UTILIZATION OF LABYRINTH SEALS TO OVERCOME LOSS IN STEAM TURBINES FOR HIGHER EFFICIENCY THROUGH CFD

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ABSTRACT

Steam and gas turbines are fundamental to deliver power. Since the dispatch of the principal turbine on the planet, there turn into an inclination to always accomplish higher efficiency. There are numerous answers for defeat misfortunes in the working steam turbine. One of such techniques is the utilization of seals. To decide thermodynamic parameters of steam, which win in the seal, we could utilize trial techniques or numerical figuring's. Test inquire about are excessively costly and tedious. Thusly, computational fluid dynamics (CFD) is progressively utilized as a part of the examination of liquid course through the maze seal. The paper depicts the outcomes utilizing CFD Simulation software with the assistance of contained a computational k-ε demonstrate.

Keywords:*Labyrinth seals; k-ǫ model; CFD calculations; Fluid-flow machines; Modeling*

I. INTRODUCTION

Steam and gas turbines are one of the essential parts in power delivering. Be that as it may, vitality efficiency of turbines isn't agreeable. Since the primary turbine was gotten under way, the principle point of specialists is to accomplish the most elevated efficiency as could reasonably be expected.

It is evaluated that a diminishment of 1% spillage via fixing the high-weight some portion of the turbine will diminish fuel utilization by 0.4%. There are numerous answers for defeat misfortunes in the working steam turbine. One of these techniques is the utilization

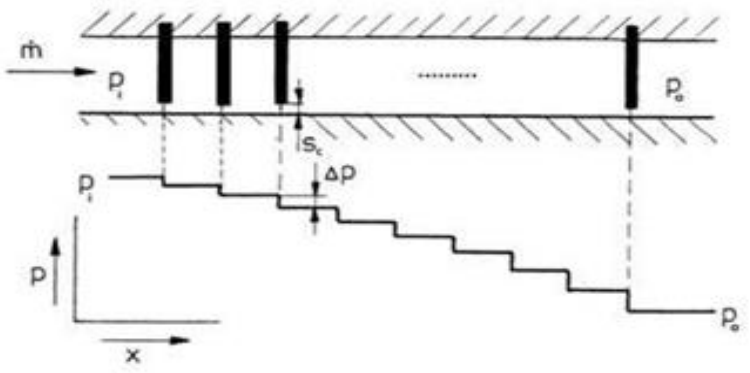

Figure 1: Scheme of the labyrinth seal without diagnostic extraction: $\dot{m}$ – mass low, p_i – inlet pressure, p_o – outlet pressure, s_c – seal clearance, p – pressure drop, p – pressure, x – the length of the labyrinth.

Labyrinth organ comprises of a series of slight openings associated with each other (Fig. 1). On account of the course through the seal, the fluid has lost the underlying estimation of the aggregate weight and in the meantime it quickened in organ opening due to the constriction of stream erosion in the fixing hole and dispersal of the motor vitality in the stuffing box. This procedure repeats in each opening and the seal chamber until the end thereof as it is appeared in Fig. 2. Late enhancements that affect the efficiency and power gas turbines require changes in all structure segments and the most critical thing is lessening of spillage through the seal. ***Chmielniak T*** **[1]** Thusly, labyrinth seals are the issue, those requirements an ever increasing number of studies and must be subjected to steady control likewise amid task of the turbine, and their setups are as yet developing. In this way, learning of the correct estimation of the release turns into a key data.

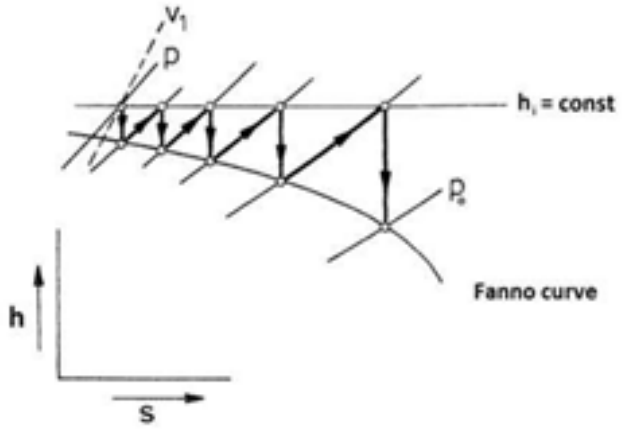

Figure 2: Fanon line for seal without extraction: v_1 – begin volume, p_i – inlet pressure, p_o – outlet pressure, h – enthalpy, s – entropy.

