

TRIAL SHORT

ABSORPTION 3D

3D GRAPH SELECTION

2D GRAPH SELECTION

PHASE BALANCE CALCULATOR

Temperature, °C: 30
 Pressure, MPa: 0.1
 Concentration, kg/kg: 0.289, 0.972
 Enthalpy, kJ/kg: -78.8, 1260.5
 Entropy, kJ/kgK: 0.274, 0.729
 Specific heat, kJ/kgK: 2.086, 2.16
 Specific volume, m³/kg: 0.000871, 1.461
 Density, kg/m³: 0.271329, 0.00011223
 Conductivity, W/mK: 0.8889, 0.02786

software for Elsevier article 129-0-10-00245 - version 2010-02-07

ABSORPTION 3D

3D GRAPH SELECTION

2D GRAPH SELECTION

1 rich solution on absorber outlet towards the pump
 2 rich solution on pump outlet towards the exchanger
 3 rich solution on desorber inlet
 4 poor solution on the desorber outlet & exchanger inlet
 5 poor solution on exchanger outlet
 6 poor solution on absorber inlet
 7 refrigerant vapour before reflash boiler
 8 liquid refrigerant before the condenser
 9 liquid refrigerant before the evaporator valve
 10 refrigerant on start to the evaporator
 11 refrigerant's vapour on evaporator outlet
 12 refrigerant's vapour on absorber inlet

software for Elsevier article 129-0-10-00245 - version 2010-02-07

ABSORPTION 3D

Cycle input table

Def. - refrigerant concentration, kg/kg	0.889
1q - temp. of desorber heating medium outlet, °C	178
2q10 - temp. difference in desorber, °C	17
3q10 - temp. of condenser cooling water in, °C	27
2q10C - temp. increase of condenser cooling water, °C	27
2q10 - temp. difference in condenser, °C	27
4q10 - temp. of rich 1 liquid & reflash heat each, °C	19
5q10 - temp. of cooler on evaporator outlet, °C	19
6q10 - temp. increase of refrigerant in evaporator, °C	19
7q10 - temp. difference in evaporator, °C	19
8q10 - temp. of absorber cooling water out, °C	27
2q10 - temp. increase of absorber cooling water, °C	27
2q10 - temp. difference in absorber, °C	27
3q10 - temp. difference on the lowest reflash sheet, °C	3
2q10 - subcool. of poor solut. on heat each, °C	3
2q10 - evaporator/condenser relative pressure increase, -	0.079, 0.079
cooling capacity, kW	1

Heat & power

Component	Q	W
Desorber	2266.2	2.07
Condenser	1211	1.16
Refrigerant heat exchanger	482	0.08
Evaporator	1007.9	0
Absorber	2266.2	2.08
Solution heat exchanger	2266.2	2.1
Reflash	891.2	0.04

Bed mass flow

Refrigerant	kg/s
Rich solution	0.00048
Poor solution	0.00079
Pump solution	0.00074
Rich water (1st & 2nd)	0.08

performance

COP: 0.325

software for Elsevier article 129-0-10-00245 - version 2010-02-07

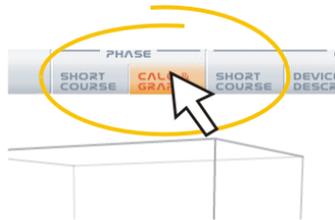
Look at upper bar, there are two groups of buttons: PHASE and CYCLE part



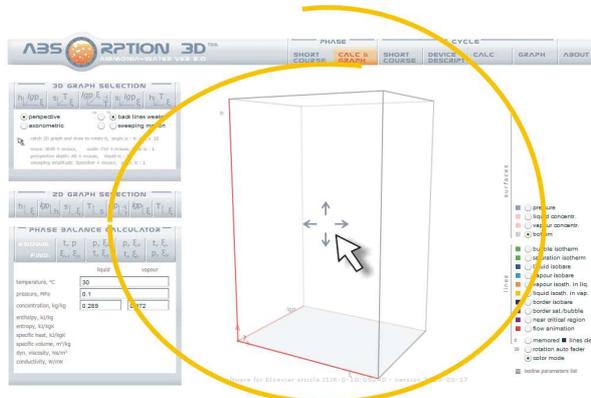
Press PHASE - SHORT COURSE, look at entrance text and figures as presented, read it



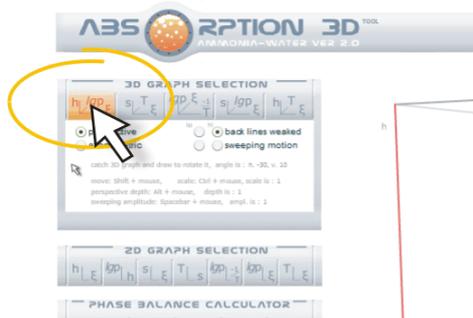
Press PHASE CALC & GRAPH, that's important part of the software



