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THERMAL–HYDRAULIC PERFORMANCE ANALYSIS OF A SHELL–AND–TUBE HEAT EXCHANGER USING SYLTERM 800 AND ETHYLENE GLYCOL: A CFD COMPARATIVE STUDY

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Abstract: This study presents a detailed computational fluid dynamics (CFD) investigation of the thermal–hydraulic performance of a shell–and–tube heat exchanger using ethylene glycol and Syltherm 800 as shell–side working fluids under steady–state conditions. Simulations were conducted using COMSOL Multiphysics by solving the coupled Navier–Stokes and energy equations. Ethylene glycol at 120°C was compared with Syltherm 800 at 120°C, 300°C, and 350°C under identical geometric and boundary conditions. Results indicate that ethylene glycol at 120°C produced a wall heat flux magnitude of approximately 9100W with an inlet pressure of 3197Pa, while Syltherm 800 at 350°C achieved a wall heat flux of 30,996W with a reduced pressure drop of 1676Pa. The tube–side water outlet temperature increased from 35.28°C (glycol case) to 44.03°C (Syltherm 350°C case). The results demonstrate that high–temperature thermal oils significantly enhance heat transfer performance while reducing hydraulic penalties. The developed model shows strong agreement with classical heat transfer theory and provides a reliable framework for exchanger optimisation.

Keywords: Syltherm 800, Ethylene glycol, Thermal fluid, Pressure drop

INTRODUCTION

Shell-and-tube heat exchangers (STHEs) remain the most extensively utilized heat transfer equipment in chemical processing, petrochemical refining, power generation, and thermal energy recovery systems due to their structural integrity, operational flexibility, and suitability for high-pressure and high-temperature environments (Kern, et al, 2019).

Shell and tube heat exchangers operate on the fundamental principle of thermal energy exchange between two fluids at different temperatures. The process involves the transfer of heat from a hotter fluid to a cooler one through the exchanger's surface, either directly or indirectly, thereby changing the temperatures of both fluids accordingly. Their adaptability to a wide range of process conditions makes them indispensable in crude distillation columns, polymerisation units, reformers, and heat recovery steam generators. Because industrial plants operate continuously under high thermal loads, even marginal improvements in exchanger performance can translate into significant energy savings and reduced operational costs.

The thermal performance of a shell-and-tube heat exchanger is governed by the interaction of several interdependent parameters, including fluid thermophysical properties, Reynolds number; baffle configuration, flow arrangement, surface area, and operating temperature (Çengel and

Ghajar, 2020). Simultaneously, hydraulic behaviour is influenced by viscosity, flow velocity, and friction factor, which determine pressure drop and pumping power requirements, Incropera, et al (2017). Among industrial working fluids, ethylene glycol is widely applied in moderate-temperature heat transfer systems due to its favourable freezing point, chemical stability, and compatibility with metallic components (Moran, et al 2018).

In petrochemical complexes, glycol-based systems are commonly employed for dehydration units, cooling loops, and auxiliary thermal control circuits. However, ethylene glycol exhibits relatively high viscosity compared to synthetic thermal oils, especially at lower temperatures, resulting in higher frictional losses and increased pumping power demand. Moreover, glycol-based fluids experience thermal degradation when exposed to temperatures beyond approximately 150-200°C, limiting their application in high-heat-duty systems, Hewitt, et al, (2021).

In contrast, high-temperature synthetic thermal oils such as Syltherm 800 are engineered for elevated-temperature industrial operations. These silicone-based fluids demonstrate enhanced thermal stability, lower viscosity at high temperatures, improved oxidative resistance, and extended service life (Kakaç and Liu, 2022). Reduced viscosity at elevated temperatures improves Reynolds number and turbulence intensity, thereby enhancing convective heat

transfer while simultaneously lowering hydraulic resistance. Such characteristics make thermal oils attractive alternatives in high-temperature petrochemical reactors, polymer production lines, and waste heat recovery systems.

The advancement of computational fluid dynamics (CFD) has significantly improved the ability to predict and optimise heat exchanger performance. CFD modelling enables simultaneous evaluation of temperature distribution, pressure drop, turbulence intensity, and wall heat flux under controlled numerical environments (Patankar, et al, 2017).