Test researches are excessively costly and tedious. Consequently, computational liquid progression (CFD) reproductions are progressively utilized as a part of the investigation of liquid move through the labyrinth seal. ***Eser D., Kazakia J.Y.:*** **[2]**

Powerful fixing in turbo machines is required with a specific end goal to limit the spillage of high-vitality working liquid, in this way diminishing the unfriendly impacts of seal spillage on general motor performance. ***Kabsch K., Szewczyk*****[3]**In spite of the advancement of new strategies in fixing innovation, labyrinth seals will keep on being the most broadly utilized fixing component in fast turbo machines. Effortlessness and minimization, unwavering quality and temperature resistance are some of its real advantages. ***Joachimiak D.:[4]*** When all is said in done,

Expanding the liquid resistance through the labyrinth seal can lessen spillage.This can be refined either by lessening the clearance measure, the advancement of another geometrical seal design and the utilization of blowing through the seal gland. Many agents handled the spillage issue through labyrinth seals for turbo apparatus. A portion of the early outline techniques accessible in the writing are simply analytical and others are analytical-test. Generous ET. ***Joachimiak D***.:[4] AL. made a similar study of these techniques and they found that such medicines gave comes about significant contrasts and inconsistencies.

II. MODEL RECEIVED TO CFD COUNTS

Processing energy of current supercomputers and additionally PCs is getting more noteworthy. It permits to perform snappy numerical reproductions with higher air conditioning curacy***.Kaszowski P.*****:[5]** It is an option for the systematic counts. In this paper numerical estimations were performed utilizing mainstream business CFD bundle FLUENT, which is one of the parts of the bundle ANSYS Fluent software. Familiar code fills in as solver to the Navier-Stokes conditions utilizing limited volume technique.

A natty gritty portrayal of the premise of vortex streams and turbulence demonstrating can be found in numerous standard writing things. ***Kosma Z.:*** **[6]**Turbulent streams are burn actuated by a variable speed field. The change from laminar to turbulent stream happens when the Reynolds number, which is one of the criteria to decide the kind of stream, surpasses a basic incentive under the reliance of the geometry which the liquid courses through.***Tong K., Cha K.S.:*****[7]** Nonlinear type of the Navies-Stokes conditions, which portray the liquid stream, causes an expansion in interruption in the stream for the situation

when the Reynolds number surpasses a basic esteem**.**This insecurity prompts changing in speed field, weight and temperature's dynamic.

One of the best approach to manage the issue of recreation of turbulent streams are Reynolds arrived at the midpoint of Navies-Stokes (RANS) conditions,**Krzyślak P.:[8]**which isolate the components of the speed field on the 'medium' and 'adjusting'. Coordinate numerical reproduction (DNS), in which all length scales and time were understood, are excessively ex-meditative, making it impossible to connected in the present processing assets.

III. SEAL GEOMETRY

Geometry of the organ accepted to the counts is introduced on Fig. 3.

The computations were performed for following parameters:

amount of sealing teeth	n:	20,
length of the seal	L:	200 mm,
height of the orifice	h:	9.5 mm,
graduation of the seals	c:	10 mm,
width of the chamber	b:	9 m,
thickness of the orifice	d:	1.0 mm,
nominal clearance of the seals	s:	0.5 m.

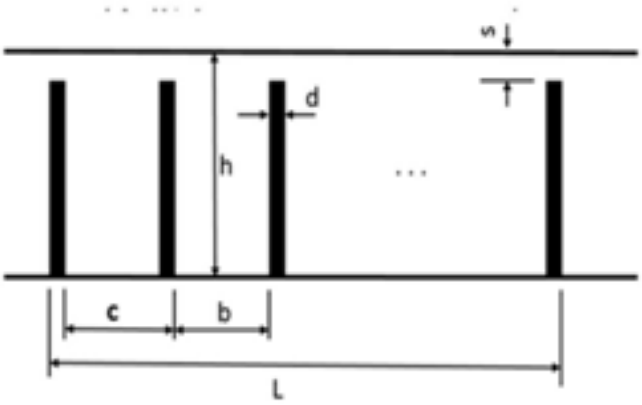

Figure 3: Geometry of gland labyrinth assumed to the calculations:b – chamber width, h – orifice height, s – nominal clearance seals, d– orifice thickness, c – seal graduation, L – seal length.

