IAPWS formulation on the Elsevier site

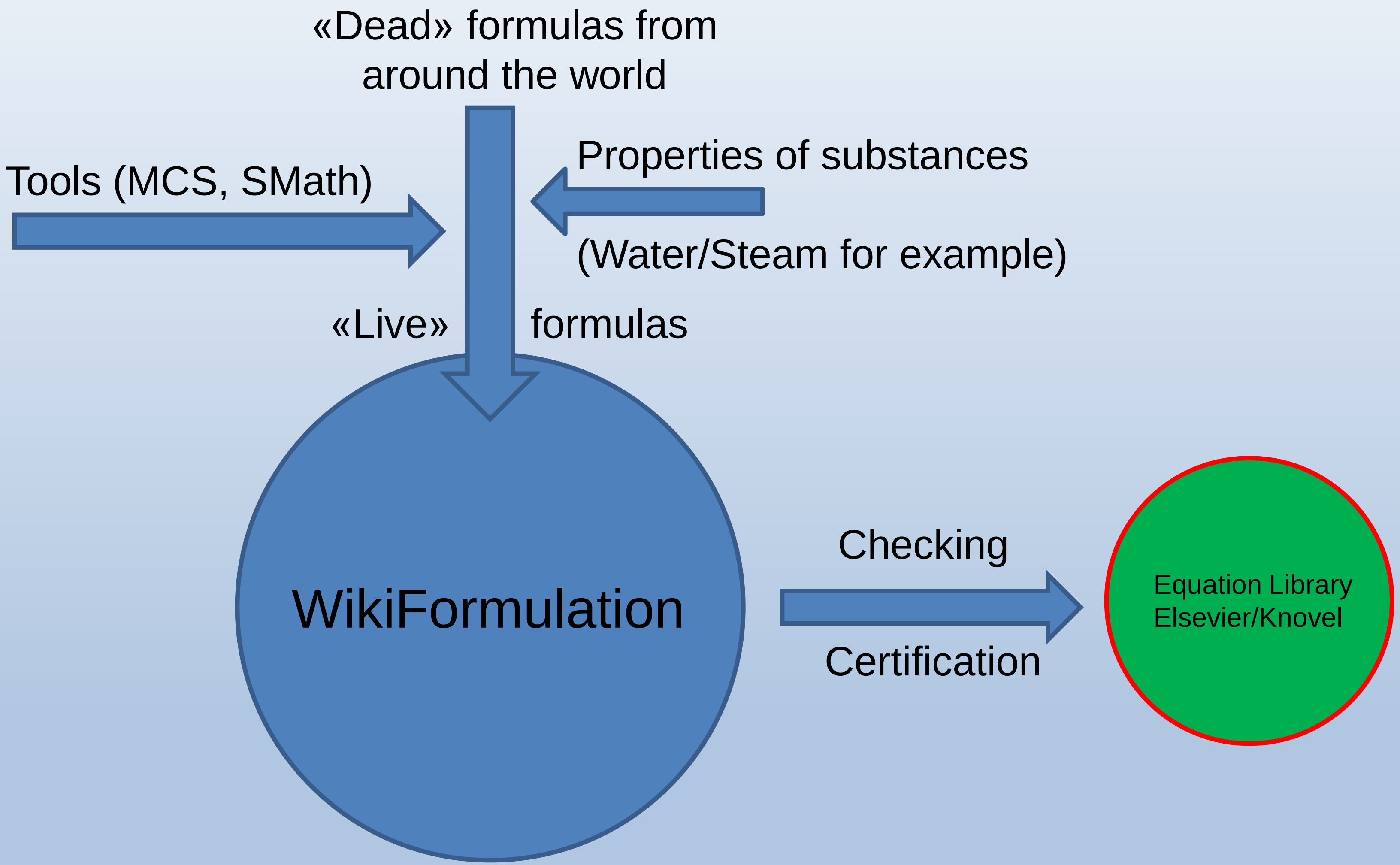
V. Ochkov

IAPWS Working Group

Thermophysical Properties of Water and Steam (TPWS)

Moscow, Russia, 24 June 2014

WikiFormulation (as WikiPedia, WikiMapa etc.)



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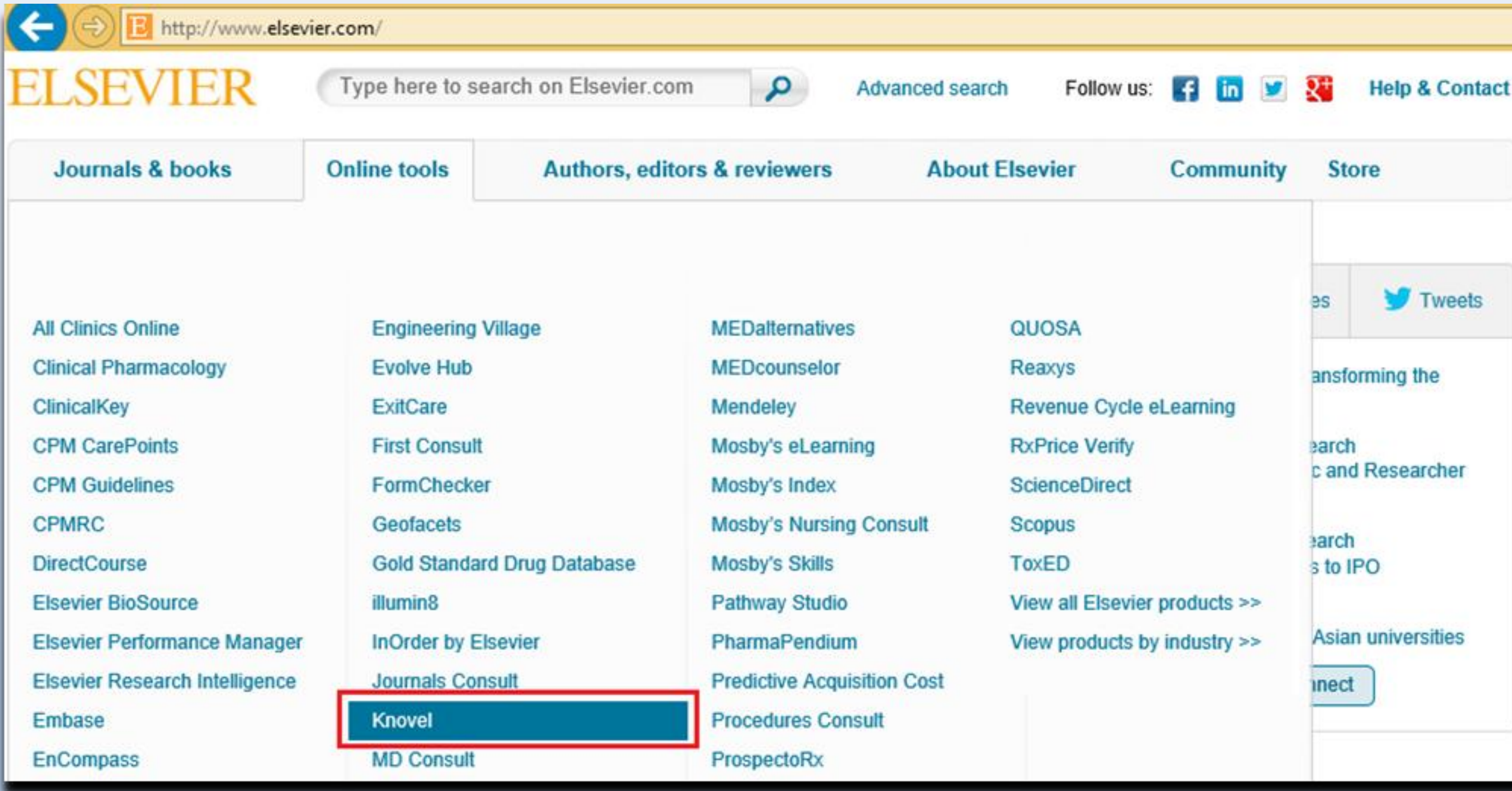

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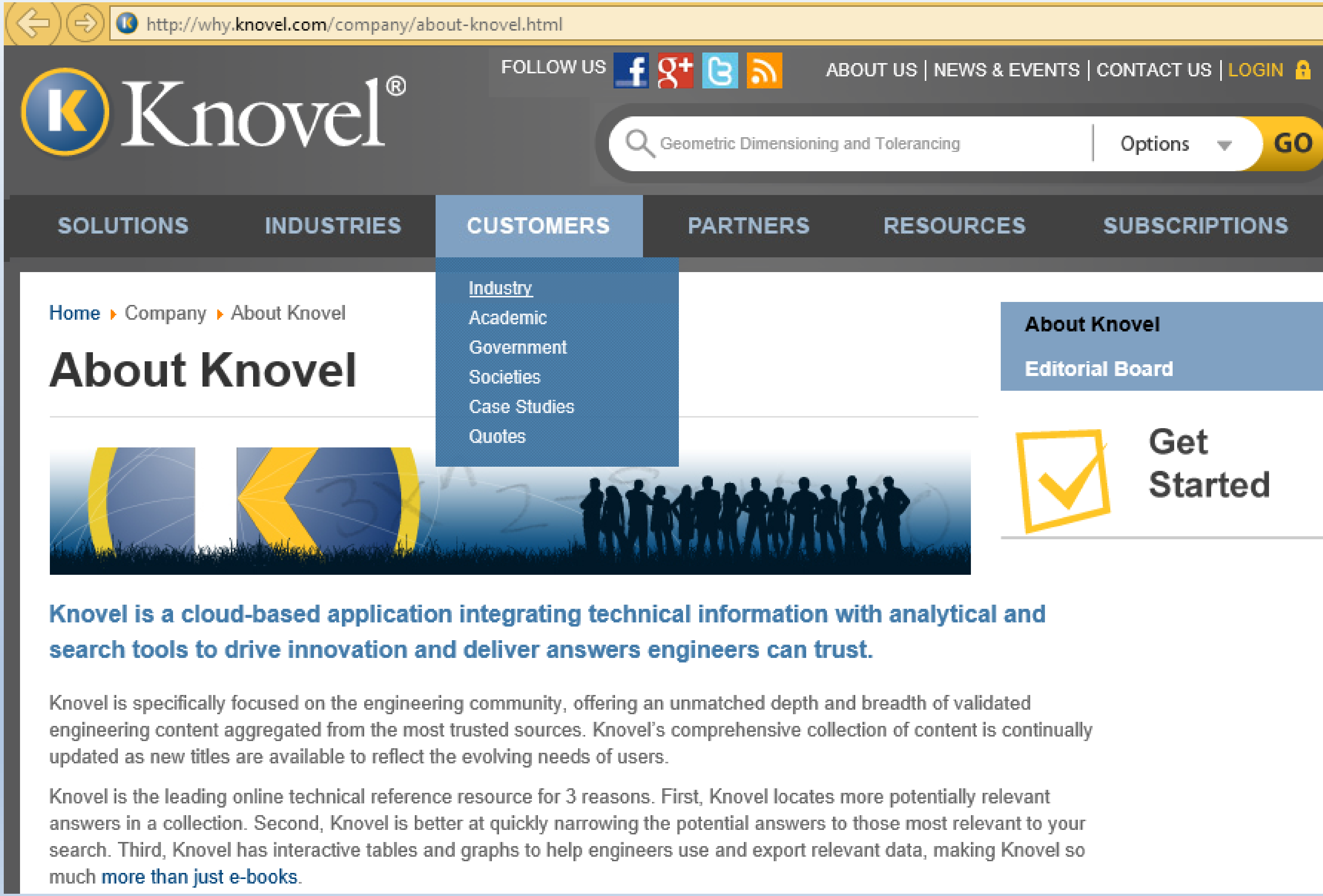