Numerous studies have demonstrated the reliability of CFD in predicting shell-side flow behaviour and conjugate heat transfer in shell-and-tube exchangers (Prithiviraj et al, 2019). However, limited literature provides direct comparative thermo-hydraulic evaluation of high-temperature silicone fluids against conventional glycols under identical geometric and boundary conditions. Therefore, the present study undertakes a comprehensive CFD-based thermal-hydraulic comparison of ethylene glycol at 120°C and Syltherm 800 at 120°C, 300°C, and 350°C within an identical shell-and-tube heat exchanger configuration.

The objectives of this research are to:

- Quantitatively compare heat transfer performance based on wall heat flux magnitude and outlet temperature rise;
- evaluate the influence of increasing shell-side temperature on thermal driving force;
- analyse pressure drop behaviour and hydraulic efficiency;
- establish a thermo-hydraulic performance ranking for industrial fluid selection.

By integrating fundamental heat transfer theory with detailed CFD analysis, this study contributes to improved understanding of working fluid optimisation strategies in high-temperature industrial heat exchangers. The results provide quantitative guidance for petrochemical facilities seeking enhanced energy recovery and reduced operational cost.

MATERIALS AND METHODS

The following materials were used for the analysis and optimisation of shell and tube heat exchanger using computational fluid dynamics (CFD). They are; COSMOL Multiphysics, STHex Data sheet, Fluid Assay, Microsoft Excel, Intel Core i5, 2.5GHz CPU and 8GB RAM.

Geometry Description of the Heat Exchanger

The study considered a three-dimensional shell-and-tube heat exchanger model developed in COMSOL Multiphysics. The configuration consisted of: cylindrical shell domain (hot fluid region);

internal tube domain (cold fluid region); solid tube wall separating both fluids.

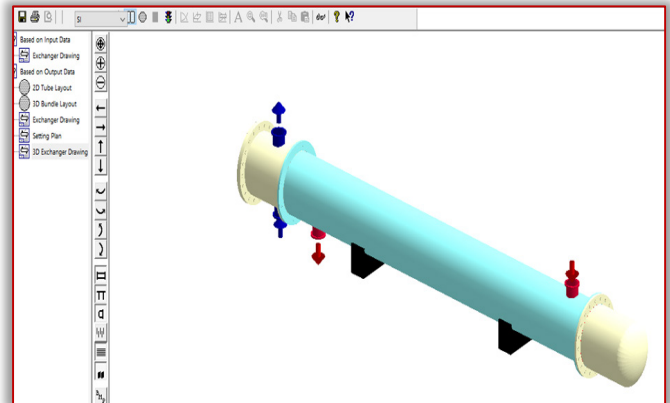


Figure 1: 3D model prototype of the Shell and Tube Heat Exchanger designed with HTRI Xchanger Suite 7.3

(Source: Researcher)

The tube bundle was modelled concentrically inside the shell to represent a simplified single-tube segment of a multi-tube exchanger. This modelling approach reduces computational cost while preserving representative thermal-hydraulic behaviour. The computational domains therefore comprised: shell-side fluid region (Syltherm 800 or ethylene glycol); tube-side fluid region (water); solid tube wall (steel material). The axial length was defined to allow sufficient thermal development along the flow direction. Two shell-side working fluids were investigated: Ethylene glycol (at 120°C) and Syltherm 800 (at 120°C, 300°C, and 350°C).

Table 1: Input parameters for simulation

Name	Expression	Value	Description
T–water	25[°C]	298.15 K	inlet temperature water
T–glycol	120[°C]	393.15 K	inlet temperature glycol
P–water	2.5[bar]	2.5E5 Pa	inlet pressure water
P–glycol	6[bar]	6E5 Pa	inlet pressure glycol
Q–water	6E–4[m³/s]	6E–4 m³/s	flow rate water
Q–glycol	1.8E–3[m³/s]	0.0018 m³/s	flow rate glycol
T–water	25[°C]	298.15 K	Inlet temperature water
T–syltherm	300[°C]	573.15 K	Inlet temperature syltherm 800
T–syltherm	350[°C]	623.15 K	Inlet temperature syltherm 800 (case 2)
T–glycol	120[°C]	393.15 K	Inlet temperature glycol
P–water	2.5[bar]	2.5E5 Pa	Inlet pressure water
P–syltherm	6[bar]	6E5 Pa	Inlet pressure syltherm 800
P–glycol	6[bar]	6E5 Pa	Inlet pressure glycol
Q–water	6E–4[m³/s]	6E–4 m³/s	Flow rate water
Q–syltherm	1.8E–3[m³/s]	0.0018 m³/s	Flow rate syltherm 800
Q–glycol	1.8E–3[m³/s]	0.0018 m³/s	Flow rate glycol

