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Proceedings of the 7th International Seminar on ORC Power Systems

Editorial Universidad de Sevilla

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(ORC2023)

4th to 6th
SEPTEMBER
SEVILLE 2023

EDITORIAL UNIVERSIDAD DE SEVILLA

Sevilla, 2024

Colección Actas
Núm.: 91

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ISBN 978-84-472-2745-7
DOI: https://dx.doi.org/10.12795/9788447227457

Diseño de cubierta y maquetación: los autores

INDEX OF CONTRIBUTIONS

SEVILLE 2023
7th International Seminar on O.R.C. Power Systems

DOI: https://dx.doi.org/10.12795/9788447227457_4

THERMODYNAMIC CONCEPT OF A NOVEL RECUPERATIVE TWO-PHASE POWER CYCLE

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ABSTRACT

The transformation of renewable or waste heat into mechanical power by the Organic Rankine Cycle (ORC) has become established as a robust and cost-effective technology. However, it must be considered that these applications normally come with a limited temperature difference between the source and the sink, which is why the maximal achievable thermal efficiency is already low in comparison with conventional power plants. In addition, this Carnot efficiency is not achievable by real ORC systems. The reasons for this are not only irreversible components or the necessary temperature differences for heat absorption or rejection, but also the need of preheating the working fluid, which is an immanent characteristic of the Rankine process itself. Thus, the mean temperature of heat absorption differs from that of a Carnot process, resulting in a limited second law efficiency. This publication describes a novel thermodynamic power cycle with the aim of completely avoiding preheating losses, which is called the Recuperative Two-Phase Power Cycle (PC-RTPC). Regarding the state changes, the process resembles the concept of the Ericsson cycle. Deviating from it, the working fluid undergoes a phase change, which implies significant advantages compared to a process using a gaseous working fluid. This is made possible by a non-linear zeotropic mixture composed of a main and an ancillary working fluid. The key element is an internal heat exchanger, which separates the two temperature levels of the source and the sink, while on its low-pressure side a condensation takes place. The primary technical challenge is an expansion into the two-phase region. For the basic cycle, which is intended to convert latent heat sources, an isothermal expansion is required. For the conversion of the sensible heat source this challenge could be avoided. This work illustrates the concept of such a cycle by a theoretical investigation and an exemplary working fluid selection for a latent heat source of 100 °C. The endoreversible cycle with an isothermal expansion is able to reach a second law efficiency of 85.8% applied to the source and sink temperatures.