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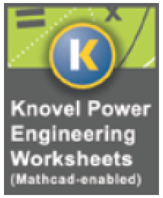

Title Details

Citation

Knovel Power Engineering Worksheets (Mathcad-enabled)

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Description: Knovel's Power Engineering Worksheets are a collection of over 370 worksheets specific to power generation and engineering and enabled by Mathcad. Areas of coverage include mathematics and motion; steam generation; water treatment; thermodynamics of ethanol, gases, water, and steam; and thermal conductivity and quasistatic Young's Modulus of metals and alloys. Mathcad is a computer-aided design platform with calculation and graphic capabilities which can be used to transcribe engineering content into solutions.
[Mathcad 14 or 15 is required.]

Table of Contents

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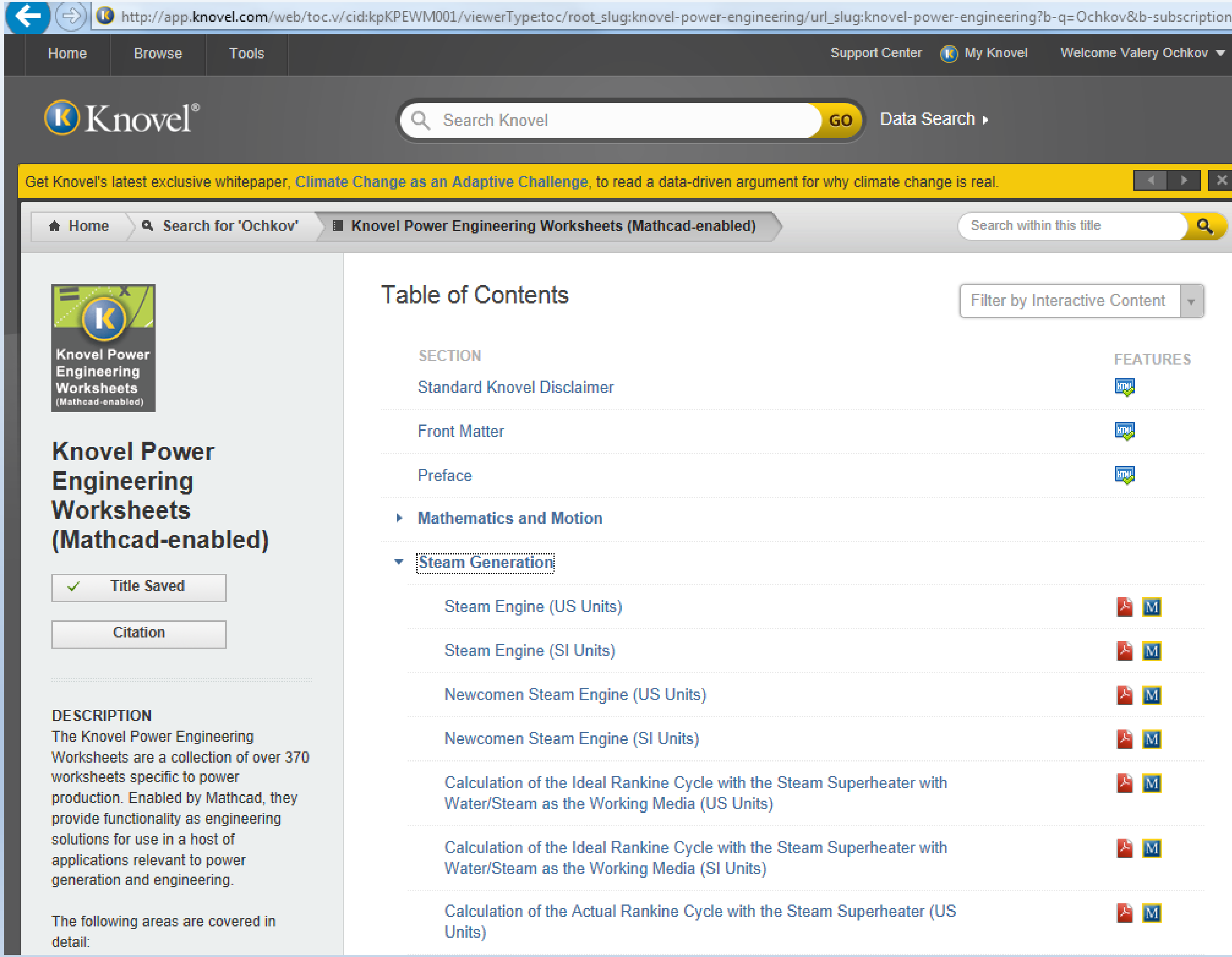

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http://content.knovel.com/content/pdf/4784/33_pe_ideal_rankine_cycle_for_superheated_steam_us_units.pdf?ekey=f2B4-AfJ7rUZJ5ViJ9hKWOB9nHWxVOIUI

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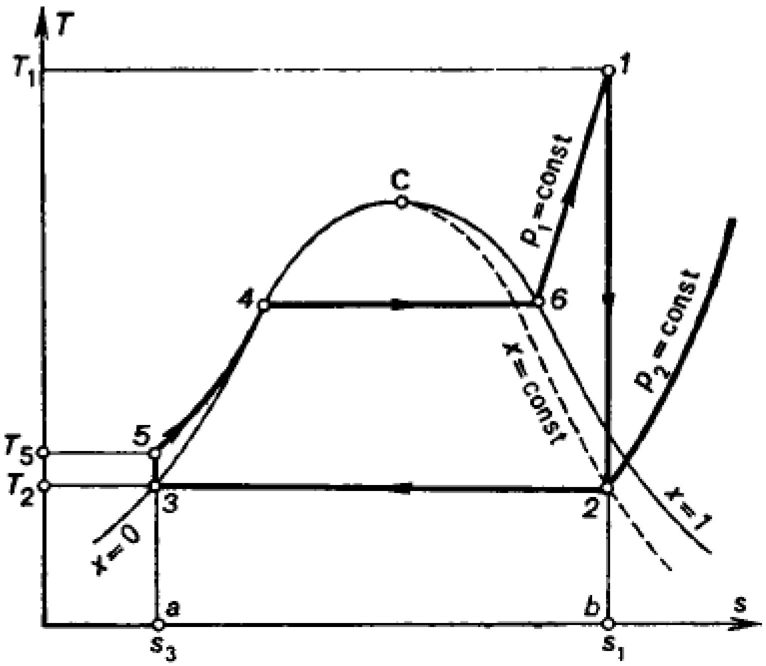
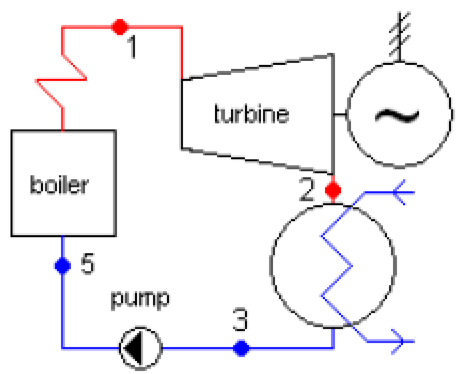
Calculation of the Ideal Rankine Cvcle with the Steam Superheater with Water/Steam as the Working Media (US Units)



The temperature of steam at the turbine inlet (point 1) $T_1 :=$ 1022 °F

The pressure of steam at the turbine inlet (point 1) $p_1 :=$ 2465.64 psi

The pressure of wet steam in the condenser (point 2) $p_2 :=$ 0.58 psi



Specific enthalpy of water (Region 2) as function of pressure and temperature

The specific enthalpy of steam at the turbine inlet: $h_1 := h_{IAPWS\text{-}IF97\text{-}Region2}(p_1, T_1) = 1474.3$ Btu/lb

Specific entropy of steam (Region 2) as function of pressure and temperature

The specific entropy of steam at the turbine inlet: $s_1 := s_{IAPWS\text{-}IF97\text{-}Region2}(p_1, T_1) = 1.539$ Btu/(lb °R)

IAPWS Formulations in Reference books

УДК 621.1.36.7 (035.5)
ББК 31.3я21
А 465

Александров А.А.
А 465 Теплофизические свойства рабочих веществ теплоэнергетики : справочник / А.А. Александров, К.А. Орлов, В.Ф. Очков. — М.: Издательский дом МЭИ, 2009. — 224 [8] с.: ил.

ISBN 978-5-383-00405-0

Приведены таблицы значений удельного объема, энтальпии, энтропии, изобарной теплоемкости, скорости звука, поверхностного натяжения, динамической вязкости, теплопроводности, числа Прандтля, статической диэлектрической постоянной, показателя преломления, ионного произведения для воды и водяного пара, рассчитанных по уравнениям, рекомендованным Международной ассоциацией по свойствам воды и водяного пара для применения в промышленных расчетах. Таблицы термодинамических свойств охватывают область параметров от температуры 0 °С до 800 °С при давлениях до 100 МПа (до 2000 °С при давлениях до 50 МПа), включая состояния насыщения и метастабильного переохлажденного пара.

Приведены также таблицы значений внутренней энергии, энтальпии и энтропии в идеально-газовом состоянии для веществ, являющихся компонентами продуктов сгорания: кислорода, азота, азота атмосферного, воздуха, диоксида углерода, оксида углерода, диоксида серы, оксида азота, диоксида азота, водяного пара и водорода. Таблицы представлены для диапазона температур от –50 до 2200 °С.