Seal geometry was displayed in Design Modeler program included to Annoys pack-age. Figure 4 demonstrates the delta divert situated in the front of the seal gulf. A development in the geometry figuring's the application before fixing the bay and outlet channel for the organ. ***Perycz S.: Steam and gas turbines*.[9]**the two channels are intended to balance out the stream and have a length of 50 mm.

A network, exhibited in Fig. 5, was outlined in one of the projects of Mesh bundle. The framework comprises of 1 701 931 cells and 1 713 of 993 hubs in which the count was made. In the fixing holes, next its dividers at a separation of 0.03 mm, the matrix was concentrated to check the limit layer. At this height the quantity of framework hubs is 10.

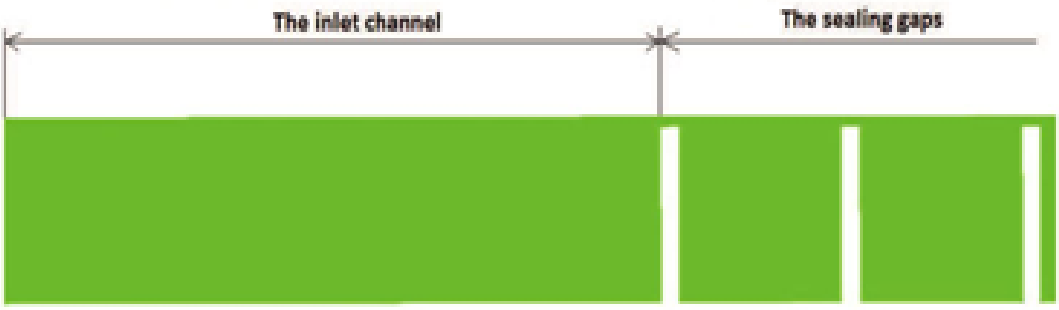

Figure 4: Fragment of gland geometry adapted to the calculation.

Figure 5: Computing grid for the gland labyrinth.

IV. CALCULATIONS

Following limit conditions were embraced to the computations: weight at the center of delta channel of the seal (equivalent to 450 000 Pa) and also weight at the exit of outlet channel (equivalent to 300 000 Pa).

They got comes about are one of the principal endeavors of this way to deal with the stream of liquid through the labyrinth organ. Comparative counts were directed in with a similar limit conditions however without demonstrated delta and outlet channels.

Figure 6 introduces the examination of weight appropriation by CFD computation both for geometry specified above and additionally estimations made in for seal-in without delta and outlet channel. ***Piwowarski M., Kosowski K.*****[10]**

In the outline, the outcomes got from numerical figuring's for the organ with the delta and outlet channel from the seal are set apart by a speck, while comes about got for the fixing without channel are set apart by a bullet. There is critical deference between the two outcomes. In the fixing without gulf channel, the weight drop is more extreme than in organ with bay channel. In the two cases, in the gulf of fixing the weight esteems are the same and equivalent 450 000 Pa. Greater weight drop is seen on the openings of fixing on account of the organ without the delta channel, than on account of fixing with the gulf channel. In the two cases, the weight deference is relatively unnoticeable in the initial two teeth of fixing.

Figure 7 shows the weight drop along the length of organ. The weight diminishes in the fixing holes and increments in organ chamber. Behind the last fixing hole, the weight quickly increases (Fig. 8), as a response of non-return valve in the outlet channel.

Much appreciated CFD estimations we accomplish the profile of weight esteems in matrix hubs over the width of the hole. Figure 9 speaks to the weight conveyance