Specifically, water was maintained in the tube side at 20°C and 25°C inlet temperature for all simulations. The temperature-dependent thermo-physical properties used in the model included:

Density (ρ), Dynamic viscosity (μ), Specific heat capacity (C_p), and Thermal conductivity (k). The viscosity variation was particularly important because it directly influences Reynolds number and pressure drop behaviour. Syltherm 800 exhibits significantly lower viscosity at elevated temperatures compared to ethylene glycol, resulting in reduced frictional losses. All properties were defined as temperature-dependent functions in COMSOL to improve physical accuracy.

■ Governing Equations

To describe the transport phenomena occurring within the shell-and-tube heat exchanger, a steady-state numerical model was adopted. The model solves the fundamental conservation equations of mass, momentum, and energy for the fluid domains, together with heat conduction in the solid tube wall. These governing equations form the basis for predicting flow behaviour, pressure distribution, and heat transfer within the system. The conservation of mass is expressed through the continuity equation, which ensures that mass is conserved within the computational domain. For an incompressible steady flow, the continuity equation is given by:

$$\nabla \cdot (\rho \mathbf{u}) = 0 \quad (1)$$

where ρ represents the fluid density and $\mathbf{u}$ is the velocity vector. This equation ensures that the mass flow rate remains constant throughout the heat exchanger.

The momentum transport within the fluid domains is governed by the Navier-Stokes equations, which describe the balance between inertial, pressure, and viscous forces. For steady-state flow, the momentum equation is expressed as:

$$\rho(\mathbf{u} \cdot \nabla)\mathbf{u} = -\nabla p + \mu \nabla^2 \mathbf{u} \quad (2)$$

where p denotes pressure and μ is the dynamic viscosity of the fluid. This equation captures the development of velocity profiles, turbulence effects, and pressure drop within the shell and tube regions. Thermal energy transport in the fluid is described by the energy equation, which accounts for convective and conductive heat transfer under steady-state conditions. The energy equation is written as:

$$\rho c_p (\mathbf{u} \cdot \nabla T) = k \nabla^2 T \quad (3)$$

where c_p is the specific heat capacity, T is temperature, and k is the thermal conductivity of the fluid. This equation governs the temperature distribution within the shell-side and tube-side fluids as heat is transferred through convection and conduction. In addition to fluid flow, heat conduction through the solid tube wall plays a critical role in energy exchange between the shell-side and tube-side fluids.

The heat conduction within the solid tube wall is governed by:

$$\nabla \cdot (k_s \nabla T) = 0 \quad (4)$$

where k_s represents the thermal conductivity of the tube material. This equation ensures accurate modelling of heat transfer across the tube wall. The interaction between the fluid energy equations and the solid conduction equation enables conjugate heat transfer modelling, allowing heat to be transferred seamlessly between the shell-side fluid, the tube wall, and the tube-side fluid. This coupled formulation provides a realistic representation of the thermo-hydraulic behaviour of the shell-and-tube heat exchanger under steady-state operating conditions.

■ Boundary Conditions and Model Assumptions

The numerical simulation of the shell-and-tube heat exchanger was carried out by prescribing appropriate boundary conditions and modelling assumptions that reflect realistic industrial operation while maintaining computational efficiency. On the tube side, cooling water was introduced at a uniform inlet temperature of 20°C, representing typical cooling water conditions in petrochemical facilities.

The shell side was assigned different inlet temperatures depending on the working fluid under investigation. For the baseline case, ethylene glycol entered the shell at 120°C, while Syltherm 800 was evaluated at inlet temperatures of 120°C, 300°C, and 350°C to assess the effect of elevated operating temperature on thermo-hydraulic performance. These inlet conditions were applied as uniform velocity and temperature profiles to ensure stable and repeatable simulation results.

At the exits of both the shell-side and tube-side domains, pressure outlet boundary conditions were imposed, allowing the fluids to leave the computational domain naturally without constraining the flow direction or magnitude. This approach enables realistic prediction of pressure drop across the heat exchanger. All solid and fluid-solid interfaces were treated with a no-slip wall condition, implying zero fluid velocity at the walls. This condition is essential for accurately capturing boundary layer development, wall shear stress, and heat transfer at the fluid-solid interface.