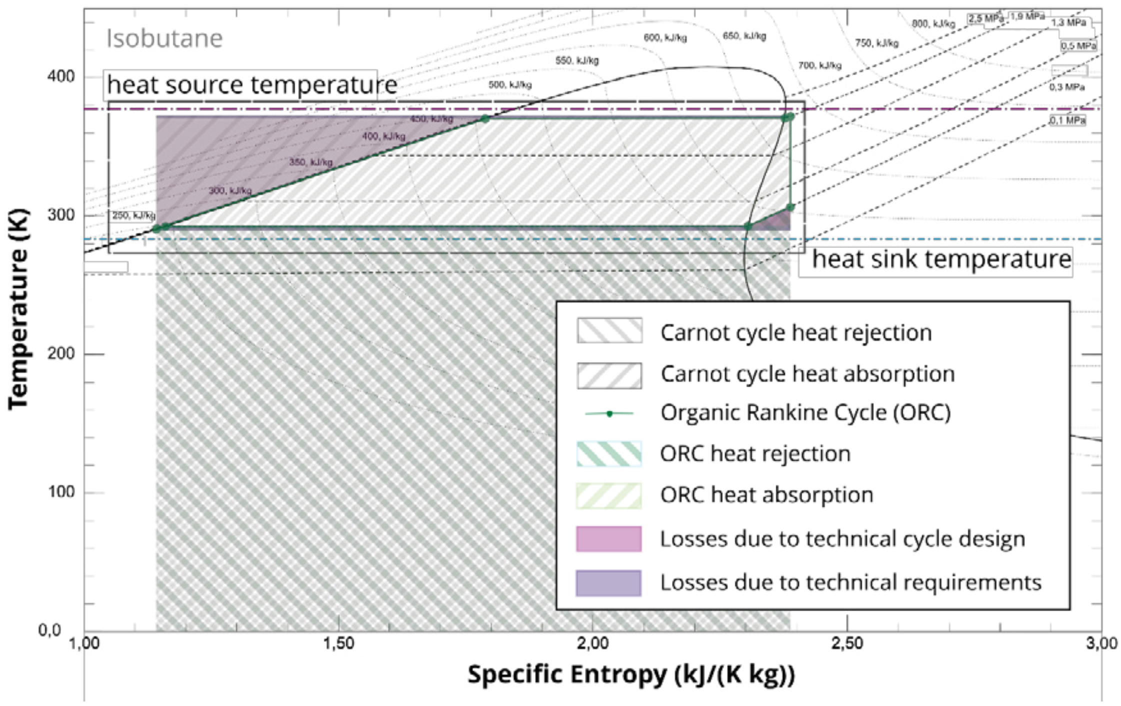
1 INTRODUCTION

The transformation of renewable or waste heat into mechanical power by the Organic Rankine Cycle (ORC) has become established as a robust and cost-effective technology. Nowadays, it is used for a range of applications, however, the currently unused technical potential is still much larger. A dominating obstacle for its usage is that the majority of applications offer only limited temperature differences between the source and the sink. That is why the maximal achievable thermal efficiency is already low in comparison with conventional power plants. In addition, this Carnot efficiency is not reachable by real ORC plants, and the second law efficiencies are normally even lower than those of conventional power plants. This results in a double negative effect that the circumstance of small temperature differences and the technology itself lead to poor thermal efficiencies, and thus to insufficient economic feasibility in many cases. Therefore, the only option to raise the thermal efficiency is to increase the second law efficiency, because the external temperature levels are normally not adjustable. This publication describes the power cycle version (PC) of a novel thermodynamic cycle, which is called the Recuperative Two-Phase Cycle (RTPC) and offers potentially a higher second law efficiency. The heat pump version of this cycle has been already presented (Bederna et al., 2023). In section 2, the underlying concept is derived from a loss analysis of a basic Organic Rankine Cycle and the concept is defined from the state of the arte. Furthermore, different ideal variants of the cycle to convert latent or sensible heat sources are presented. In section 3 an exemplary cycle is designed to convert a latent heat source of 100 °C using a latent sink of 15 °C.

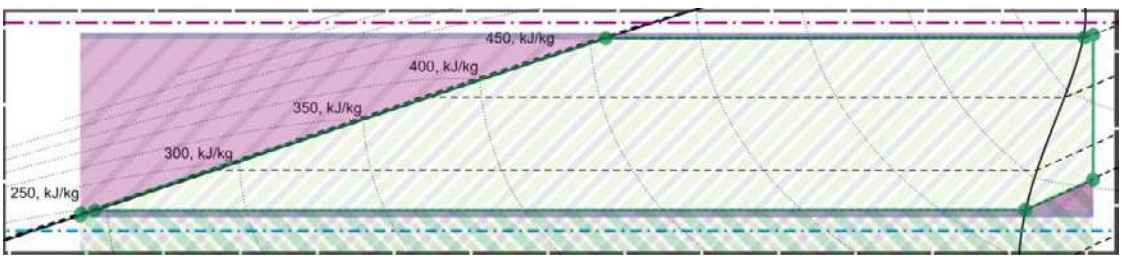
2 CONCEPTION OF THE RECUPERATIVE TWO-PHASE POWER CYCLE

2.1 Loss Analysis of the Organic Rankine Cycle

If an increase of the second law efficiency is intended, a precise knowledge of the reasons for exergy destruction is needed. Therefore, an exergetic analysis of the cycle, the components and the interaction between the cycle and the source and sink is essential. A classification of the loss sources is helpful because certain sources of losses are avoidable, while others are inevitable. A first classification distinguishes endogenous losses and exogenous losses. Endogenous irreversibilities occur due to irreversibilities in the components, in particular due to friction, heat losses or leakage. They can only be influenced by higher component quality, to a limited extent. Exogenous losses describe a derivation from the ideal cycle and are additionally subdivided into three types in this publication. To illustrate these subtypes, an endoreversible basic ORC using the working fluid isobutane (R-600a) for an application with a temperature difference of 95 K between a latent heat source and latent heat sink is illustrated in Figure 1 (a). The visualization of the fluid data is exported from REFPROP (Lemmon et al., 2018), slightly modified and extended by the cycle. In Figure 1 (b) the detail of the cycle is enlarged.



(a) T, s diagram illustrating the importance of each loss source



(b) Detail of the cycle

Figure 1: Visualization of exergetic losses of an endoreversible ORC

First, unavoidable exergetic losses occur due to a necessary temperature difference for the heat transfer between the cycle, the heat source and the heat sink. Only a higher heat transfer coefficient or a larger heat exchanger surface area can reduce these losses, thus the reduction potential is limited. The second subtype are losses caused by technical requirements and these are marked by the dark purple color in Figure 1. Superheating could be needed to prevent turbines from being damaged by liquid slugging. Subcooling to avoid cavitation in the feeding-pump can also be such a technical requirement which leads to a higher temperature difference in the heat exchangers. Potential reduction of this disadvantage is offered by a two-phase expansion or a geodetic suction pressure enhancement instead of subcooling at the inlet of the pump. The last subtype includes the deviations of the changes of state of the real from the ideal cycle. Thereby these losses will be called cycle-related and are marked in light purple in Figure 1. An endoreversible Organic Rankine Cycle is composed of an isochoric pressure rise, an isobaric heat absorption, an isentropic expansion and an isobaric heat rejection. Therefore, a deviation from the Carnot cycle occurs when the isobars of an ORC are not equal to isotherms. Additionally, an isochoric pressure rise is slightly different from an isentropic pressure rise. It is visible in Figure 1 that the derivation of the preheating temperature from the ideal heat absorption temperature of the Carnot cycle has the dominating effect, while the difference due to the isochoric pressure rise is negligible. A widespread approach to reduce this preheating losses in Rankine steam cycles is the regenerative feed preheating, which is achieved by injecting partially depressurized steam. For an ORC, this is normally not implemented due to the high number of pumps and increased technical complexity. Further cycle-related exergy destruction can result from the superheated working fluid after the expansion process. In this case, a recuperator can be introduced to preheat the liquid by the superheated exhaust gas. This approach can nearly eliminate the expansion losses, but the preheating losses are only reducible to a limited extent. Generally, preheating losses can only be avoided in ORC systems when an additional sensible heat source with an adequate temperature profile for preheating is available.