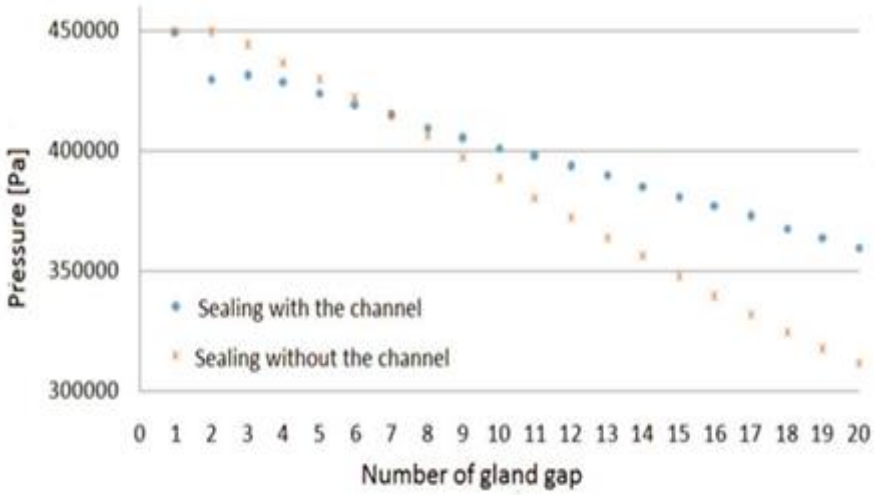

Figure 6: The comparison of pressure distribution for gland with and without the inlet channel.

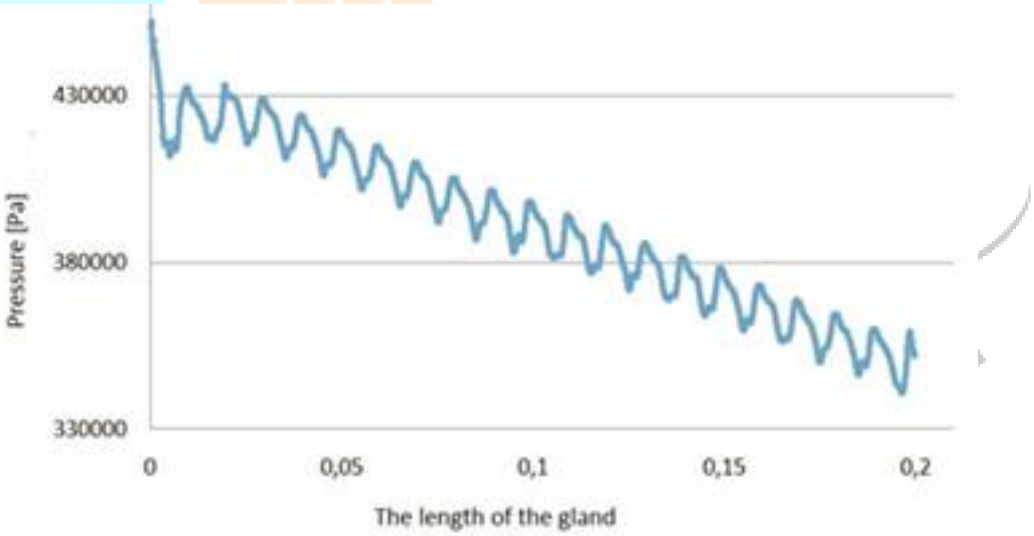

Figure 7: The pressure distribution along the length of gland with the inlet channel.

Along the weight esteems diminishing, the quantity of organ hole increments. From the chart it could be inferred that the most extreme weight on the profile is accomplished at a tallness of 0.41 mm. The state of the weight profile is redundant in all holes aside from the whole no. v 1.

Figure 10 represents the correlation of liquid speed along the length of the organ between the fixing with and without the channels, found right amidst hole. ***Schramm V., Denecke J., Kim S., Wittig S*** **[11]** In the principal case the speed achieved maximal esteems rose to 310 m/s in fixing holes, while in the stuffing box liquid backs off to around 260 m/s. In the second case

esteems are significantly littler and achieve their greatest at the penultimate hole, which is equivalent 117 m/s.