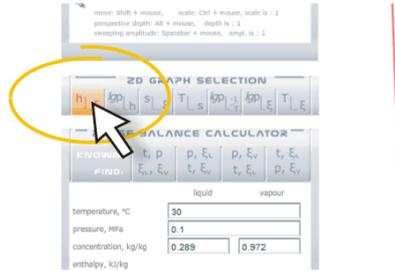
Look at the box on the screen, that's 3D space, drag left-right, up-down



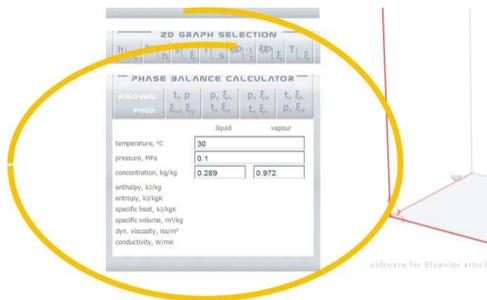
Press "h-ξ-lgp" button in 3D GRAPH SELECTION frame, that's first kind of 3D graph available, all 3D graphs are empty at this moment, only axes and their labels are visible



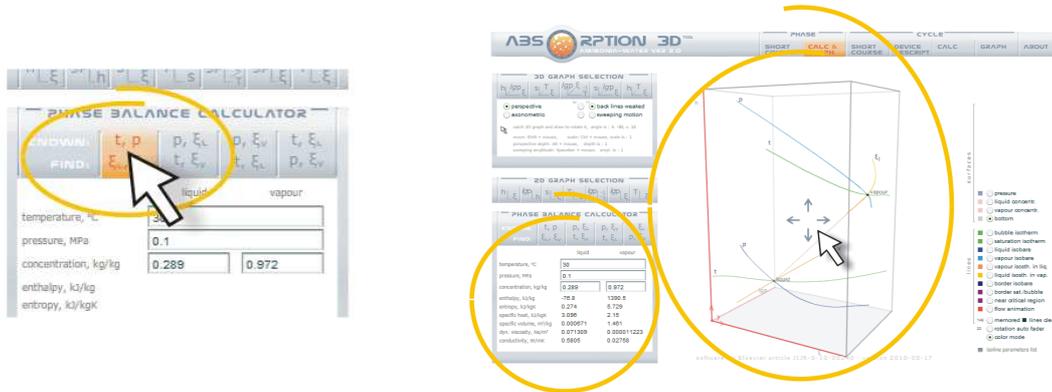
Look at 2D GRAPH SELECTION frame, press "h- ξ" button. Wait and see - 3D box is transforming to 2D box, try to use next buttons, see new boxes, all they are empty at this moment, only axis and their labels are visible, press "h- ξ -lgp" button again" to return to 3D view



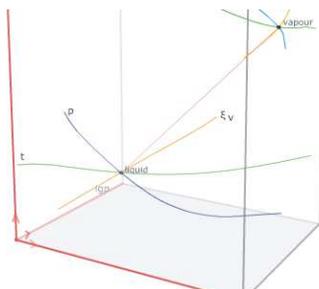
Look at left and bottom at PHASE BALANCE CALCULATOR, that's tool for calculation of phase balance according to written data



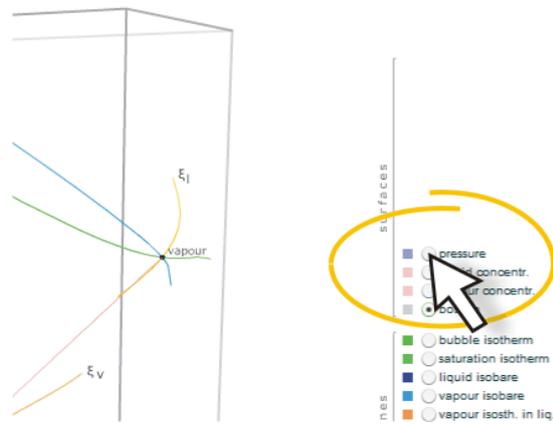
Press left button "t, p, ξ l, ξ v", wait for 3D view. Look at calculator frame - there are all main thermodynamic parameters presented. Look at 3D box - phases balance is visible, wait and see, try to drag the box, feel the 3D space