2.2 Organic Rankine Cycle with an Isothermal Expansion

For configurations with only one heat source, it is an option to decrease the preheating losses by an increased recuperation effect due to a non-adiabatic expansion process. Optimally, the heat supply during the expansion is high enough to ensure an isothermal expansion (Figure 2). Thereby, the exhaust gas temperature after the expansion process (point 5) is still the same as before (point 4). 25

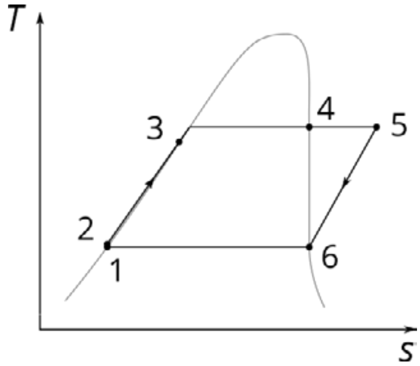
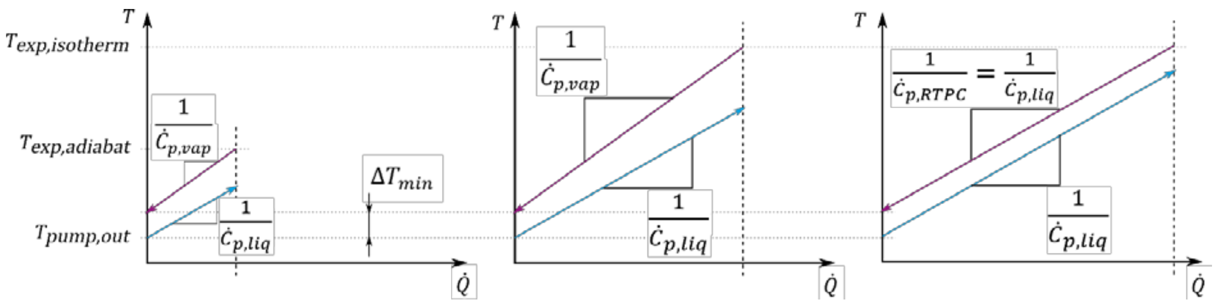


Figure 2: Concept of an Organic Rankine Cycle with an isothermal expansion

This concept was presented for the first time by Woodland et al. (2010) for ORCs, where it was proposed to flood volumetric expanders with hot oil to ensure a sufficient heat supply for a near-isothermal expansion. Igobo and Davies (2014) presented a review on low-temperature power cycles with quasi-isothermal expansion and concluded that there are two main methods to realize the heat supply in volumetric expanders. The first method is surface heating, which is more used for reciprocating piston machine, and the second is liquid flooding, which is investigated more in rotary expanders. It was summarized that the challenges for liquid flooding are high pressure drops and losses due to viscosity, while for the expander surface heating the speed must be lower to enable the heat transfer. Based on this, Igobo (2015) performed experimental tests with a reciprocating piston expander with heated surfaces and could prove an isothermal expansion for piston speeds below $0.2\ m \cdot min^{-1}$. Ziviani et al. (2018) investigated theoretically the concept of the oil flooding in ORC and predicted a performance enhancement of approximately 8 % for the fluid R-1233zd(E). Furthermore, an experimental test rig for such a cycle was built. However, the theoretical predictions could not be demonstrated in the ensuing tests because the optional pressure levels could not be adjusted, resonance occurred in the oil line and the friction in the expander and the oil pump were higher than expected (Li et al., 2021). In summary, several technical challenges and a fundamental thermodynamic disadvantage can be identified in the context of this approach. The realization of the isothermal expansion itself presents a significant challenge. For the liquid flooding, losses due to viscosity and friction have to be taken into account and with heated surfaces, the heat transfer is not high enough to ensure a reasonable rotational speed. Furthermore, it has to be mentioned that also the recuperator causes disadvantages, especially due to the superheated vapor state of the fluid on the low-pressure side. Thus, the internal heat transfer is low and the specific volume is high, which is why large surface areas and internal volumes are required. Thermodynamically, with this approach it is not possible to avoid completely the preheating losses, even if the expansion is isothermally conducted. This is due to the higher heat capacity of the liquid in comparison to the superheated gas. In Figure 2, this is indicated by a slightly lower temperature of state point 3 compared to point 5. The new concept of the Recuperative Two-Phase Cycle, and in particular its power cycle form (PC-RTPC) aims to avoid these technical and thermodynamic disadvantages.

2.3 Ideal Recuperative Two-Phase Power Cycle (PC-RTPC)

The target of the new cycle is to avoid superheated vapor states and operates in the two-phase region, instead. This increases the heat transfer in the recuperator but also in the expansion process and equalizes the heat capacity flows in the recuperator. In **Figure 3**, a comparison of different internal recuperation processes is made. The heat capacity flow of the high-pressurize liquid $\dot{C}_{p,liq}$ is the same in all configurations. In comparisons with the basic ORC, shown in Figure 3(a), the isothermal expansion, shown in Figure 3(b), increases the preheating effect in the liquid by a higher vapor inlet temperature but does not change the vapor capacity flow $\dot{C}_{p,vap}$. To maximize the recuperation, and thus, to minimize the preheating losses, the capacity flows of both sides must be equalized, as shown in Figure 3(c). This enabled in the RTPC concept by partial condensation on the low-pressure side with simultaneous temperature change. 26