CFD character permit to perception of wonders happening in the sealing. Figured maps make it conceivable to display the conveyance of weight and

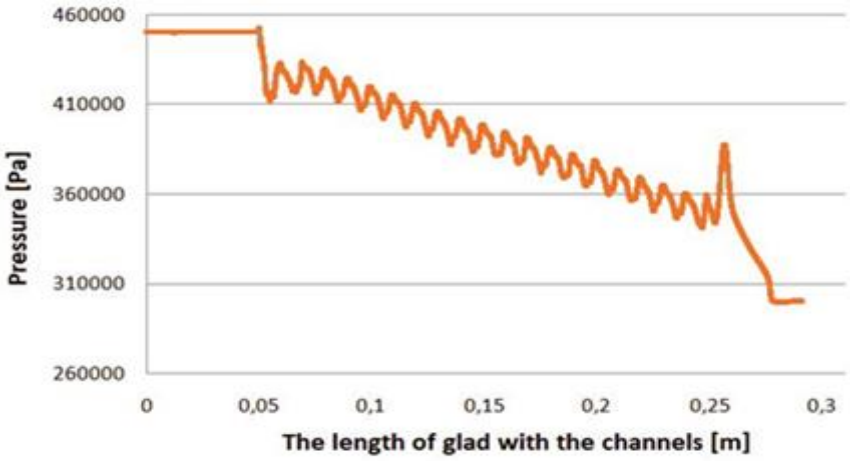

Figure 8: The pressure distribution along the sealing with the presentation of the pressure in the channels.

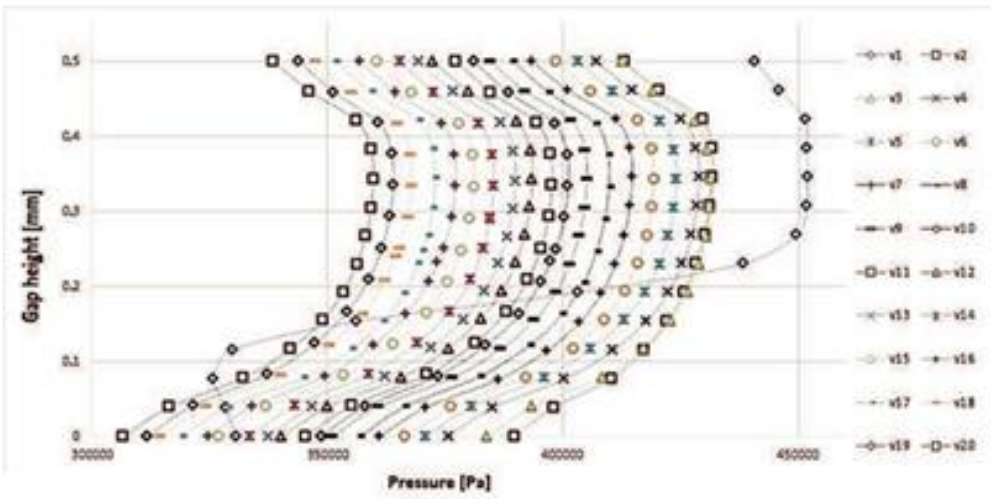

Figure 9: The pressure profile at gap height for each of sealing teeth

Speed in such way that truly affects the creative energy and comprehends and clarify the outcomes. Numerical computations spare a great deal of time, which would be squandered on achieve the outcomes by the trial technique and make the experience considerably quicker thanks probability to define the limit conditions officially near the normal outcome. Figures 11 and 12 introduce the representation of results by shading map said above.***Trütnovsky K.:***

[12]Figure 11 demonstrates the circulation of gas speed both in fixing chamber and fixing holes and in outlet channel, while in Fig. 12 we can see the perception of weight dispersion.