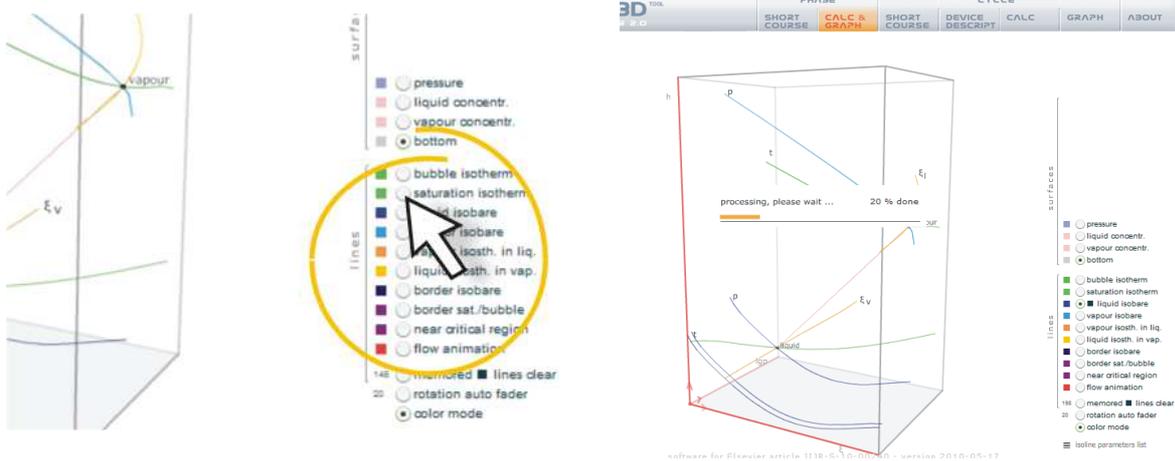
There are coloured lines on 3D view presented. Blue line means isobare, green means isotherm, yellow means isosthere, red represents splitting of the phases balance



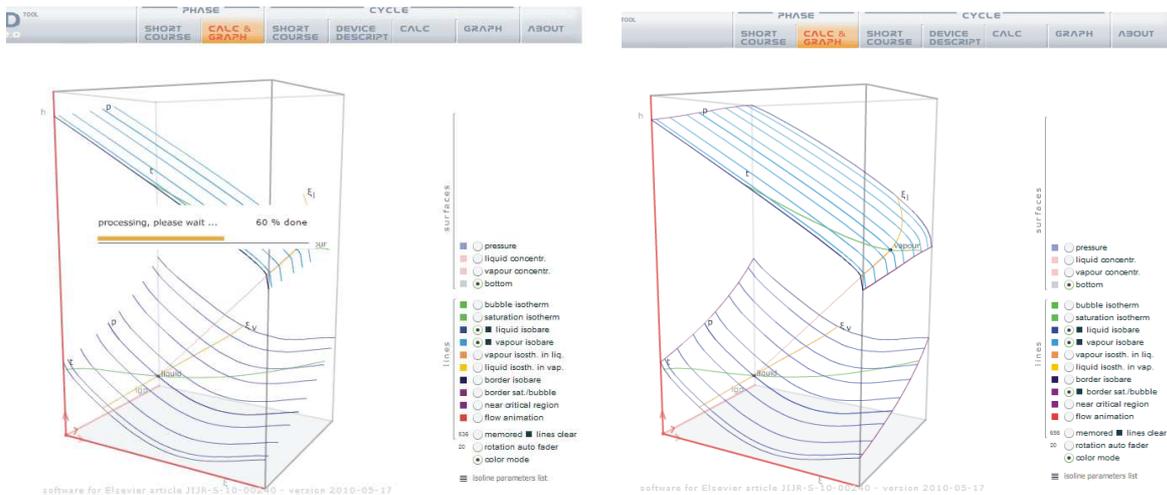
Look at right side of the screen at upper radios, press "pressure", look at the surface of constant pressure presented, turn it off, try another radios, move 3D box if needed



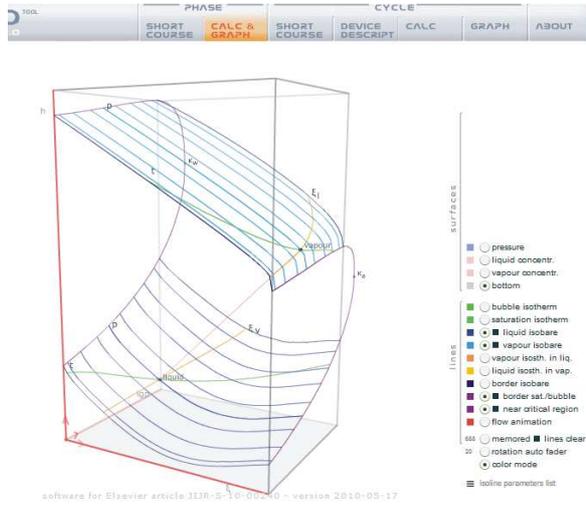
Look at the bottom radios of isolines collected, at first press "liquid isobare", wait and see isobares presented on screen, don't turn-off the radio