(a) Conventional ORC (b) ORC with isothermal expansion (c) Recuperative Two-Phase Power Cycle

Figure 3: Comparison of characteristics of internal recuperation

When the high-pressure and the low-pressure isobar of the ideal recuperation process are combined with isotherms, the shape of the Ericsson cycle appears. The ideal Ericsson cycle contains four changes of state: isobaric heat absorption, isothermal compression, isobaric heat rejection, and an isothermal expansion, and is able to achieve the Carnot efficiency, as well. The conventional technical implementation of the Ericsson cycle is carried out with a gaseous working fluid. Nevertheless, gaseous working fluids have significant disadvantages in terms of volumetric power density and heat transfer compared to working fluids that undergo a phase change process. The RTPC can also approximate the shape of an Ericsson cycle and avoid both disadvantages (Figure 4). Its key approach is to perform the cycle only with liquid or two-phase fluid by means of a mixture with highly nonlinear temperature glide in the two-phase region (Bederna and Hesse, 2021). All the changes of state associated with the PC-RTPC-EC are listed in Table 1.

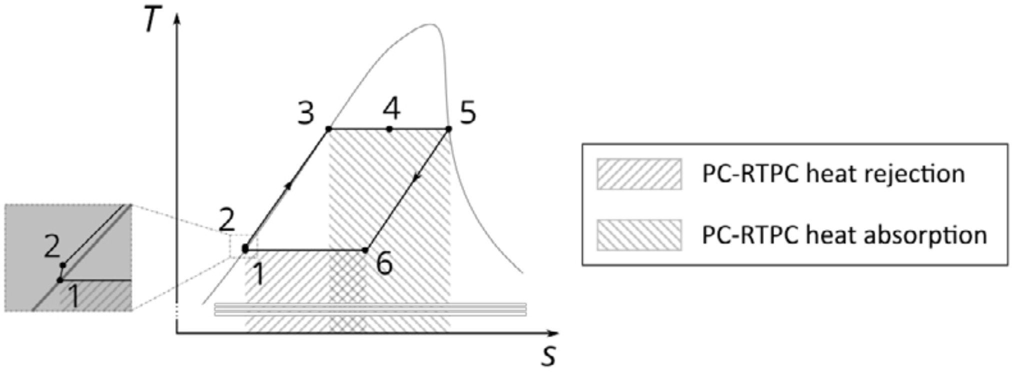


Figure 4: Ideal Recuperative Two-Phase Power Cycle realizing the Ericsson Cycle (PC-RTPC-EC)

It can be seen in Figure 1 that the isochoric pressure rise (1→2) does not cause a relevant temperature rise, why the shape is nearly identical with the Ericsson cycle. Thus, it can be assumed for the ideal Recuperative Two-Phase Power Cycle in Ericsson cycle shape (PC-RTPC-EC) that the efficiency is similar to the Carnot efficiency ($\eta_{PC-RTPC-EC,ideal} \approx \eta_{Carnot}$). This cycle concept could be used to convert latent heat sources by latent or slightly gliding sinks, such as the environment.

Table 1: Changes of state of the endoreversible
Recuperative Two-Phase Power Cycle to realize the Ericsson cycle (PC-RTPC-EC)

1 → 2	isochoric	pressure rise	adiabatic	liquid
2 → 3	isobaric	preheating	heat recuperation	liquid
3 → 4	isobaric and isotherm	evaporation	heat absorption	two-phase
4 → 5	isotherm	expansion	heat absorption	two-phase
5 → 6	isobaric	condensation	heat recuperation	two-phase
6 → 1	isobaric and isotherm	condensation	heat rejection	two-phase

If the heat source does not correspond to a latent heat reservoir, but instead a stream should be cooled down, the cycle configuration can be adapted to this. For this purpose, the isothermal expansion is replaced by two or more stages of an isobaric heat absorption (3a→4a and 3b→4b) followed by an isentropic expansion (3a→4a and 3b→4b) (Figure 5).

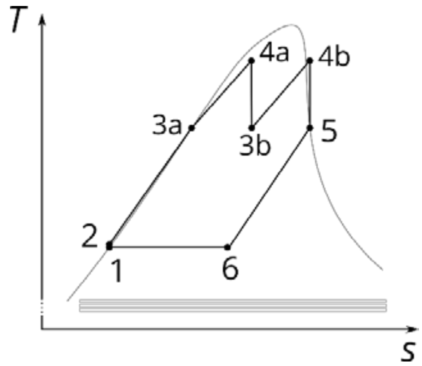


Figure 5: Ideal Recuperative Two-Phase Power Cycle with two stages realizing a trilateral cycle

Depending on the working fluid used and the temperature levels, the change of state 4b → 5 is within or outside the two-phase region. All other expansion processes always imply expansion of two-phase fluid. It should be emphasized that, in this configuration, the technically challenging isothermal expansion can be avoided. It should also be noted, however, that the characteristics of the working fluids do not permit the use of any temperature difference on the source side. In principle, the number of stages must increase for smaller temperature differences between the state points 3 and 4.