Представлены все уравнения, использованные при составлении таблиц, и адреса сайтов в Интернете, где данные уравнения открыты для интерактивной работы с ними. Справочник дополнен интерактивным сайтом Интернета с адресом **http://twt.mpei.ru/rbtpp**.

Справочник предназначен для работников проектных организаций, инженерно-технического персонала тепловых электростанций и промышленных энергетических установок, может служить также в качестве учебного пособия для студентов высших и средних технических учебных заведений.

УДК 621.1.36.7 (035.5)
ББК 31.3я21

Thermophysical properties of working substances of thermal engineering: reference book / A.A. Alexandrov, K.A. Orlov, V.F. Ochkov. – M.: MPEI Publishing House, 2009.— 224 p.

The tables of values of specific volume, specific enthalpy, specific entropy, specific isobaric heat capacity, sound velocity, surface tension, dynamic viscosity, heat conductivity, Prandtl number, static dielectric constant, refractive index and ionization constant are presented for water and steam. The tables are calculated by equations recommended for industrial calculations by International Association for the Properties of Water and Steam. The tables of thermodynamic properties embrace the region of parameters for temperatures from 0°C to 800°C at the pressures up to 100 MPa and up to 2000°C at pressures up to 50 MPa including saturation states and states of metastable subcooled steam.

The tables are presented also for values of specific internal energy, specific enthalpy and specific entropy in ideal-gas state for substances which are the components of fuel combustion products: oxygen, nitrogen, atmospheric nitrogen, air, carbon dioxide, carbon oxide, sulfur dioxide, nitrogen oxide, nitrogen dioxide, steam and hydrogen. The tables embrace interval of temperatures from –50°C to 2200°C.

All equations used for calculations of tables are presented together with addresses of sites in Internet where these equations are opened for interactive work.

The reference book is supplemented with Internet interactive site with the address **http://twt.mpei.ru/rbtpp**.

The book is destined to workers of designing organizations, engineering-technical personal of power plants and also may serves as educational supply for students of technical universities and colleges.

ISBN 978-5-383-00405-0

«Живые» формулы

IAPWS Formulations in Reference Book and on Mathcad calculation server

Уравнения линии насыщения (область 4)[1]

Уравнение, описывающее линию насыщения, представлено в виде неявного квадратного уравнения

$$\beta^2\vartheta^2 + n_1\beta^2\vartheta + n_2\beta^2 + n_3\beta\vartheta^2 + n_4\beta\vartheta + n_5\beta + n_6\vartheta^2 + n_7\vartheta + n_8 =$$

где

$$\beta = (p_s / p^*)^{1/4}$$

и

$$\vartheta = T_s / T^* + n_9 / [\, T_s / T^* \; - n_{10} \,]$$

при $p^* = 1$ МПа, $T^* = 1$ К. Коэффициенты уравнения пре

табл. 8.

Уравнение (9) может быть разрешено в явном виде как

давления насыщения p_s, так и относительно температуры н

Решение его относительно давления насыщения дает основн

линии насыщения

$$\frac{p_s}{p^*} = \left[\frac{2C}{-B + (B^2 - 4AC)^{1/2}} \right]^4,$$

где $p^* = 1$ МПа и $A = \vartheta^2 + n_1\vartheta + n_2$;

$$B = n_3\vartheta^2 + n_4\vartheta + n_5;$$

$$C = n_6\vartheta^2 + n_7\vartheta + n_8,$$

а решение относительно температуры насыщения – д

уравнение

$$\frac{T_s}{T^*} = \frac{n_{10} + D - [(n_{10} + D)^2 - 4(n_9 + n_{10}D)]^{1/2}}{2}$$

[1] http://twt.mpei.ac.ru/rbtpp/Region4

http://twt.mpei.ac.ru/MCS/Worksheets/WSP/Region4t.xmcd

Temperature and pressure water/steam on saturated line

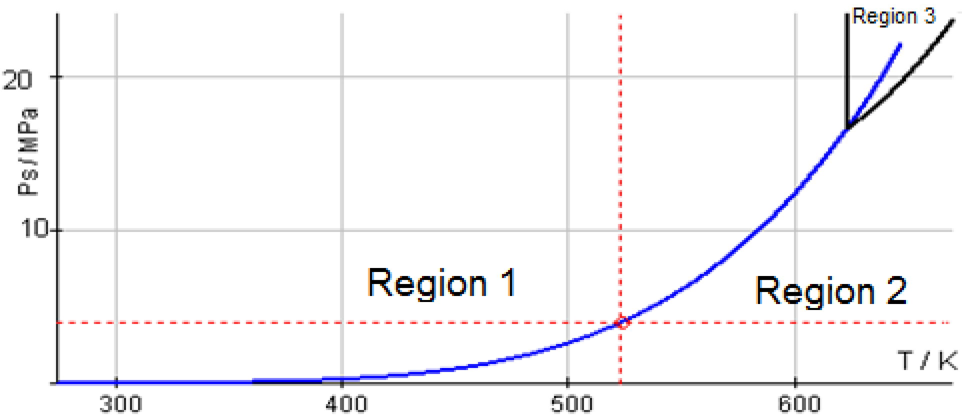
T := 250 °C Recalculate

$T = 523.15\,K$ $T^* := 1K$ $\theta := T/T^* + \frac{n_9}{T/T^* - n_{10}} = 523.1516$

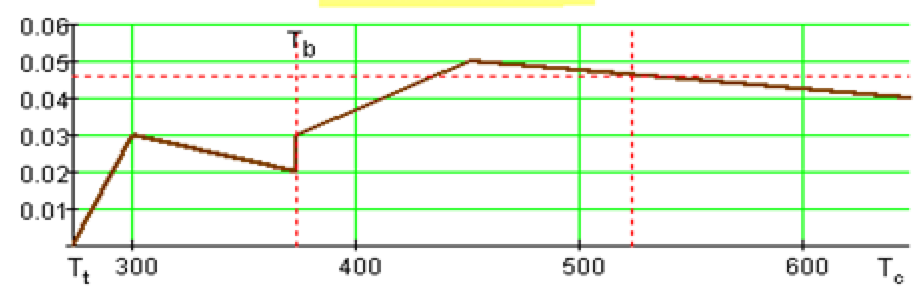
n_{1-10} >>>

$$\beta^2\cdot\theta^2 + n_1\cdot\beta^2\cdot\theta + n_2\cdot\beta^2 + n_3\cdot\beta\cdot\theta^2 + n_4\cdot\beta\cdot\theta + n_5\cdot\beta + n_6\cdot\theta^2 + n_7\cdot\theta + n_8 = 0$$

$\beta = 1.412082$ $p^* := 10^6\cdot Pa$ $p_s := \beta^4\cdot p^* = 3.9759391\,MPa$



$\pm\, \Delta Ps/Ps = 0.0463\ \%$



IAPWS Tables in Reference Book and on Mathcad calculation server

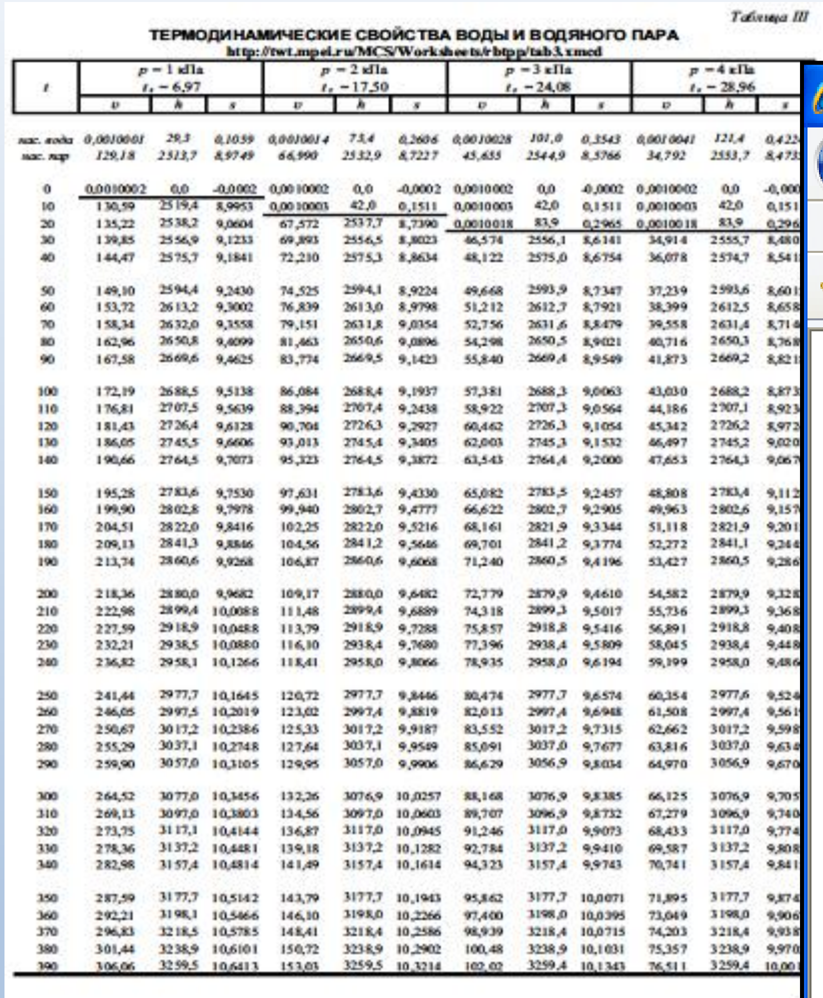
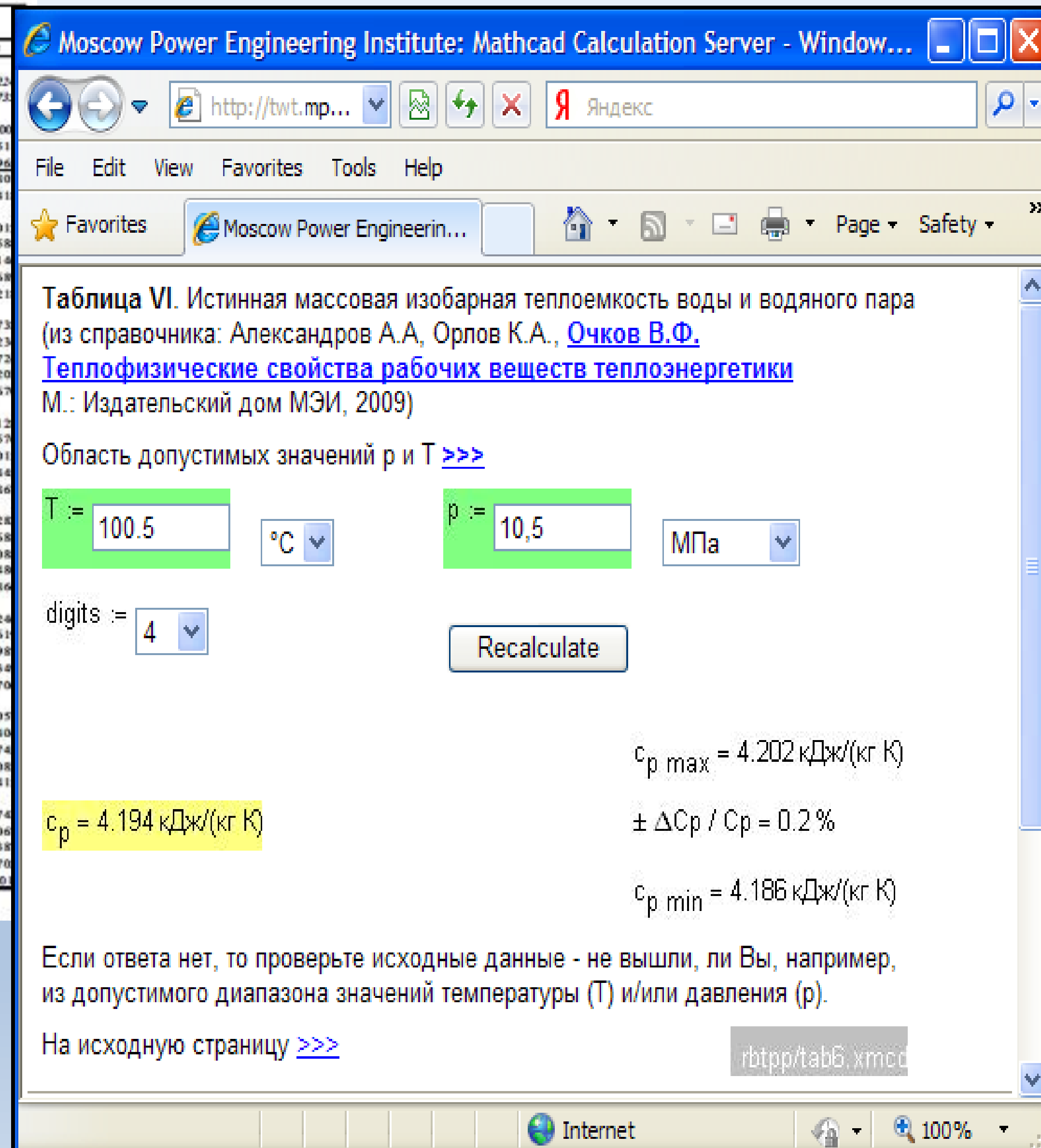