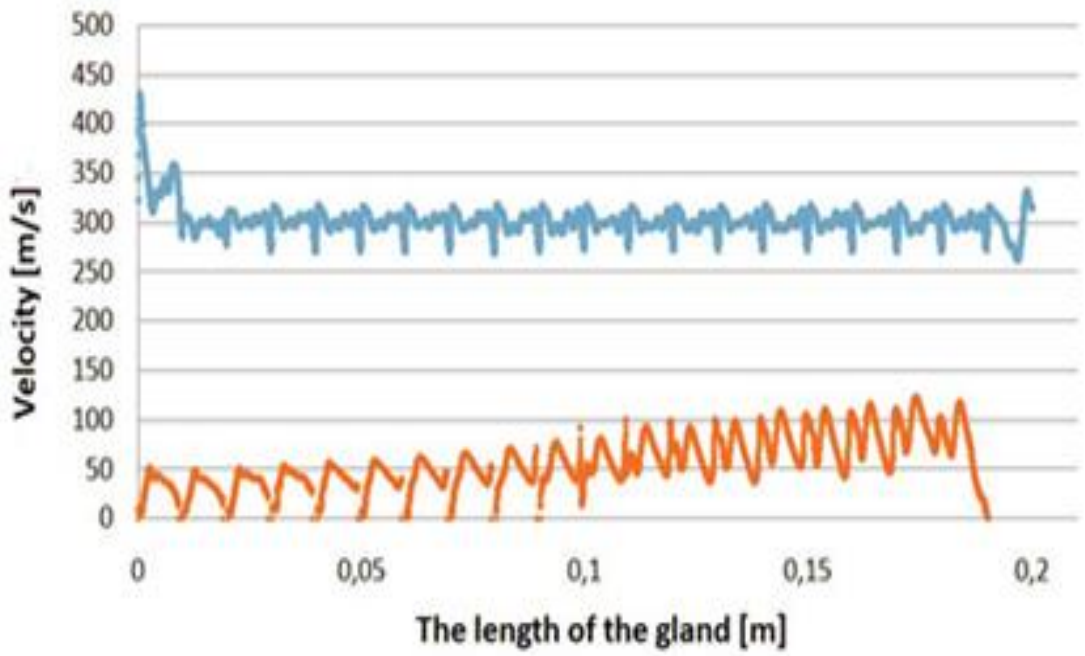

Figure 10: The graph of fluid velocity along the length of the packing.

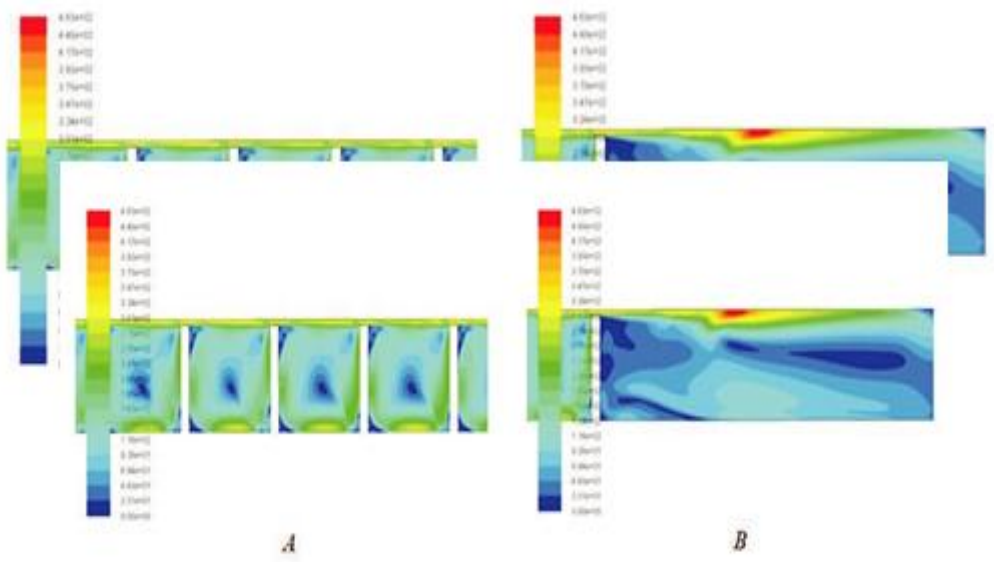

Figure 11: A) The field of gas velocity in the gaps and chambers of the labyrinth seals, B) the field of gas velocity in the outlet channel of the labyrinth seals

V. CONCLUSIONS

The outcomes, displayed in this paper, are among the first for geometry with demarked bay and outlet channels. They are endeavor to another way to deal with the figuring of labyrinth organs. Additionally tests would appear if the outcomes are re-producible and predictable with the real state. From the outcomes got utilizing CFD figuring's, made for organ with the gulf and outlet divert in the seal, it demonstrates that the weight drop in the organ with the two channels is gentler. A sudden increment in weight accurse at the outlet of the seal, which demonstrates that we should check what happens when we change the length of the channel. The speed of the stream is significantly higher in contrast with the organ without channels.

In the writing, there are portrayed numerous computational models related

Figure 12: Pressure distribution in the labyrinth seals

to labyrinth organs. Be that as it may, explanatory models don't give much data about changes in thermodynamic parameters for the length of the labyrinth seal. Numerical counts, particularly limited component strategy, permit to get the estimation of any parameter of the thermodynamic anyplace on seal, i.e., in the hubs of the framework.

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