2.4 Realizing Recuperative Two-Phase Power Cycles

In order to realize an RTPC, specific zeotropic mixtures are needed as a working fluid. These mixtures consist of a main and at least one auxiliary fluid. In order to achieve the necessary inhomogeneous temperature glide characteristics, the different fluid components have to have very different normal boiling points and critical temperatures, and the composition fractions must also be very unequal. It is intended that the temperature glide of the mixture corresponds to the temperature difference between the high and low temperature levels of the cycle. By selecting the main fluid and the auxiliary fluid with the highest critical temperatures, the pressure level and the temperature difference can be roughly set. With regard to the low-pressure level, the largest part of the evaporation should be isothermal, while in the range of high vapor quality the entire temperature glide should occur linearly. Unfortunately, real fluids cannot exactly achieve this required discontinuous curve. To get an idea of this behavior, the exemplary mixture of 98 mol% n-butane (main fluid) and 2 mol% dodecane (auxiliary fluid) and ideally required isobars are shown in Figure 6.

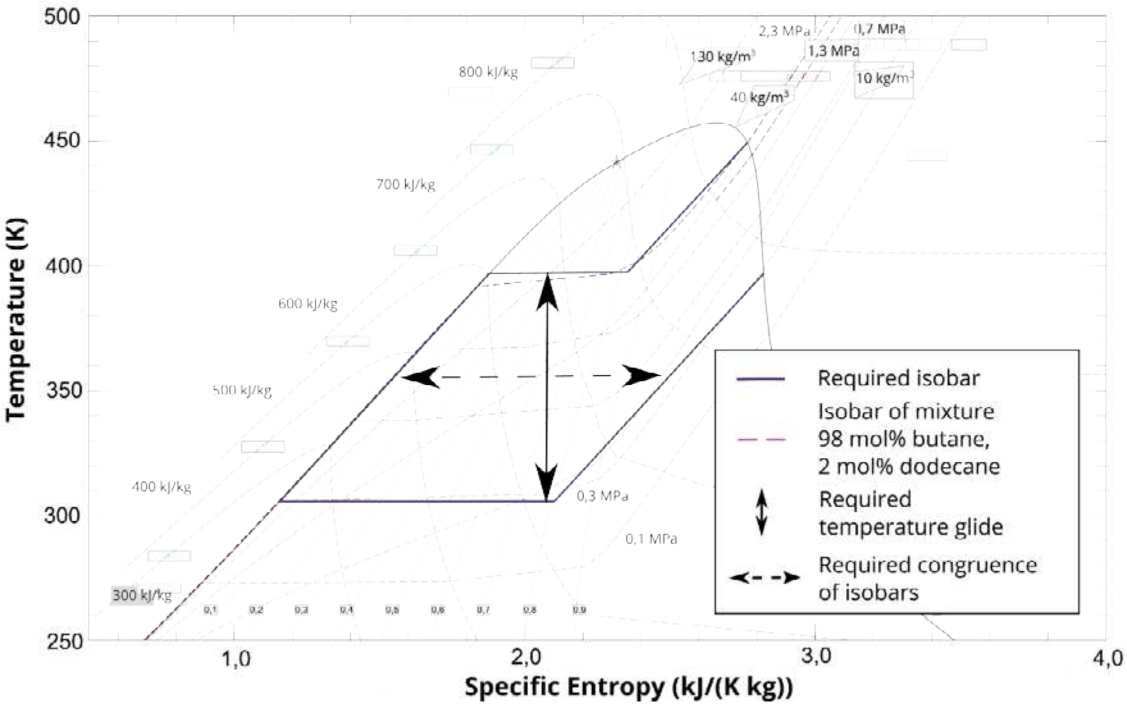


Figure 6: Real mixture data (REFPROP 10) in comparison with the required isobars of an RTPC

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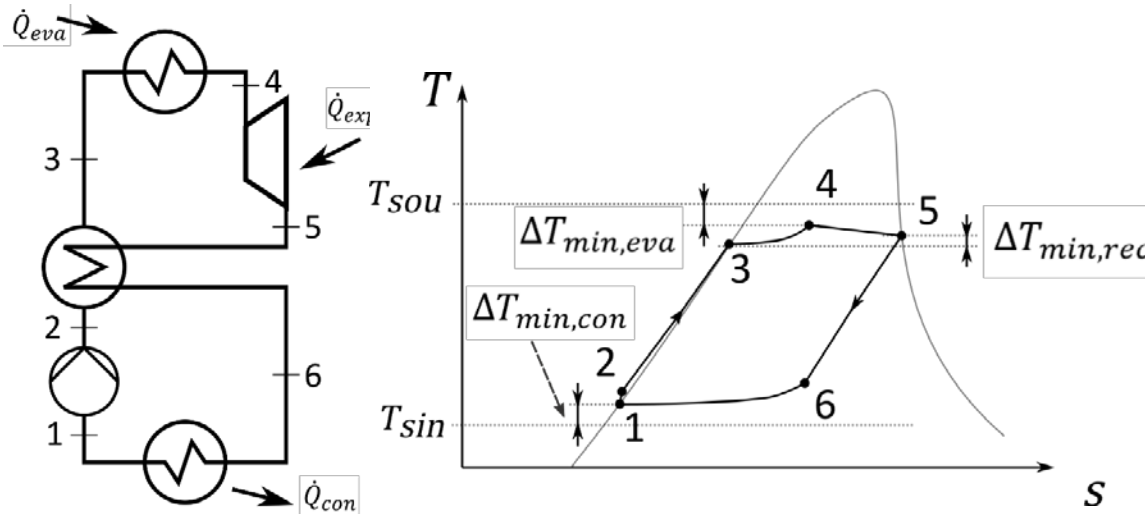
To match the capacity flows in the recuperator, the temperature slope of the liquid isobars must correspond to the temperature slope in the second part of the evaporation. The characteristics of the isobars in the two-phase region are mainly influenced by the ratio of the fluid components. Additional auxiliary fluids can be used to linearize the temperature glide. The exact optimization of the mixture fluid is a complex challenge due to the high number of possible mixture combinations. Additionally, the strong influence between the process parameters, the mixture components and the composition has to be adjusted simultaneously. Apart from the fluid selection, the RTPC presents several challenges associated with the technical realization. Zeotropic mixtures, especially with a large temperature glide, cause a composition shift within the process (Zhou et al., 2017). This shift can change the local fluid properties and thus corrupt the compatibility of the fluid streams in the recuperator, which can lead to unexpected exergy losses. In addition, it is known from zeotropic mixtures that the different phase change behavior can inhibit heat transfer (Weith et al., 2014). For the realization of a PC-RTPC-EC, a near-isothermal expansion is necessary, which is the main technical challenge. In comparison with approaches discussed in section 2.2, the RTPC has the advantage of a phase change in the working chamber, which is why significantly higher internal heat transfer coefficient can be assumed. Therefore, the RTPC could enable new opportunities in the context of the isothermal compression in volumetric machines. Apart from this, a multi-stage approach would be conceivable. Nevertheless, these stages have to occur in the two-phase region.