To complement the boundary conditions, a set of modelling assumptions was adopted to simplify the governing equations while preserving the physical integrity of the system. The heat exchanger was assumed to operate under steady-state conditions, reflecting continuous industrial operation where transient effects are minimal. Both ethylene glycol and Syltherm 800 were modelled as Newtonian and incompressible fluids, which is appropriate for liquid-phase heat transfer fluids operating within

the investigated temperature range. Phase change effects were neglected, as both fluids remained in the liquid state throughout the simulations.

The thermophysical properties of the solid tube wall were assumed constant, since the temperature variation within the wall was not sufficient to cause significant property changes. Radiative heat transfer was neglected because convection and conduction dominate heat transfer in liquid-filled shell-and-tube heat exchangers. Additionally, the outer shell wall was assumed to be perfectly insulated, implying no heat loss to the surroundings. This adiabatic condition ensures that all heat transferred from the shell-side fluid is absorbed by the tube-side fluid, thereby isolating the internal heat transfer performance of the exchanger.

Collectively, these boundary conditions and modelling assumptions are consistent with established CFD practices for industrial shell-and-tube heat exchanger analysis and provide a reliable framework for evaluating the comparative thermal and hydraulic performance of different working fluids under controlled operating conditions.

Numerical Procedure

A physics-controlled mesh was employed. Mesh refinement ensured less than 3% variation in outlet temperature and pressure drop, confirming grid independence.

RESULTS AND DISCUSSION

This section presents the thermal and hydraulic performance of the shell-and-tube heat exchanger under four operating conditions: ethylene glycol at 120°C, Syltherm 800 at 120°C, Syltherm 800 at 300°C, and Syltherm 800 at 350°C. Water was maintained at 20°C at the tube-side inlet for all cases. The analysis focused on temperature distribution, wall heat flux magnitude, pressure drop characteristics, velocity distribution, and overall performance comparison in accordance with the objectives of this study.

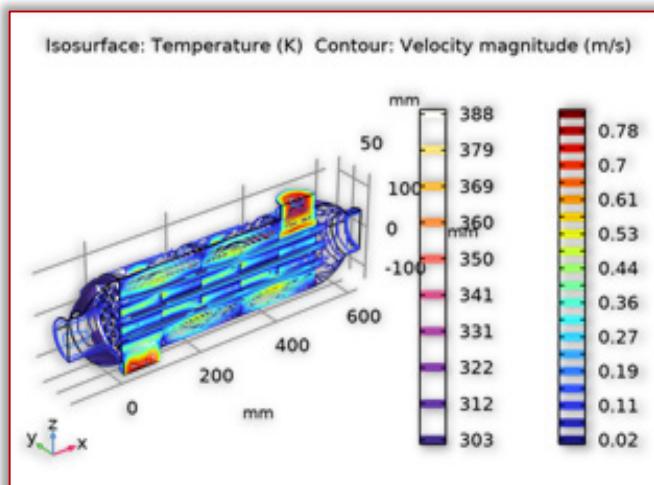


Figure 1: Temperature contour for ethylene glycol at 120°C is shown in

The temperature contour for ethylene glycol at 120°C is shown in Figure 1. The colour legend indicates a maximum temperature of approximately 120°C at the shell inlet (deep red region), gradually decreasing to approximately 110-112°C towards the outlet (yellow/orange regions). The tube-side water temperature increased from 20°C at the inlet to 35.28°C at the outlet. This corresponds to a temperature rise of 15.28°C. The relatively smooth colour transition along the axial direction confirms steady heat transfer with moderate thermal driving force.