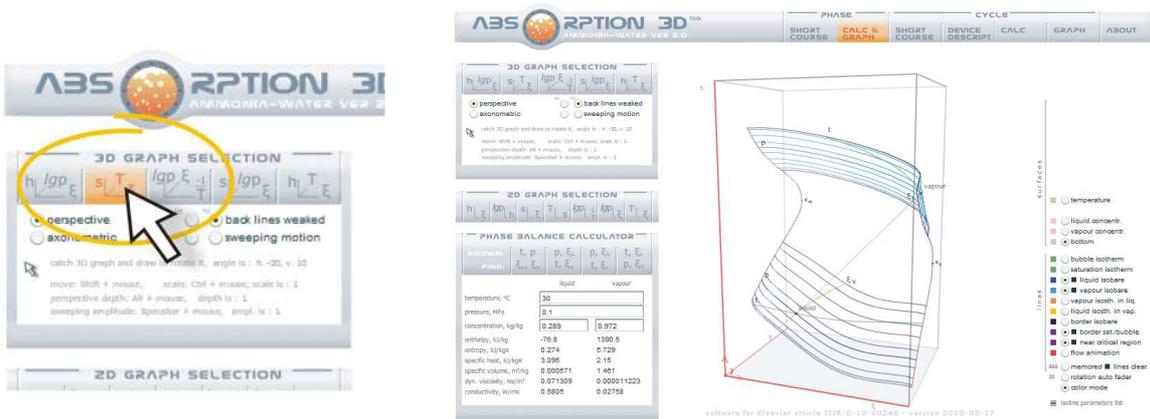
Press "vapour isobare", wait and see isobares presented, don't turn-off the radio



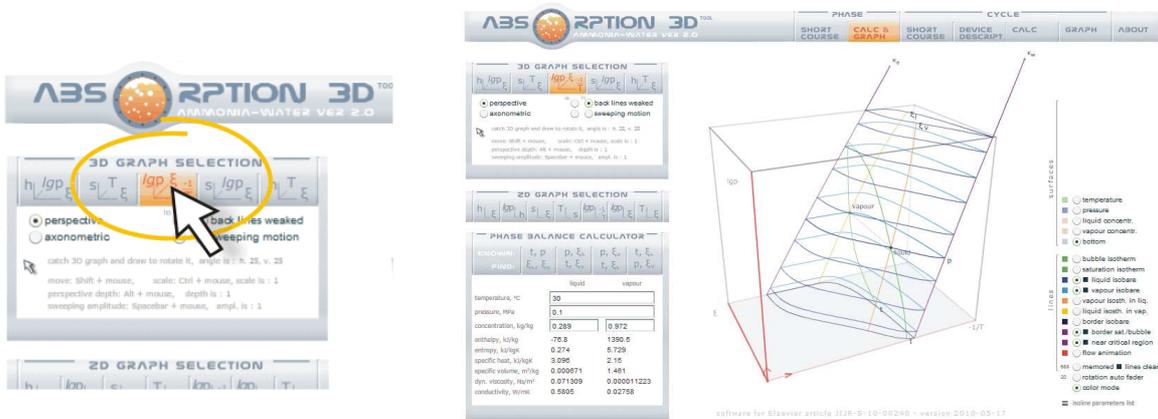
Press "border sat./bubble", wait and see saturation and bubble lines presented on screen, don't turn-off the radio, feel the 3D space, move the box if needed, still don't turn-off the radio



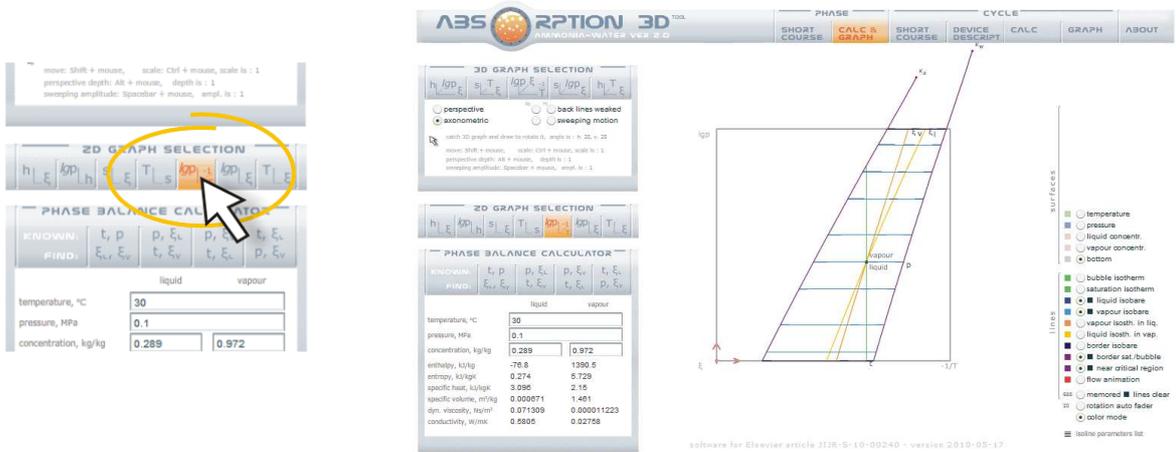
Up to this moment isobare lines are visible. You are still in the " $h - \xi - lgp$ " graph, press " $s - \xi - T$ " button, wait and see 3D space presented, recognize graph properties