3 DESIGN OF THE POWER CYCLE REALIZING THE ERICSSON CYCLE

3.1 Basic Calculations

The state point calculation of an ideal endoreversible PC-RTPC-EC with a latent source and sink and minimal temperature differences differ from the analytical calculation approaches of ORCs (Figure 7).



(a) Cycle configuration (b) T, s diagram

Figure 7: Calculation of an endoreversible PC-RTPC-EC

First, the minimal cycle temperature T_1 is defined by Eq. (1) and this temperature defines the low-pressure level. With that pressure the Temperature T_5 is set considering the state of the dew line.

$$T_1 = T_{sin} + \Delta T_{min,con} \quad (1)$$

The maximal temperature in the cycle T_4 is defined by source temperature T_{sou} and the minimal temperature in the evaporator and expander (Eq. (2)) and the evaporation inlet temperature T_3 is defined for by the minimal temperature difference in the recuperator according to Eq. (3).

$$T_4 = T_{sou} - \Delta T_{min,eva} \quad (2)$$

$$T_3 = T_5 - \Delta T_{min,rec} \quad (3)$$

The high-pressure level is calculated based on T_3 for a saturated liquid. Furthermore, the Temperature T_6 is determined while through the energy balance in the recuperator (Eq. (4)).

$$h_3 - h_2 = h_5 - h_6 \quad (4)$$

For the description of the quasi-isothermal compression, Eq. (5) and Eq. (6) can be used.

$$\dot{q}_{exp} = (T_4 + T_5)/2 \cdot (s_5 - s_4) \quad (5)$$

$$w_{exp} = h_5 - h_4 - \dot{q}_{exp} \quad (6)$$

For the analysis of the entire cycle, Eq. (7), which defines the thermal efficiency η_{th} by the specific net power output and the specific heat flows, and Eq. (8) of the second law efficiency η_{II} can be applied.

$$\eta_{th,HP-RTPC-EC} = \left(w_{exp} - h_2 - h_1\right) \cdot (\dot{q}_{exp} + h_4 - h_3)^{-1} \quad (7)$$

$$\eta_{II,PC-RTPC-EC} = \eta_{th,HP-RTPC-EC} \cdot {\eta_{Carnot}}^{-1} \quad (8)$$

3.2 Case Study of the Conversion of a Latent Low-temperature heat Source

For a preliminary evaluation of the possible thermodynamic potential of this cycle for the conversion of latent low-temperature sources an endoreversible RTPC is calculated and compared with the presented qualitative evaluation of Rankine power cycles. For this, the assumption is made that an isothermal expansion in the two-phase region is feasible. Although this is not realistic regarding the currently used compressors, it could be achieved at a very slow expansion velocity in a leakage-free machine. Above, it represents the thermodynamic limiting case. A latent heat source of 100 °C and a sink of 15 °C following ambient conditions are defined. Thus, the appropriated cycle configuration is the PC-RTPC-EC, approximating the shape of the ideal Ericsson cycle. It demands an isothermal expansion. The mixture selection is done manually out of alkanes and alkenes using the fluid data of REFPROP 10. First, butane is chosen as main fluid due to its suitable pressure level during condensation at the given sink temperature. Decane is the appropriate auxiliary fluid of butane to ensure the required temperature lift, as illustrated in Figure 7.