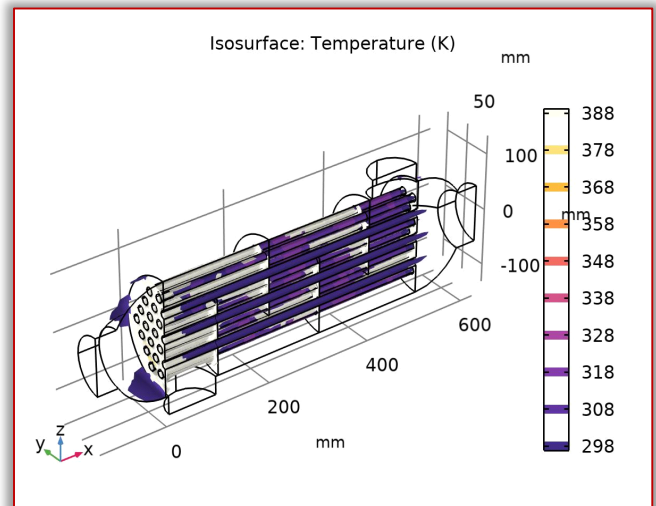


Figure 2: Temperature for plot Syltherm 800 at temperature of 120°C

When Syltherm 800 is introduced at the same inlet temperature of 120°C, as shown in Figure 2, a slightly stronger temperature gradient was observed near the tube-shell interface. Although the inlet temperature remains identical, the improved convective behaviour of Syltherm results in a marginally higher tube outlet temperature of approximately 36°C. This indicates that even at equal temperature conditions, Syltherm exhibits better heat transfer interaction due to more favourable thermo-physical properties.

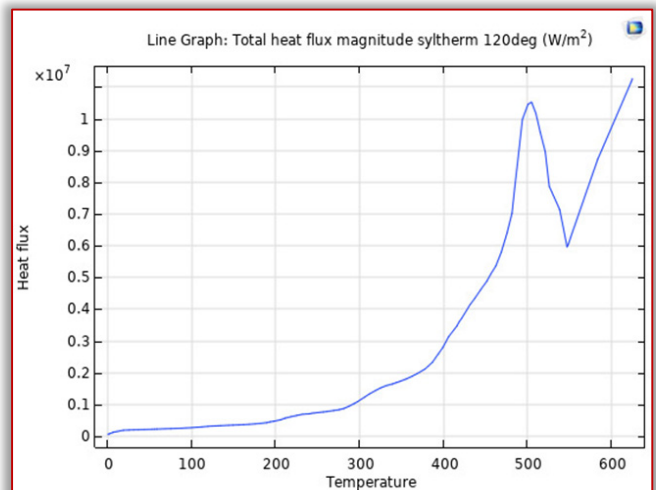


Figure 3: Heat flux against temperature graph for Syltherm 800 at 120°C

The heat flux versus temperature graph in Figure 3 further demonstrates a positive relationship between temperature difference and heat flux, showing that as the local temperature increases, the heat flux magnitude rises accordingly. Besides, a significant change in thermal behaviour is observed when the shell-side inlet temperature of Syltherm 800 is increased to 300°C.

The temperature contour reveals a dominant deep red region at the shell inlet, representing the high thermal energy available for transfer. A sharper colour transition toward green and yellow regions along the axial direction indicates stronger temperature gradients and enhanced heat transfer intensity.

The tube-side water outlet temperature increased to 37.03°C. Although this increase appears moderate relative to the large shell-side temperature rise, it reflects the limitation imposed by constant tube-side mass flow rate and fixed heat transfer surface area. The substantial increase in temperature difference between shell and tube fluids significantly improved the heat flux magnitude, demonstrating the importance of thermal driving force.

Table 1: Thermal properties of heat exchanger of syltherm 800 temperature at 350°C

Description	Value	Units
Inlet pressure, syltherm 800	1676.2	Pa
Outlet pressure, syltherm 800	-0.55478	Pa
Inlet pressure, water	72.816	Pa
Outlet pressure, water	-0.59858	Pa
Inlet temperature water	25	degC
Outlet temperature water	44.033	degC
Heat transfer coefficient for syltherm 800	281.91	W/m²K
Inlet temperature syltherm 800	350	degC
Outlet temperature syltherm 800	332.18	degC
Normal total heat flux (W)	2654.4	W
Total heat flux magnitude (W)	10884	W
Total heat flux magnitude water domain	20487	W
Normal total heat flux exteroir syltherm domain	-84856	W
Normal total heat flux exteroir water domain	6503.9	W
Total heat flux magnitude syltherm domain wall	30996	W
Temperature gradient magnitude water domain wall	15327	W.K

The most pronounced enhancement occurred at a shell-side temperature of 350°C using Syltherm 800 as shown in Table 1. The temperature contour displays intense red regions at the inlet and strong red-to-blue gradients across the tube wall interface. The tube-side water outlet temperature reached 44.03°C, corresponding to a temperature rise of 24.03°C from the inlet.