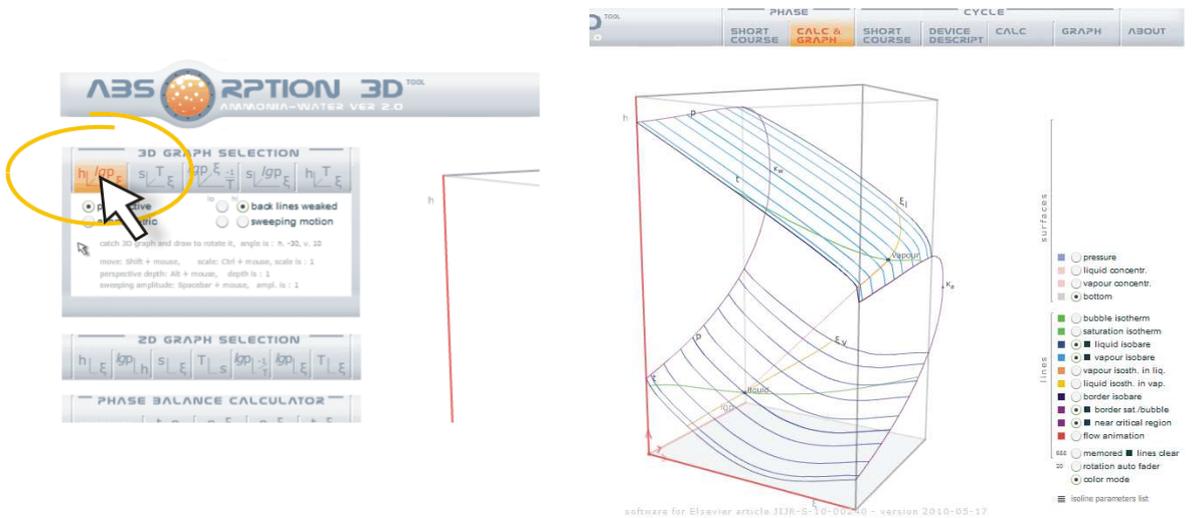
Press " $lgp-1/T - \xi$ " button, wait and recognize graph properties



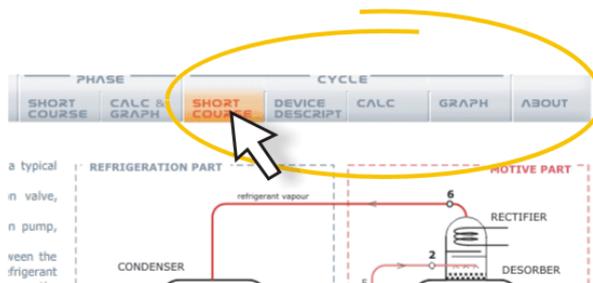
To transform 3D view, press "lgp-1/T" button on 2D GRAPH SELECTION frame, wait and recognize isobare lines presented. Try to use other buttons to see next 2D graphs.



Press "h-ξ-lgp" button again" to return to 3D view, press "border sat./bubble" radio, wait to complete, press "border isobare", wait to complete them, press "near critical region", wait to complete, feel thermodynamic 3D space of phases balance on this graph, You may also press "s-ξ-T" button and feel thermodynamic 3D space of phases balance on this graph, press "lgp-1/T-ξ" button and feel 3D space of phases balance on this graph



Return to upper bar, go to CYCLE part,



Press CALCULATE button on the bottom of that screen, wait for results, look at calculated values. If you wish to return to point's name or cycle animation you may press DEVICE DESCRIPT button again.

fluid mass flow (m kg/s)

- refrigerant
- rich solution
- poor solution
- rich solution circ. coeff.

cycle input data:

parameter	value	range
pref - refrigerant concentration, kg/kg	0.995	0.995
tg - temp. of desorber heating medium outlet, °C	170	140-195
Δtdes - temp. difference in desorber, °C	3	3-6
tw1c - temp. of condenser cooling water on inlet, °C	27	20-30
Δtwc - temp. increase of condenser cooling water, °C	5	3-15
Δtc - temp. difference in condenser, °C	3	3-6
Δtbr - temp. decr. of liquid in refiger. heat exch., °C	10	5-15
te2 - temp. of coolant on evaporator outlet, °C	-20	-10--40
Δter - temp. increase of refrigerant in evaporator, °C	10	7-12
Δte - temp. difference in evaporator, °C	3	3-6
tw1a - temp. of absorber cooling water inlet, °C	27	20-30
Δtw1a - temp. increase of absorber cooling water, °C	5	3-15
Δta - temp. difference in absorber, °C	3	3-6
Δlps - temp. difference on the lowest rectifier shelf, °C	10	5-15
Δlps - subcool. of poor solut. on heat exch. outlet, °C	5	0-10
evaporator/absorber relative pressure decreas. ...	0.075	0.075
cooling capacity, kW	1	

cycle calculation results:

point	t / °C	p / kPa	h / kJ/kg	x / kg/kg	h / kg/s	h / kg/h
1	35	0.078	0.222	-18.8	0.393	
1'	35	1.35	0.222	-18.8	0.39	
2	120.8	1.35	0.222	393.1	1.598	
2'	131.9	1.35	0.222	416.2	1.659	
3	107	1.35	0.072	659.9	2.053	
4	58.0	1.35	0.072	108	0.812	
4'	68.0	0.076	0.072	108	0.812	
5	131.9	1.35	0.81	1775.5	6.407	
6	62.8	1.35	0.995	1378.7	4.470	
7	35	1.35	0.995	165.7	0.572	
8	25	1.35	0.995	0	0.41	
9	-33	0.082	0.995	0.313	116.9	1.083
10	-23	0.082	0.995	0.95	1174.8	5.041
11	-2.2	0.082	0.995	0.956	1223.6	5.507

heat & power

device	q / kW	Q / MW
desorber	3250.2	3.07
condenser	1211	1.14
refrigerant heat exchanger	48.8	0.05
evaporator	1027.9	1
absorber	2205.9	2.09
solution heat exchanger	2536.2	2.4
rectifier	891.2	0.84

fluid mass flow (m kg/s)

fluid	m / kg/s	kg/h
refrigerant	0.00946	
rich solution	0.00519	
poor solution	0.004874	
rich solution circ. coeff.	0.156	

performance

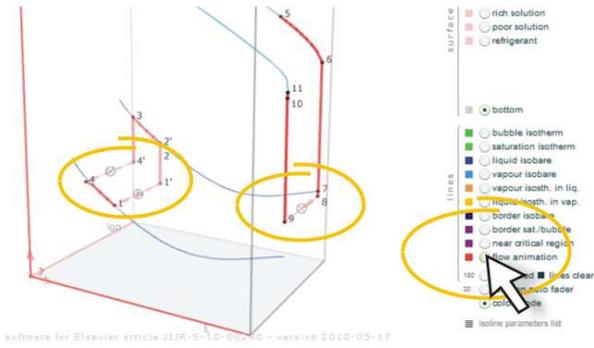
COP: 0.325

Press GRAPH button. Look at 3D box of cycle calculated. Wait and recognize cycle points presented at first on h-ξ-lgp graph