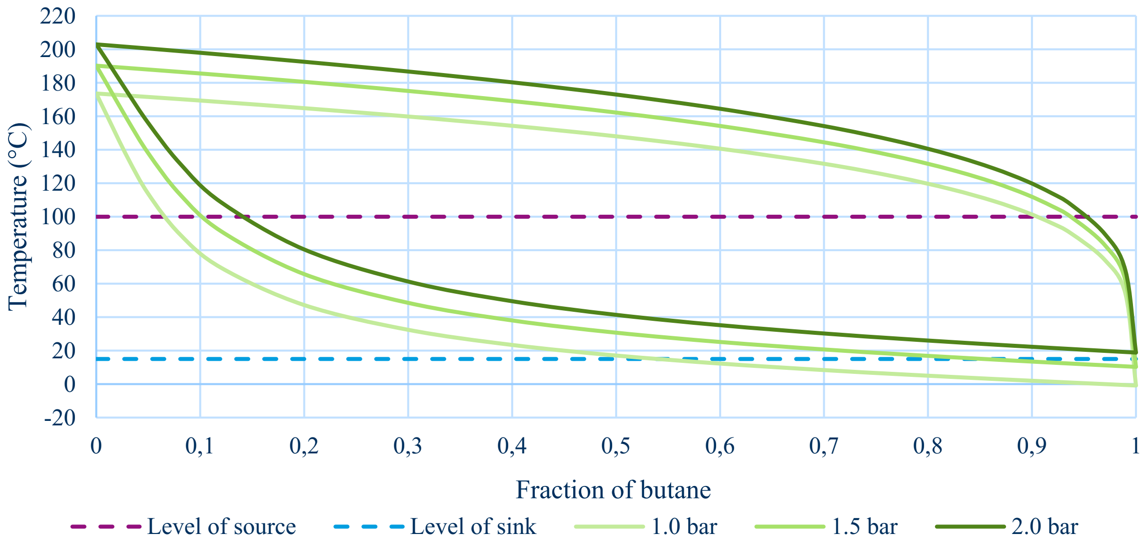
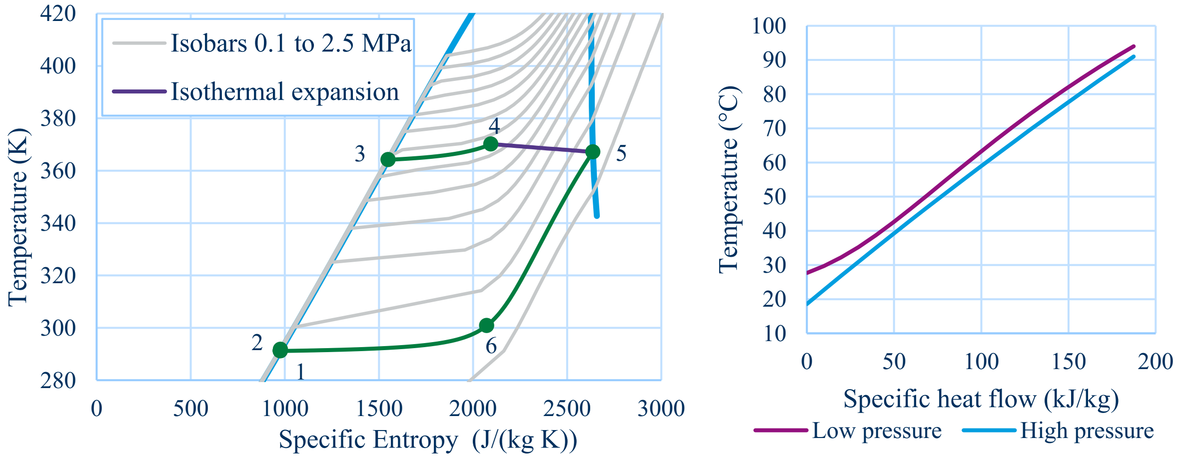


Figure 7: T, x diagram of a butane decane mixture (REFPROP 10)

The PC-RTPC-EC is calculated based on the Eq. (2) to Eq. (8). All minimal temperature differences are set to 3 K. Furthermore it is defined, that the half of the heat provided by the source is transferred by the evaporator. Different from an endoreversible calculation a pump efficiency of 80 % is set. For this case, an optimal mixture composition of 96.1 mol% butane and 3.9 mol% decane can be identified. With the resulting low-pressure level of 1.9 bar and the high-pressure level of 12.1 bar a second law efficiency of 85.8 % can be achieved. Figure 8 (a) shows the entire cycle with an expander inlet vapor quality of 0.7. In Figure 8 (b) the temperature characteristic in the recuperator is displayed.



(a) T,s - diagram of the cycle (b) T,q - diagram of the recuperator

Figure 8: Recuperative Two-Phase Power Cycle in Ericsson shape with a working fluid mixture of 96.1 mol% butane and 3.9 mol% decane and an isothermal expansion

It becomes clear that with the use of this real mixture a derivation from the ideal Ericsson cycle arises due to the non-ideal isothermal evaporation (3 → 4) and condensation (6 → 1), as well as due to the temperature difference in the recuperator. In Figure 9, the results of an exergy analysis are presented. First of all, it has to be emphasized that the preheating losses, which dominate the endoreversible Rankine cycle described above, are eliminated. Due to the defined pump efficiency, endogenious losses of 0.5 % occurs. The non-avoidable exogenious exergy destructions of the first subtype (due to the necessary minimal temperature differences for the heat transfer) amount 6.4 %. Losses due to technical requirements, described as the second subtype, are not present, because a two-phase expansion is allowed and the required subcooling in the pump is currently neglected. Further losses are those due to the cycle design (third subtype). In the case of the RTPC, these are mainly caused by the difference between the required isothermal heat transfer and the real mixture behavior in the evaporator and condenser (4.6 %) as well as the introduction of a recuperation process in comparison with the Carnot cycle (2.4 %). While a minimal temperature difference in the recuperator is mandatory and not avoidable, in Figure 8 (b) it becomes clear that the glide during the recuperation process on the low-pressure side is not linear, resulting in a varying temperature difference, which must be considered as an additional exergetic loss. A better mixture components and compositions selection by an optimization approach could be a key to reduce this type of losses beyond the current state. For example, it would be possible to consider other fluid pairs with even more differing thermodynamic behavior (e.g. alkane + cycloalkanes) or to add further auxiliary fluids to linearize the temperature glide during the recuperation. In this study, the losses due to the nearly-isothermal expansion are very low. Nevertheless, the expansion process represents the main uncertainty to transfer the current results and derive the potential of a realistic RTPC-EC.