Таблица III

ТЕРМОДИНАМИЧЕСКИЕ СВОЙСТВА ВОДЫ И ВОДЯНОГО ПАРА
http://twt.mpei.ru/MCS/Worksheets/rbtpp/tab3.xmcd

t	p = 1 кПа, t_s = 6,97			p = 2 кПа, t_s = 17,50			p = 3 кПа, t_s = 24,08			p = 4 кПа, t_s = 28,96		
	v	h	s	v	h	s	v	h	s	v	h	s
нас. вода	0,0010001	29,3	0,1059	0,0010014	73,4	0,2606	0,0010028	101,0	0,3543	0,0010041	121,4	0,422
нас. пар	129,18	2513,7	8,9749	66,990	2532,9	8,7227	45,655	2544,9	8,5766	34,792	2553,7	8,473
0	0,0010002	0,0	-0,0002	0,0010002	0,0	-0,0002	0,0010002	0,0	-0,0002	0,0010002	0,0	-0,000
10	130,59	2519,4	8,9953	0,0010003	42,0	0,1511	0,0010003	42,0	0,1511	0,0010003	42,0	0,151
20	135,22	2538,2	9,0604	67,572	2537,7	8,7390	0,0010018	83,9	0,2965	0,0010018	83,9	0,296
30	139,85	2556,9	9,1233	69,893	2556,5	8,8023	46,574	2556,1	8,6141	34,914	2555,7	8,480
40	144,47	2575,7	9,1841	72,210	2575,3	8,8634	48,122	2575,0	8,6754	36,078	2574,7	8,541
50	149,10	2594,4	9,2430	74,525	2594,1	8,9224	49,668	2593,9	8,7347	37,239	2593,6	8,601
60	153,72	2613,2	9,3002	76,839	2613,0	8,9798	51,212	2612,7	8,7921	38,399	2612,5	8,658
70	158,34	2632,0	9,3558	79,151	2631,8	9,0354	52,756	2631,6	8,8479	39,558	2631,4	8,714
80	162,96	2650,8	9,4099	81,463	2650,6	9,0896	54,298	2650,5	8,9021	40,716	2650,3	8,768
90	167,58	2669,6	9,4625	83,774	2669,5	9,1423	55,840	2669,4	8,9549	41,873	2669,2	8,821
100	172,19	2688,5	9,5138	86,084	2688,4	9,1937	57,381	2688,3	9,0063	43,030	2688,2	8,873
110	176,81	2707,5	9,5639	88,394	2707,4	9,2438	58,922	2707,3	9,0564	44,186	2707,1	8,923
120	181,43	2726,4	9,6128	90,704	2726,3	9,2927	60,462	2726,3	9,1054	45,342	2726,2	8,972
130	186,05	2745,5	9,6606	93,013	2745,4	9,3405	62,003	2745,3	9,1532	46,497	2745,2	9,020
140	190,66	2764,5	9,7073	95,323	2764,5	9,3872	63,543	2764,4	9,2000	47,653	2764,3	9,067
150	195,28	2783,6	9,7530	97,631	2783,6	9,4330	65,082	2783,5	9,2457	48,808	2783,4	9,112
160	199,90	2802,8	9,7978	99,940	2802,7	9,4777	66,622	2802,7	9,2905	49,963	2802,6	9,157
170	204,51	2822,0	9,8416	102,25	2822,0	9,5216	68,161	2821,9	9,3344	51,118	2821,9	9,201
180	209,13	2841,3	9,8846	104,56	2841,2	9,5646	69,701	2841,2	9,3774	52,272	2841,1	9,244
190	213,74	2860,6	9,9268	106,87	2860,6	9,6068	71,240	2860,5	9,4196	53,427	2860,5	9,286
200	218,36	2880,0	9,9682	109,17	2880,0	9,6482	72,779	2879,9	9,4610	54,582	2879,9	9,328
210	222,98	2899,4	10,0088	111,48	2899,4	9,6889	74,318	2899,3	9,5017	55,736	2899,3	9,368
220	227,59	2918,9	10,0488	113,79	2918,9	9,7288	75,857	2918,8	9,5416	56,891	2918,8	9,408
230	232,21	2938,5	10,0880	116,10	2938,4	9,7680	77,396	2938,4	9,5809	58,045	2938,4	9,448
240	236,82	2958,1	10,1266	118,41	2958,0	9,8066	78,935	2958,0	9,6194	59,199	2958,0	9,486
250	241,44	2977,7	10,1645	120,72	2977,7	9,8446	80,474	2977,7	9,6574	60,354	2977,6	9,524
260	246,05	2997,5	10,2019	123,02	2997,4	9,8819	82,013	2997,4	9,6948	61,508	2997,4	9,561
270	250,67	3017,2	10,2386	125,33	3017,2	9,9187	83,552	3017,2	9,7315	62,662	3017,2	9,598
280	255,29	3037,1	10,2748	127,64	3037,1	9,9549	85,091	3037,0	9,7677	63,816	3037,0	9,634
290	259,90	3057,0	10,3105	129,95	3057,0	9,9906	86,629	3056,9	9,8034	64,970	3056,9	9,670
300	264,52	3077,0	10,3456	132,26	3076,9	10,0257	88,168	3076,9	9,8385	66,125	3076,9	9,705
310	269,13	3097,0	10,3803	134,56	3097,0	10,0603	89,707	3096,9	9,8732	67,279	3096,9	9,740
320	273,75	3117,1	10,4144	136,87	3117,0	10,0945	91,246	3117,0	9,9073	68,433	3117,0	9,774
330	278,36	3137,2	10,4481	139,18	3137,2	10,1282	92,784	3137,2	9,9410	69,587	3137,2	9,808
340	282,98	3157,4	10,4814	141,49	3157,4	10,1614	94,323	3157,4	9,9743	70,741	3157,4	9,841
350	287,59	3177,7	10,5142	143,79	3177,7	10,1943	95,862	3177,7	10,0071	71,895	3177,7	9,874
360	292,21	3198,1	10,5466	146,10	3198,0	10,2266	97,400	3198,0	10,0395	73,049	3198,0	9,906
370	296,83	3218,5	10,5785	148,41	3218,4	10,2586	98,939	3218,4	10,0715	74,203	3218,4	9,938
380	301,44	3238,9	10,6101	150,72	3238,9	10,2902	100,48	3238,9	10,1031	75,357	3238,9	9,970
390	306,06	3259,5	10,6413	153,03	3259,5	10,3214	102,02	3259,4	10,1343	76,511	3259,4	10,00



