade, and (ii) the annual peak variation of stainless steel prices was consistently about twice that of cement. This indicates that projects relying on stainless steel are exposed to significantly greater short-term price volatility than those based on concrete.

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