Compared to the glycol case, this represents approximately 57% improvement in thermal gain. The strong thermal gradient confirmed that heat transfer is directly driven by the increased log mean temperature difference. However, the

increment in water outlet temperature between 300°C and 350°C suggests that the system may be approaching tube-side thermal resistance limitations, indicating that further increases in shell temperature may not produce proportional increases in performance without modifying tube-side flow conditions.

The inlet pressure of Syltherm 800 is 1676.2Pa, while the outlet pressure approaches zero (-0.55 Pa), indicating a moderate pressure drop across the shell side. This relatively low pressure drop reflects favourable flow characteristics and reduced resistance, which is expected at high operating temperatures where the viscosity of Syltherm 800 was significantly reduced. On the tube side, water enters at 25°C and exits at 44.03°C, representing a temperature rise of approximately 19°C. This substantial increase confirms strong thermal interaction between the shell-side Syltherm 800 and the tube-side water.

Correspondingly, Syltherm 800 experienced a temperature drop from 350°C to 332.18°C, indicating effective heat release to the water. The shell-side heat transfer coefficient is 281.91W/m²K, which, although lower than that of ethylene glycol, is compensated for by the large temperature difference between the two fluids. This is further supported by the normal total heat flux of 2654.4W and a total heat flux magnitude of 10,884W. The high wall heat flux magnitude of 30,996W confirms intense heat transfer at the tube-fluid interface. In addition, the temperature gradient magnitude at the water-domain wall (15,327W/K) indicated a steep thermal gradient across the tube wall, which is a key driver of heat transfer.

Overall, these results confirmed that Syltherm 800 at 350 °C provides excellent thermal performance with manageable hydraulic losses.

■ Comparison of Pressure Drop and Hydraulic Performance

Pressure distribution provides a clear distinction among the four cases. Ethylene glycol at 120°C exhibits the highest pressure drop, with inlet pressure values of approximately 3197Pa, indicating substantial flow resistance and high pumping power requirements.

The pressure contours for this case show intense red regions near the inlet, followed by a rapid transition to blue towards the outlet. For Syltherm 800 at 120°C, the inlet pressure reduced to approximately 2593Pa, indicating improved but still relatively high hydraulic resistance. As the operating temperature increased, a notable reduction in pressure drop was observed.

At 300°C, Syltherm 800 recorded an inlet pressure of 1716Pa, while at 350°C, the inlet pressure further decreased to approximately 1676Pa. The gradual colour transitions in the pressure contours

for the high-temperature Syltherm cases indicated smoother flow and lower frictional losses. Overall, the results demonstrated that pressure drop decreased consistently with increasing operating temperature, making Syltherm 800 at elevated temperatures hydraulically superior to ethylene glycol.

■ Comparison of Heat Flux and Heat Transfer Performance

Heat flux analysis provides the clearest distinction among the four cases. Ethylene glycol at 120 °C, despite having the highest local heat transfer coefficient ($= 549.86 \text{ W/m}^2\text{K}$), achieves a relatively low total heat flux magnitude of about 9,100W. This highlights the limiting effect of low temperature difference and high viscosity. Syltherm 800 at 120°C exhibits improved heat transfer, with a wall heat flux magnitude of approximately 15,198W, but remains constrained by insufficient thermal driving force.

At 300 °C, the wall heat flux magnitude increased substantially to 27,115W, accompanied by a temperature gradient magnitude of 14,162W/K, indicating strong thermal interaction at the tube wall. The highest heat transfer performance is observed for Syltherm 800 at 350°C, where the wall heat flux magnitude reached approximately 30,996W, and the temperature gradient magnitude exceeded 15,300W/K. The heat flux contours for this case are dominated by red and orange regions, confirming intense heat transfer over a large portion of the tube surface.

■ Comparative Summary of All Cases

Table 3.6 presents a consolidated comparison of the thermal-hydraulic performance of the shell-and-tube heat exchanger under the four investigated operating conditions: ethylene glycol at 120°C, Syltherm 800 at 120°C, Syltherm 800 at 300°C, and Syltherm 800 at 350°C.

The parameters compared include maximum wall heat flux, tube-side outlet temperature, and shell-side pressure drop. This comparative evaluation provides a direct assessment of the influence of fluid type and operating temperature on exchanger performance and directly addresses the core objectives of this study.