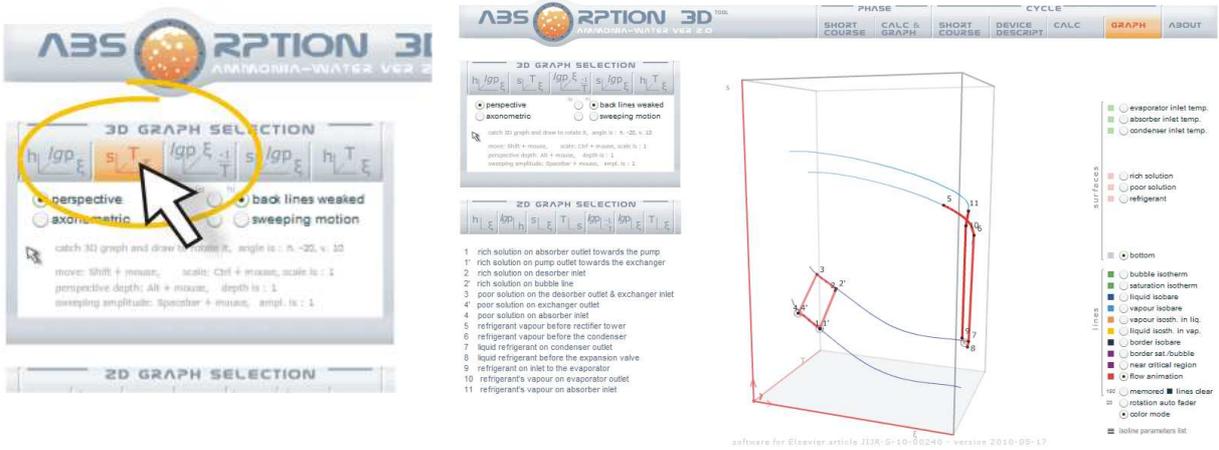
3D GRAPH SELECTION

h₁ / Δp₁ / s₁ / T₁ / Δp₂ / s₂ / T₂ / Δp₃ / s₃ / T₃ / Δp₄ / s₄ / T₄ / Δp₅ / s₅ / T₅ / Δp₆ / s₆ / T₆ / Δp₇ / s₇ / T₇ / Δp₈ / s₈ / T₈ / Δp₉ / s₉ / T₉ / Δp₁₀ / s₁₀ / T₁₀ / Δp₁₁ / s₁₁ / T₁₁ / Δp₁₂ / s₁₂ / T₁₂ / Δp₁₃ / s₁₃ / T₁₃ / Δp₁₄ / s₁₄ / T₁₄ / Δp₁₅ / s₁₅ / T₁₅ / Δp₁₆ / s₁₆ / T₁₆ / Δp₁₇ / s₁₇ / T₁₇ / Δp₁₈ / s₁₈ / T₁₈ / Δp₁₉ / s₁₉ / T₁₉ / Δp₂₀ / s₂₀ / T₂₀ / Δp₂₁ / s₂₁ / T₂₁ / Δp₂₂ / s₂₂ / T₂₂ / Δp₂₃ / s₂₃ / T₂₃ / Δp₂₄ / s₂₄ / T₂₄ / Δp₂₅ / s₂₅ / T₂₅ / Δp₂₆ / s₂₆ / T₂₆ / Δp₂₇ / s₂₇ / T₂₇ / Δp₂₈ / s₂₈ / T₂₈ / Δp₂₉ / s₂₉ / T₂₉ / Δp₃₀ / s₃₀ / T₃₀ / Δp₃₁ / s₃₁ / T₃₁ / Δp₃₂ / s₃₂ / T₃₂ / Δp₃₃ / s₃₃ / T₃₃ / Δp₃₄ / s₃₄ / T₃₄ / Δp₃₅ / s₃₅ / T₃₅ / Δp₃₆ / s₃₆ / T₃₆ / Δp₃₇ / s₃₇ / T₃₇ / Δp₃₈ / s₃₈ / T₃₈ / Δp₃₉ / s₃₉ / T₃₉ / Δp₄₀ / s₄₀ / T₄₀ / Δp₄₁ / s₄₁ / T₄₁ / Δp₄₂ / s₄₂ / T₄₂ / Δp₄₃ / s₄₃ / T₄₃ / Δp₄₄ / s₄₄ / T₄₄ / Δp₄₅ / s₄₅ / T₄₅ / Δp₄₆ / s₄₆ / T₄₆ / Δp₄₇ / s₄₇ / T₄₇ / Δp₄₈ / s₄₈ / T₄₈ / Δp₄₉ / s₄₉ / T₄₉ / Δp₅₀ / s₅₀ / T₅₀ / Δp₅₁ / s₅₁ / T₅₁ / Δp₅₂ / s₅₂ / T₅₂ / Δp₅₃ / s₅₃ / T₅₃ / Δp₅₄ / s₅₄ / 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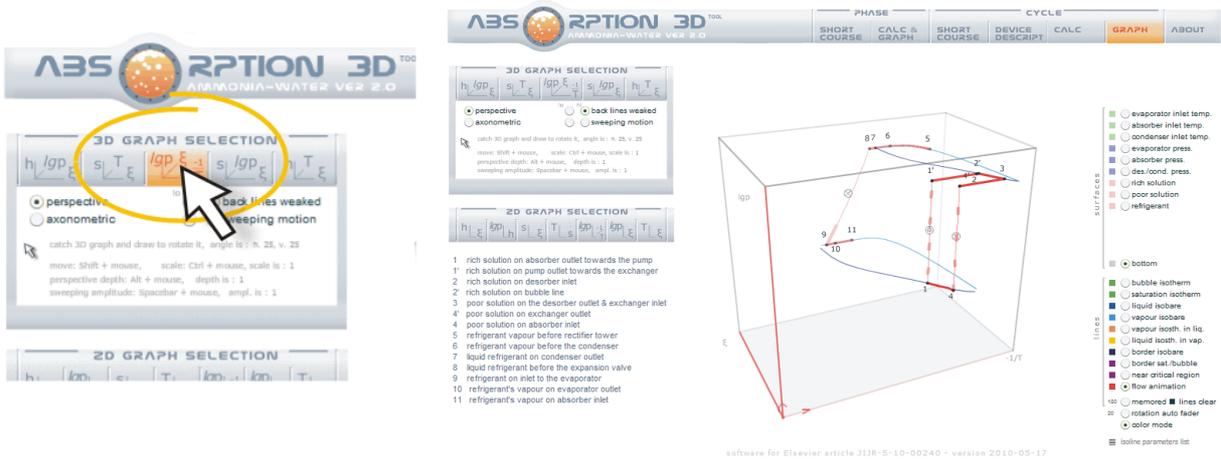
Press "flow animation" radios and look at animation, press again to switch it off,



Press "s-ξ-T" button and recognize cycle points on this graph



Press "l_{gp}-1/T-ξ" button and recognize cycle points on this graph



Rules and options

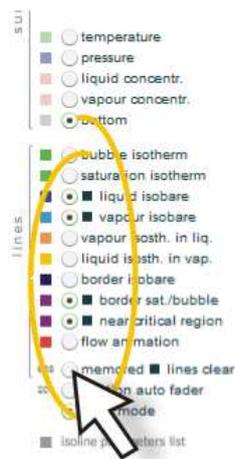
You may add some isolines to graph, you may transform 3D view to 2D view according to the button pressed.