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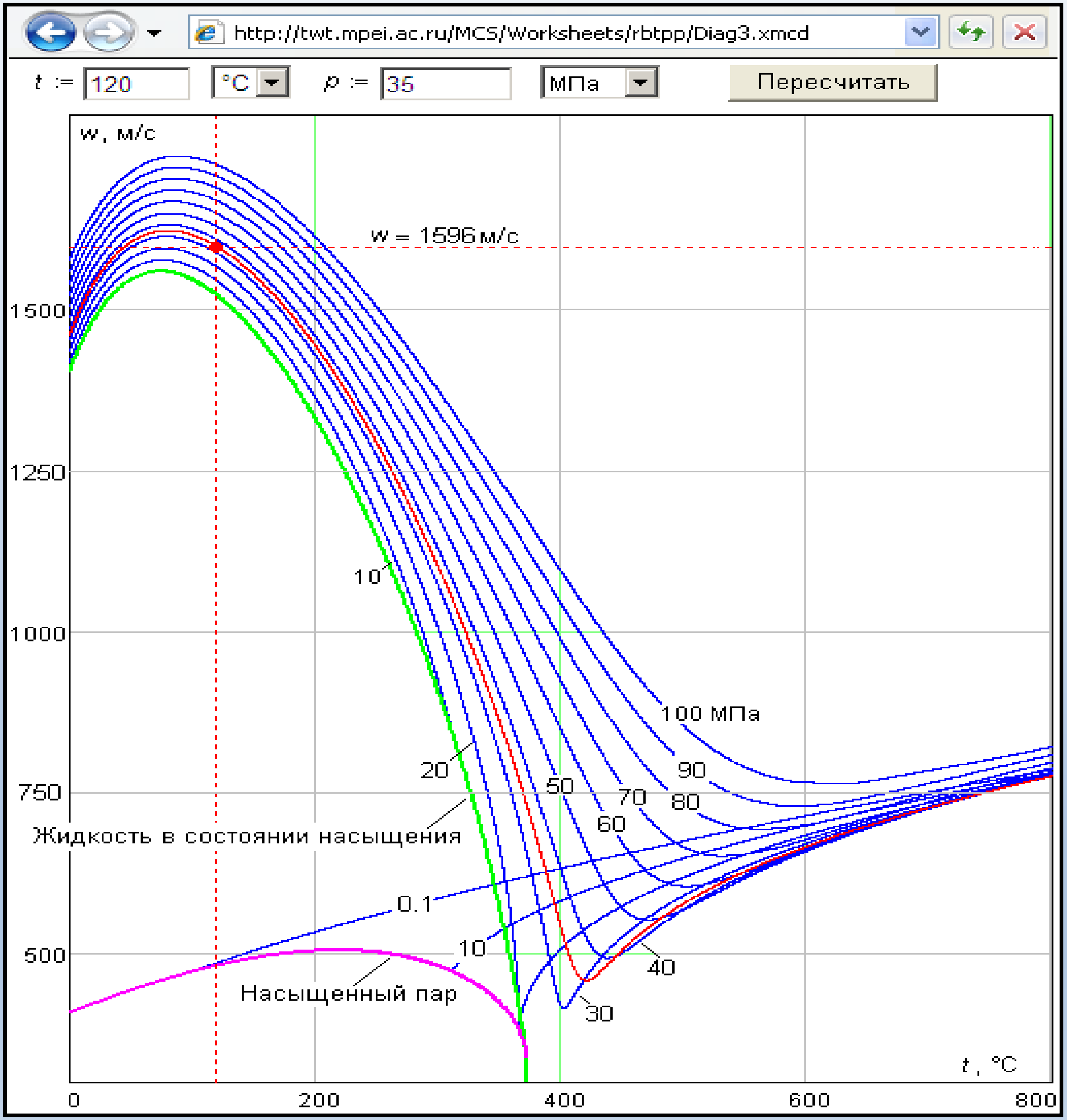
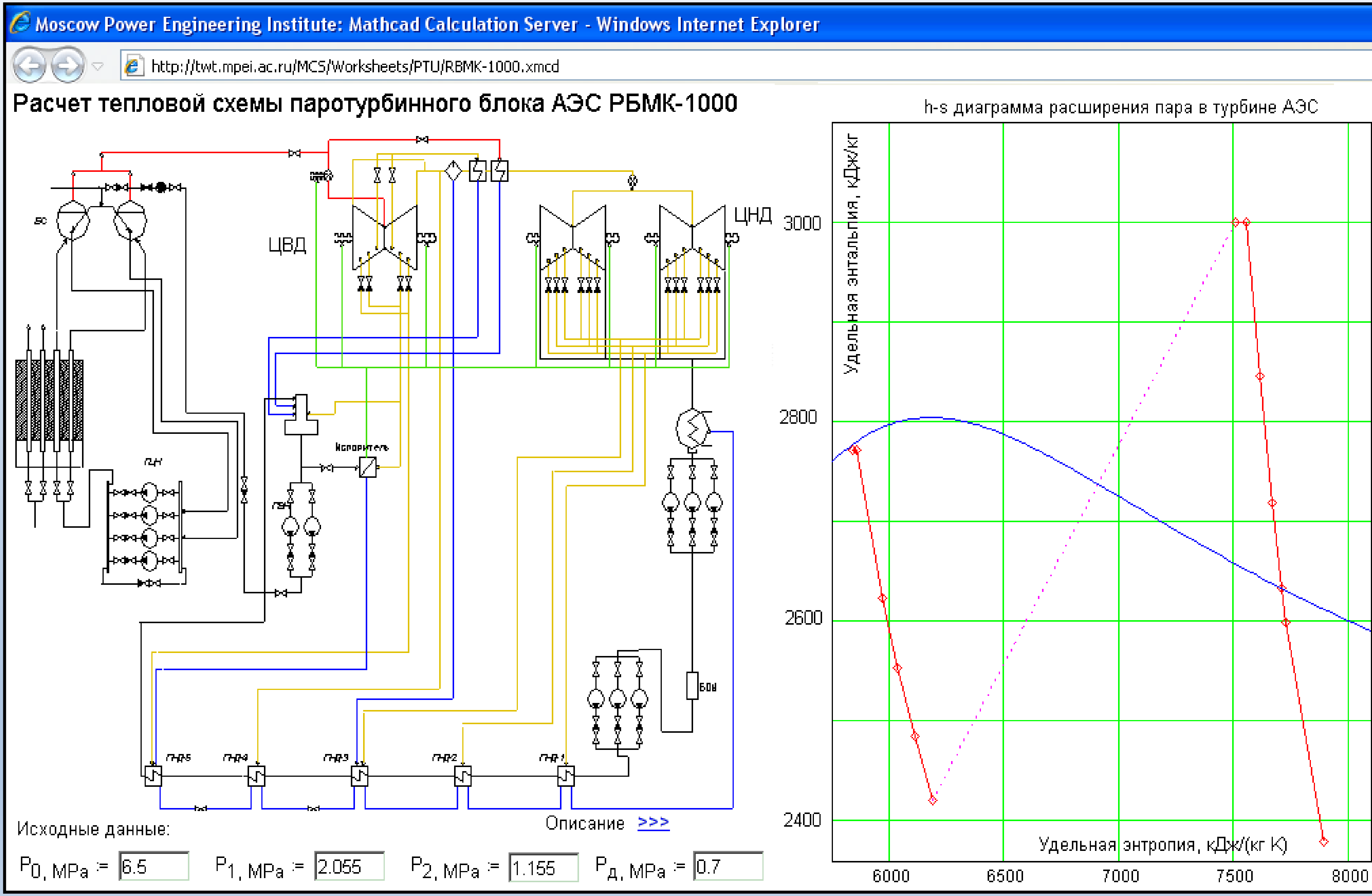


«Живые» диаграммы

Nuclear Power Plant calculation with IAPWS Formulations on Mathcad server



Links on live Mathcad calculation from IAPWS site

http://www.iapws.org/relguide/ThCond.htm

IAPWS

Release on the IAPWS Formulation 2011 for the Thermal Conductivity of Ordinary Water Substance (September 2011)

PDF of document

Description
This formulation is recommended for the calculation of the thermal conductivity of ordinary water in its fluid phases.
The formulation consists of a dilute-gas term that is only a function of temperature, a finite-density term as a function of temperature and density, and a near-critical term as a function of temperature and density.
The region of validity the entire stable fluid region from the melting curve to 1173 K at pressures to 100 MPa, with lower maximum temperatures at higher pressures up to 1000 MPa; see the release document for details. It extrapolates in a physically reasonable way outside this region.

Online calculation
The Russian National Committee of IAPWS (through Moscow Power Engineering Institute) has provided online calculation pages, which may be useful in program development and verification. **Note that IAPWS is not responsible for the content of these online calculation pages:**

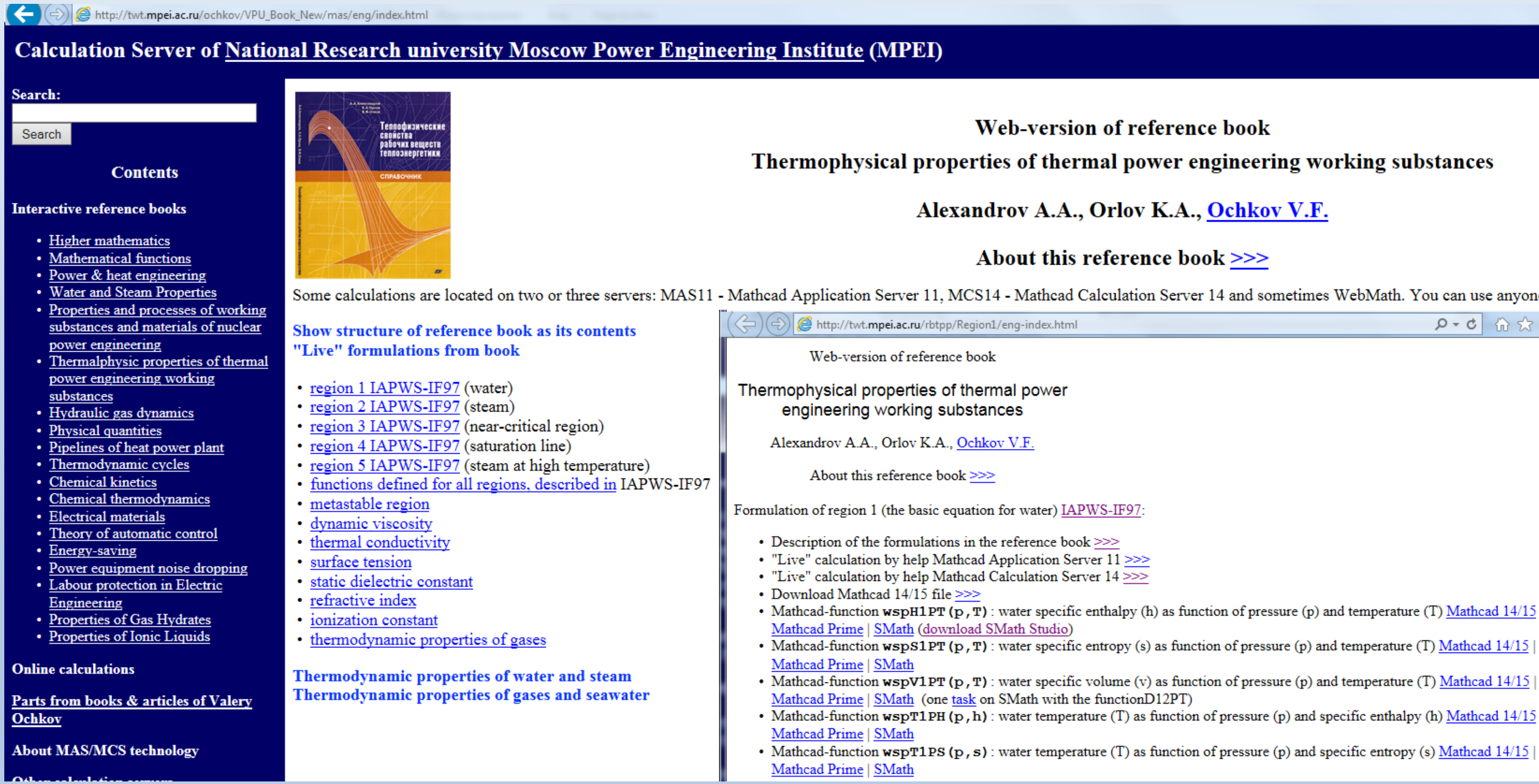
- for general and scientific use
- for industrial use