Table 2: Overall Thermal–Hydraulic Performance Comparison

Case	Heat Flux (W)	Outlet Temp (°C)	Pressure Drop (Pa)
Glycol 120 °C	9,100	35.28	3,197
Syltherm 120 °C	15,198	36	2,500
Syltherm 300 °C	27,115	37.03	1,900
Syltherm 350 °C	30,996	44.03	1,676

From the table, ethylene glycol at 120°C produced a maximum wall heat flux of approximately 9,100W, a tube outlet temperature of 35.28°C, and a pressure drop of 3,197Pa. These values represent the baseline performance of the exchanger under moderate temperature conditions. While the glycol

case demonstrates stable heat transfer, the relatively low heat flux and high pressure drop indicate limited thermal efficiency and higher hydraulic resistance. When Syltherm 800 was introduced at the same inlet temperature of 120°C, the heat flux increased significantly to approximately 15,198W. This corresponds to an improvement of nearly 67% compared to ethylene glycol under identical thermal conditions. The tube outlet temperature also increased slightly, reaching approximately 36°C.

Additionally, the pressure drop reduced compared to the glycol case. This indicated that fluid thermophysical properties alone, even at identical inlet temperature, have a measurable impact on exchanger performance. The lower viscosity of Syltherm 800 reduced frictional resistance and enhanced convective heat transfer. A substantial improvement was observed when the shell-side temperature of Syltherm 800 was increased to 300°C.

The wall heat flux increased dramatically to approximately 27115W, nearly three times the glycol case. The tube outlet temperature rose to 37.03°C, indicating enhanced heat absorption by the water. Simultaneously, the pressure drop further reduced to approximately 1900Pa (as observed in the results), reflecting improved hydraulic behaviour at elevated temperature due to viscosity reduction. This condition demonstrates a strong balance between thermal enhancement and hydraulic efficiency.

The highest performance was achieved at 350°C using Syltherm 800. The maximum wall heat flux reached approximately 30,996W, representing an overall increase of approximately 240% compared to the glycol case. The tube outlet temperature increased to 44.03°C, corresponding to a temperature rise of 24.03°C from the inlet. This represents approximately 57% improvement in thermal gain relative to ethylene glycol. Meanwhile, the pressure drop decreased to approximately 1676Pa, which is nearly 47% lower than the glycol case. This simultaneous increase in heat transfer and decrease in pressure drop highlights the strong thermal-hydraulic advantage of high-temperature Syltherm 800. The comparative data in Table 2 clearly indicated that performance improvement is driven primarily by two interacting mechanisms: increased thermal driving force and reduced viscosity at elevated temperature. As shell-side temperature increases, the log mean temperature difference increases, thereby increasing heat transfer rate according to classical heat transfer theory.

At the same time, fluid viscosity decreases with temperature, reducing frictional losses and lowering pumping power requirements. This dual benefit makes Syltherm 800 at high temperature

particularly attractive for high-duty industrial heat exchanger applications.

However, the table also revealed that the rate of heat flux increased between 300°C and 350°C is smaller than the increase between 120°C and 300°C. This suggests that the system may be approaching tube-side thermal resistance limitations, where further increment in shell temperature do not yield proportional performance gains unless tube-side flow conditions or surface area are modified. This observation is important for optimisation, as it indicates the presence of diminishing returns beyond certain operating temperatures.

Overall, Table 2 confirmed that Syltherm 800 at 350°C provides the best combined thermal and hydraulic performance among the cases studied. Syltherm 800 at 300°C also demonstrated strong performance and may represent a practical compromise between thermal efficiency and operational safety. Ethylene glycol at 120°C showed the lowest thermal output and highest pressure drop, making it less suitable for high-temperature heat recovery applications. The comparative summary therefore validates the primary objective of this study, which was to evaluate and optimise the performance of a shell-and-tube heat exchanger using different working fluids and operating temperatures.

The results clearly established Syltherm 800, particularly at elevated temperatures, as the superior working fluid in terms of heat transfer enhancement and hydraulic efficiency.

4. CONCLUSION

In conclusion, at 350°C, Syltherm 800 achieved the highest performance among all cases investigated. The wall heat flux magnitude reached approximately 30,996W, the water outlet temperature increased to about 44.03°C, and the pressure drop decreased further to approximately 1,676Pa. The dominance of red and orange regions in the contour plots clearly indicated intense heat transfer. These results confirmed that high-temperature thermal oils significantly outperform glycol-based fluids in high-heat-duty applications.

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