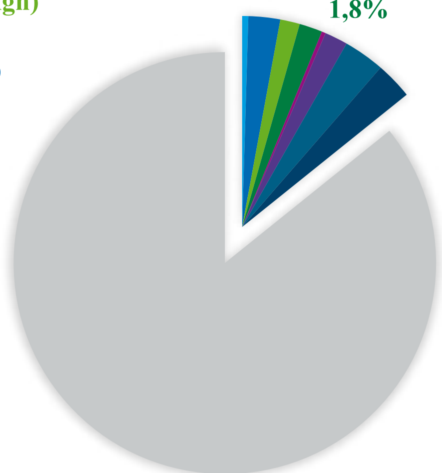


Figure 9: Relative net power output and exergy destruction in the components (heat source = 100 %)

The temperature profile of the cycle inside the evaporator and the expander is not isotherm. In the case of a sensible heat source with a slightly gliding temperature profile, this would correlate much better with the cycle shape. Thus, the second law efficiency would be even higher due to reduced cycle design losses during the heat absorption.

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4 CONCLUSIONS

The main conclusions of this publication can be summarized as the following:

- The power cycle version of the novel thermodynamic Recuperative Two-Phase Cycle (PC-RTPC) has been presented. It aims to avoid the normally dominating preheating losses in ORCs by an extended internal recuperation, which is made possible by a condensation on the low-pressure side of the recuperator. Thereby, the ideal, thermodynamic version of this cycle (without any temperature differences and losses) can reach the Carnot efficiency.
- Technically, the process can be realized by an inhomogeneous zeotropic mixture composed out of fluids with very different normal boiling temperatures, according to the sink and the source.

- Different cycle versions are possible to convert latent heat sources or sensible sources with a limited minimal temperature. For sensible heat sources, a near-isothermal expansion is avoided.
- The thermodynamic potential was demonstrated by a first calculation of an endoreversible cycle in the shape of an Ericsson cycle converting a latent heat source of 100 °C by a sink of 15 °C and a second law efficiency of 85.8% was achieved. However, the maximum thermodynamically achievable second law efficiency is unknown, due to the lack of an optimization.
- Currently, there are still questions regarding the technical feasibility. On the one hand, the real behavior of the mixture under flow conditions is unknown, but it has a significant impact on the recuperation process. On the other hand, the technical realization of a practicable isothermal expansion, as it would be necessary for the conversion of isothermal heat sources, is debatable.

In order to further validate the cycle concept, two directions will be taken as the next working steps. First, an optimization procedure for identifying ideal mixtures will be set up. Second, the behavior of a real mixture with the inhomogeneous temperature glide characteristic shall be observed experimentally. For this purpose, a test rig is already being set up to investigate the recuperation process. In addition, the influence of a composition shift of the circulating mixture within the whole cycle can be determined.

NOMENCLATURE

$\dot{C}_p$	Heat capacity flow	$(kW \cdot K^{-1})$	s	specific entropy	$(kJ \cdot (K \cdot kg)^{-1})$
η	Efficiency	(-)	T	temperature	(K)
h	specific enthalpy	$(kJ \cdot kg^{-1})$	ΔT	temperature difference	(K)
$\dot{q}$	Specific heat flow	$(kW \cdot kg^{-1})$	w	specific work	$(kJ \cdot kg^{-1})$

Subscript

con	condenser	liq	liquid	rec	recuperator	th	thermal
eva	ecaporator	min	minimum	sin	sink	vap	vapor
exp	expander	out	outlet	sou	source	II	second law

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This book contains the compilation of works contributed to the *7th International Seminar on Organic Rankine Cycle Power Systems* (ORC 2023), held in Seville between the 4th and 6th of September 2023. The event was hosted by Universidad de Sevilla on behalf of the Knowledge Centre on Organic Rankine Cycle Technology (KCORC), incorporated in The Netherlands.

The ORC conference, organized biennially, stems as the only conference that is specific to ORC technology, therefore gathering a diverse community whose affiliation spans across all the interested stakeholders, not only in this particular technology but also and in a broader context, in the energy transition. Original equipment manufacturers, professional associations, end-users, investors, policy makers, academics, scientists feel at home at ORC 2023.

The almost 100 proceedings in this book cover a wide variety of topics, from fundamentals to system integration through component design, accounting for thermodynamic performance as well as component design. In addition to this, and as a new track in 2023, works on heat pump technology were also accepted in order to raise awareness of the strong ties between both technologies, specifically in energy storage applications.

This book provides an excellent overview of the current maturity of power systems based on Organic Rankine Cycle technology for applications as diverse as geothermal and waste heat recovery in industry or downstream of other prime movers (e.g., marine applications). It is also an excellent source of information to understand the current challenges faced by the technology, stemming from a very competitive market and increasingly stringent environmental regulations.

The organizers of ORC 2023 hope that the reader finds this work as exciting as the attendees to the conference and, maybe, make the decision to join the 8th edition to the conference in 2025.

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