Mathcad problems

- Mathcad is a software of one company (PTC)
- The price of Mathcad is 1500 – 7000$
- Mathcad based only on Windows

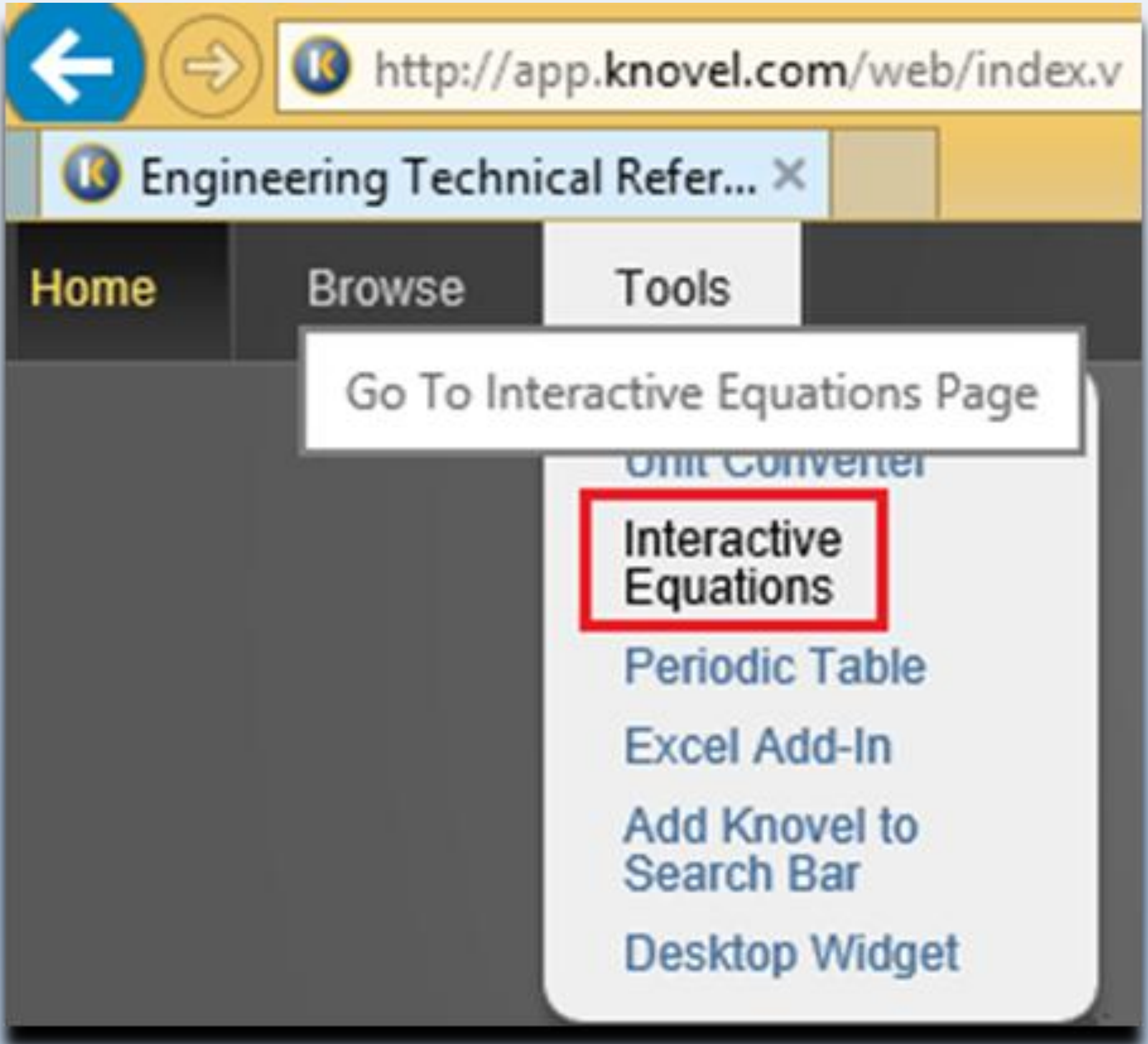
Free new Mathcad – SMath (www.smath.info)

Online calculations, “clouds” functions, download Mathcad and SMath sheets from the book



What is it SMath (Knovel CalcTool)?

Calculations on Elsevier/Knovel site



One reference book with «dead» formulas

http://app.knovel.com/web/view/swf/show.v/rcid:kpASHRAEA2/cid:kt00AFVIV3/viewerType:pdf/root_slug:ashrae-handbook-heating-3

Browse | 2012 ASHRAE Handbook - Heating | 44.9 Affinity Laws

boundaries for operation of the system. The net vertical difference between the curves is the difference in friction loss developed by the distribution mains for the two extremes of possible loads. The area in which the system operates depends on the diverse loading or unloading imposed by the terminal units. This area represents the pumping energy that can be conserved with one-speed, two-speed, or variable-speed pumps after a review of the pump power, efficiency, and affinity relationships.

PUMP POWER

The theoretical power to circulate water in a hydronic system is the **water power P_w** and is calculated as follows:

$$P_w = \dot{m}\Delta p/\rho \qquad (3)$$

where

$\dot{m}$ = mass flow of fluid, kg/s

Δp = pressure increase, Pa

Figure 21 shows how water power increases with flow.

The total power P_t required to operate the pump is determined by the manufacturer's test of an actual pump running under standard conditions to produce the required flow and pressure as shown in Figure 11.

PUMP EFFICIENCY

Pump efficiency is determined by comparing the output power to the input power:

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{P_w}{P_t} \times 100\% \qquad (4)$$

Figure 22 shows a typical efficiency versus flow curve.

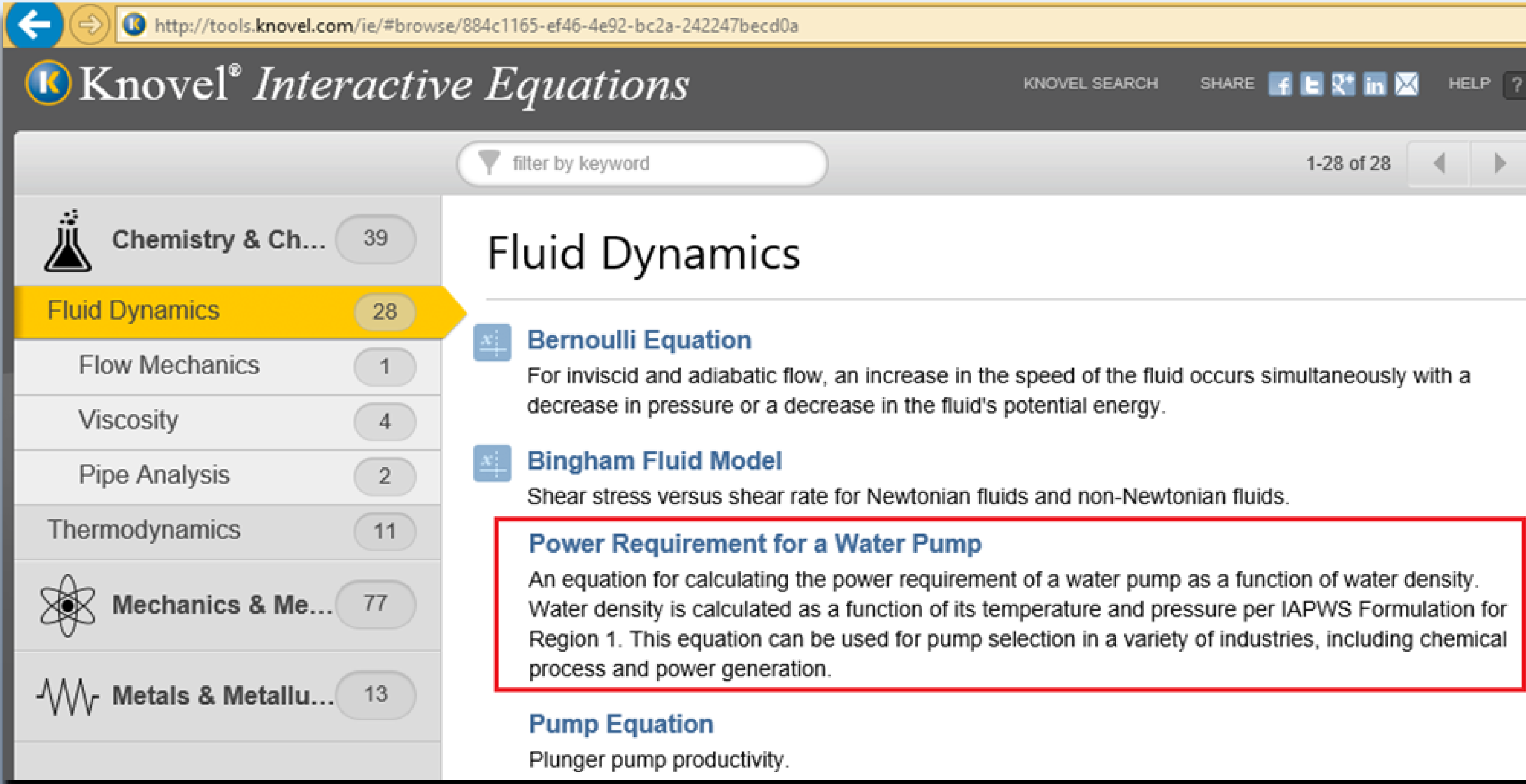
The pump manufacturer usually plots the efficiencies for a given volute and impeller size on the pump curve to help the designer select the proper pump (Figure 23). The best efficiency point (BEP) is the optimum efficiency for this pump; operation above and below this point is less efficient. The locus of all the BEPs for each impeller size lies on a system curve that passes through the origin (Figure 24).