To enlarge the view - press "CTRL" key and drag the mouse right-left,

To move the view - press "SHIFT" key and drag the mouse right-left, up-down,

To change properties of the perspective used - press "ALT" key and drag the mouse right-left,

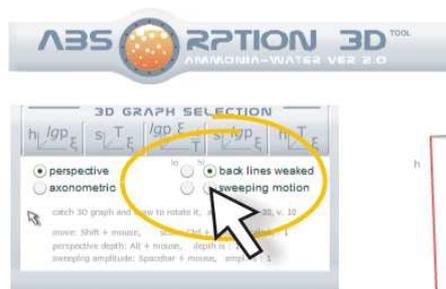
If many isolines are used, you can see many black box signs on the right side of the screen near the radios. It means the many lines are stored in processor memory. It slows down rotation of 3D view when you drag and move it. If it's a trouble press "memored lines clear" radio. All isolines collected up to this moment are cleared. Speed of of the view motion should increase.



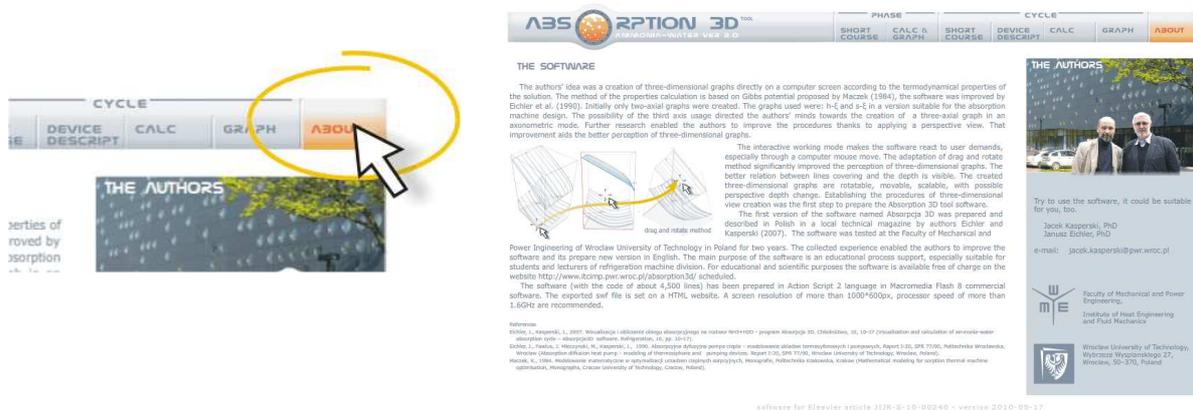
Processor of the computer used should be really good. More than 1,6GHz of the processor's clock speed is recommended. Two cores makes the calculation speed better. To see the processor's engagement degree look at the orange coloured animation of desorber on the upper bar. If bubbles flow up, the processor speed is fulfilling all demands. When bubbles stop - the processor is working very hard.



Press "sweeping motion" radio on 3D GRAPH SELECTION (left, upper frame), wait 10 sec and look at full motion. Press "sweeping motion" again and wait, the box motion is slows down and stops at the end.



Look at the upper bar and press ABOUT button, there is the software description text.



THE SOFTWARE

The authors' idea was a creation of three-dimensional graphs directly on a computer screen according to the thermodynamical properties of the solution. The method of the properties calculation is based on Gibbs potential proposed by Marczak (1984), the software was improved by Eichler et al. (1990). Initially only two-axial graphs were created. The graphs used were: h-C and s-C in a version suitable for the absorption machine design. The possibility of the third axis usage directed the authors' minds towards the creation of a three-axial graph in an axonometric mode. Further research enabled the authors to improve the procedures thanks to applying a perspective view. That improvement aids the better perception of three-dimensional graphs.

The interactive working mode makes the software react to user demands, especially through a computer mouse move. The adaptation of drag and rotate method significantly improved the perception of three-dimensional graphs. The better relation between lines covering and the depth is visible. The created three-dimensional graphs are rotatable, movable, scalable, with possible perspective depth change. Establishing the procedures of three-dimensional view creation was the first step to prepare the Absorption 3D tool software.

The first version of the software named Absorption 3D was prepared and described in Polish in a local technical magazine by authors Eichler and Kasperski (2007). The software was tested at the Faculty of Mechanical and Power Engineering of Wrocław University of Technology in Poland for two years. The collected experience enabled the authors to improve the software and its prepare new version in English. The main purpose of the software is an educational process support, especially suitable for students and lecturers of refrigeration machine division. For educational and scientific purposes the software is available free of charge on the website <http://www.itcimp.pwr.wroc.pl/absorption3d/> scheduled.

The software (with the code of about 4,500 lines) has been prepared in Action Script 2 language in Macromedia Flash 8 commercial software. The exported swf file is set on a HTML website. A screen resolution of more than 1000*600px, processor speed of more than 1.6GHz are recommended.

THE AUTHORS

Try to use the software, it could be suitable for you, too.

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software for Elsevier article 3138-0-10-00240 - version 2010-05-17

That's all.

The software *Absorption 3D tool* and tutorial have been prepared for submission "Ammonia-water absorption cycle on three-dimensional graphs - The Absorption 3D tool software" - manuscript number JIIR-D-10-00172.

Tutorial version 2010-05-20
Software version 2010-05-19
available at <http://www.itcimp.pwr.wroc.pl/absorption3d/>

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