AFFINITY LAWS

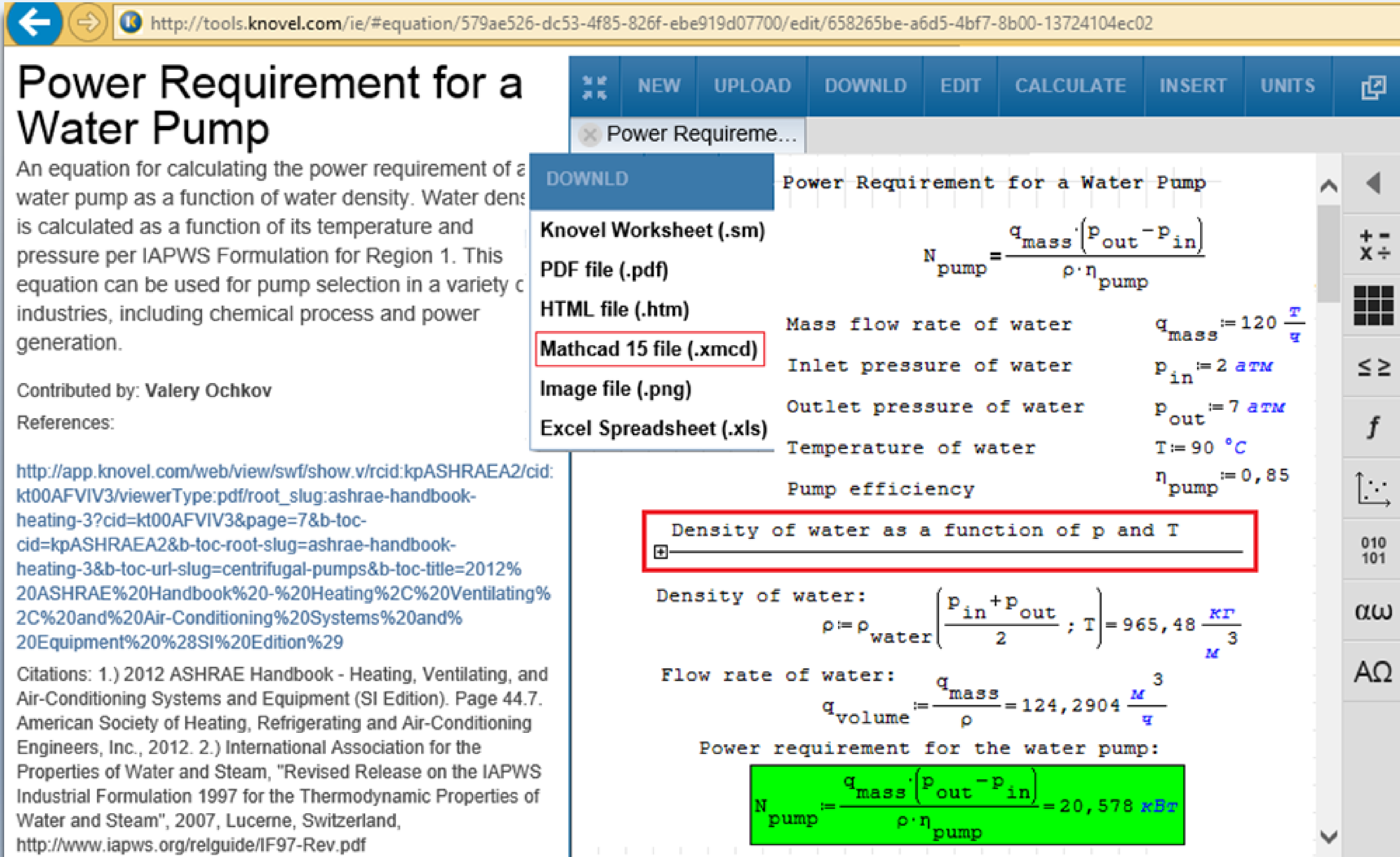
The centrifugal pump, which imparts a velocity to a fluid and converts the velocity energy to pressure energy, can be categorized by a set of relationships called **affinity laws** (Table 1). The laws can be described as similarity processes that follow these rules:

1. Flow (capacity) varies with rotating speed N (i.e., the peripheral velocity of the impeller).

Calculations on Elsevier/Knovel site



Calculations on Elsevier/Knovel site



Calculations on Elsevier/Knovel site

Density of water as a function of p and T

$\rho_{water}(p\,;T) :=$

"Revised Release on the IAPWS Industrial Formulation 1997"
"for the Thermodynamic Properties of Water and Steam"
"see http://www.iapws.org/relguide/IF97-Rev.pdf"
"Density of water (Region 1) as function of pressure and temperature"

$\gamma(w\,;\tau) :=$ "Gibbs free energy"

$I := (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 2\ 2\ 2\ 2\ 2\ 3\ 3\ 3\ 4\ 4\ 4\ 5\ 8\ 8$

$J := (-2\ -1\ 0\ 1\ 2\ 3\ 4\ 5\ -9\ -7\ -1\ 0\ 1\ 3\ -3\ 0\ 1\ 3\ 17\ -4\ 0\ 6\ -5$

$n := \left(1{,}463297121316 7\cdot 10^{-1}\ -8{,}454818716911 4\cdot 10^{-1}\ -3{,}7563603\right.$

$$\sum_{i=1}^{34}\left[n_i\cdot\frac{d}{dw}\left[(7{,}1-w)^{I_i}\right]\cdot(\tau-1{,}222)^{J_i}\right]$$

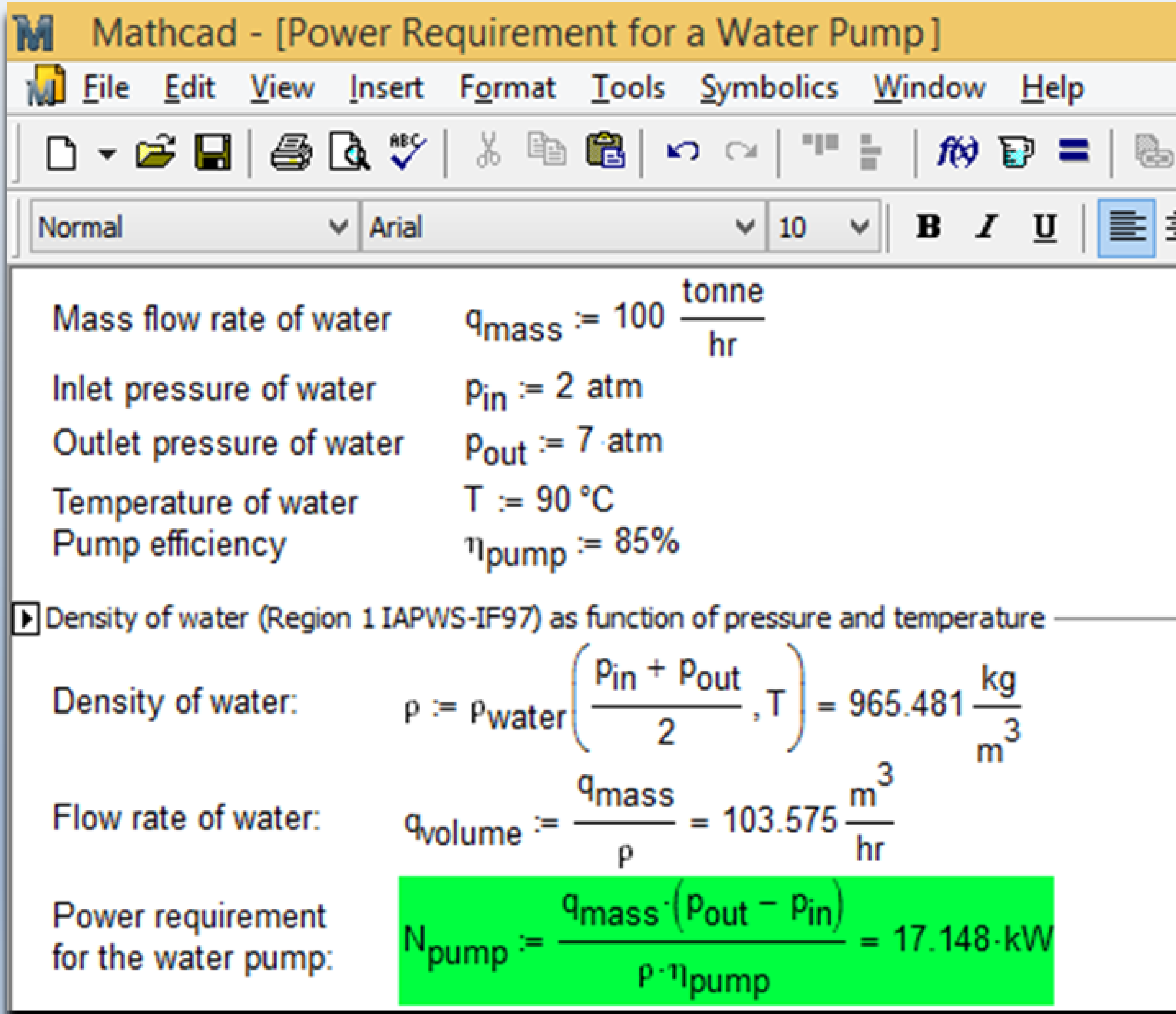
$R := 0{,}461526\,\frac{кДж}{кг\ К}$

$w := \frac{p}{16{,}53\ МПа}$

$\tau := \frac{1386\ К}{T}$

$$\frac{1}{\frac{R\cdot T}{p}\cdot w\cdot\gamma(w\,;\tau)}$$

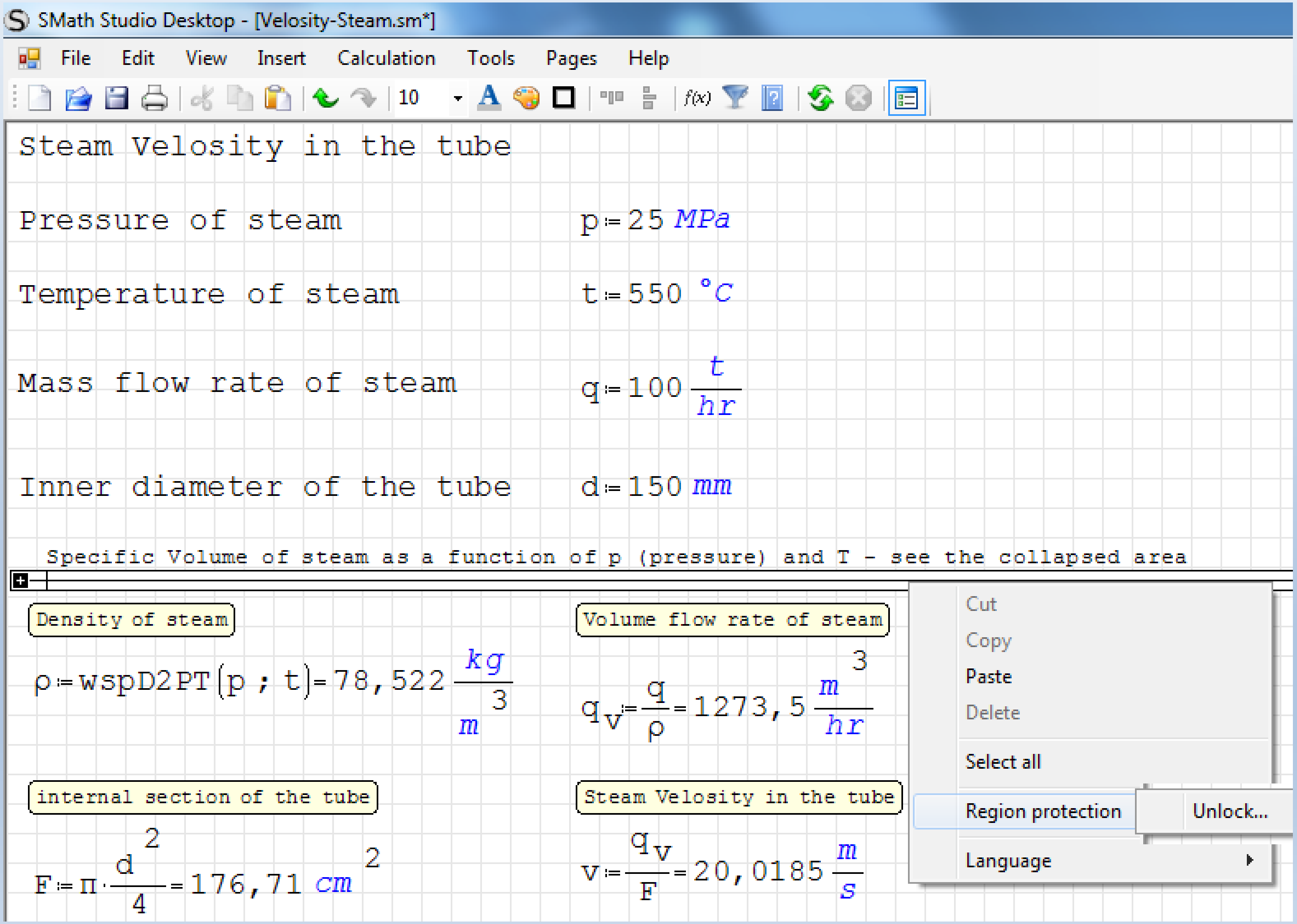
Download Mathcad sheet from Elsevier/Knovel site



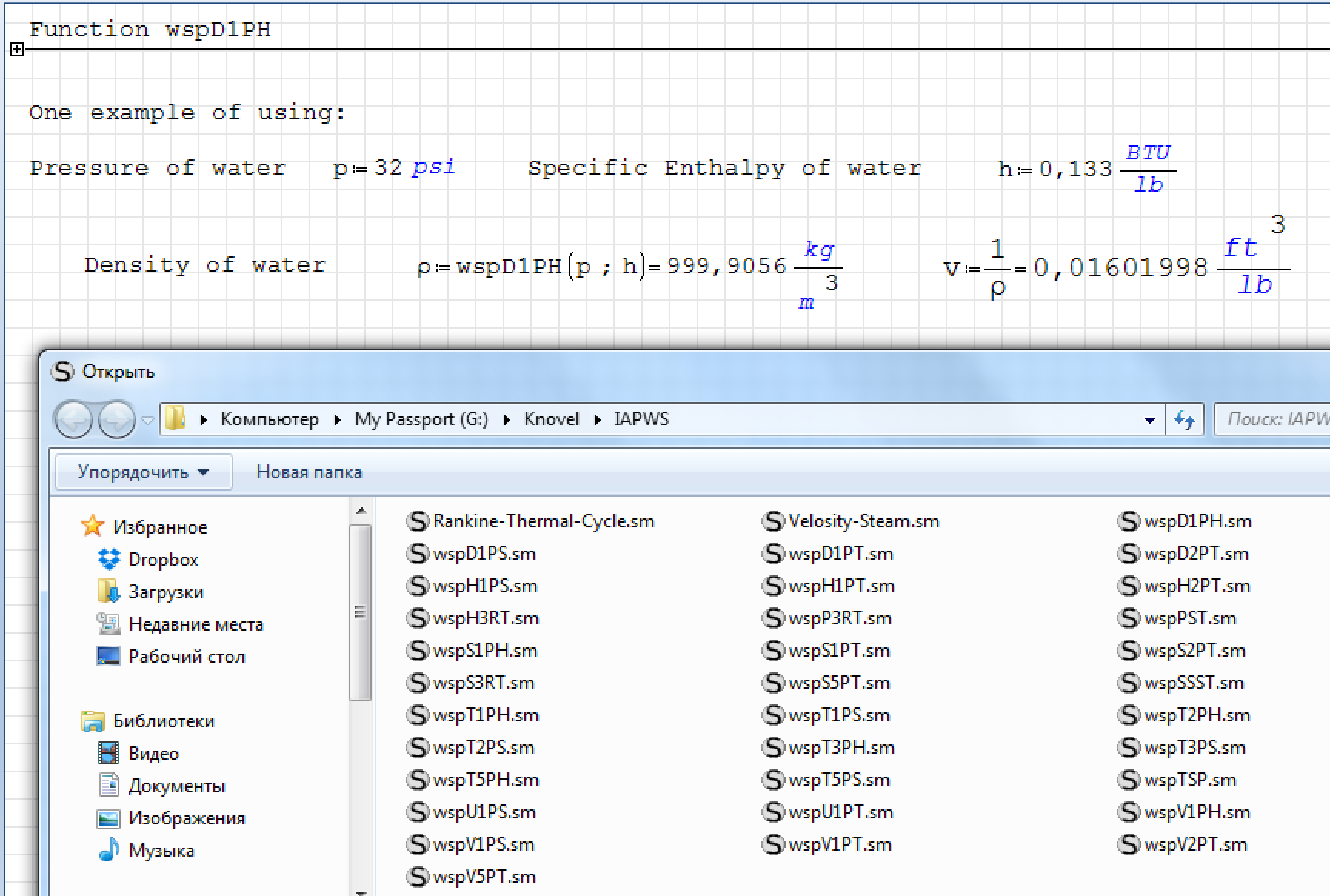
Download Excel sheet from Elsevier/Knovel site

	A	B	C	C
1	**Расчет массового расхода воды**			
2				
3	**Исходные данные**			
4	Объемный расход воды	$м^3/ч$	100	100
5	Давление воды	атм	7	7
6	Температура воды	°C	90	90
7				
8	**Промежуточные данные**			
9	Объемный расход воды	$м^3/с$	0,027778	=C4/3600
10	Давление воды	Па	709275	=C5*101325
11	Температура воды	К	363,15	=C6+273,15
12	Плотность воды	$кг/м^3$	965,319	=wspDPT(C10;C11)
13				
14	**Ответ**			
15	Массовый расход воды	кг/с	26,814	=C9*C12
16	Массовый расход воды	т/ч	96,532	=C15*3600/1000

Protection of the IAPWS function



First SMath wsp-files

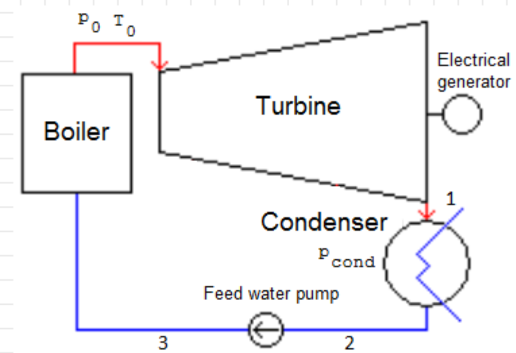


One real problem with wsp functions

SMath Studio Desktop - [Rankine-Thermal-Cycle.sm]

File Edit View Insert Calculation Tools Pages Help

Calculation of the thermal efficiency of the steam turbine (Rankine) cycle



Input data:

$p_0 := 13\ MPa$ $T_0 := 550\ °C$

$p_{cond} := 4\ kPa$

We must use 11 wsp SMath function from Knovel EquLibrary

⊞—Function wspH2PT

Specific enthalpy of fresh steam (the turbine inlet):

$h_0 := wspH2PT(p_0, T_0) = 3471.4\ \frac{kJ}{kg}$

⊞—Function wspS2PT

Specific entropy of fresh steam (the turbine inlet):

$s_0 := wspS2PT(p_0, T_0) = 6.6087\ \frac{kJ}{kg\ K}$

⊞—Function wspTSP

Temperature in the condenser:

$T_{cond} := wspTSP(p_{cond}) = 28.96\ °C$

Specific entropy of steam in the outlet of the turbine an ideal process of the steam extension)

$s_1 := s_0 = 6.609\ \frac{kJ}{kg\ K}$

⊞—Function wspSSWT

⊞—Function wspSSST

⊞—Function wspXTS

Dryness of steam in outlet of turbine:

$x_1 := wspXTS(T_{cond}, s_1) = 0.7684$

⊞—Function wspHSST

⊞—Function wspHSWT

⊞—Function wspHSTX

Specific enthalpy of wet steam in outlet of turbine:

$h_1 := wspHSTX(T_{cond}, x_1) = 1990.3\ \frac{kJ}{kg}$

Specific work of steam in turbine:

$l_t := h_0 - h_1 = 1481.04\ \frac{kJ}{kg}$

Specific enthalpy of water at saturated line at temperature in the condenser

$h_2 := wspHSWT(T_{cond}) = 121.4\ \frac{kJ}{kg}$

Specific entropy of water at saturated line at temperature in the condenser

$s_2 := wspSSWT(T_{cond}) = 0.4224\ \frac{kJ}{kg\ K}$

Pressure of feed water:

$p_3 := p_0 = 13\ MPa$

Specific entropy of feed water (an ideal process in the pump):

$s_3 := s_2 = 0.4224\ \frac{kJ}{kg\ K}$

⊞—Temperature of water (Region 1) as function of pressure and entropy.

Temperature of feed water:

$T_3 := wspT1PS(p_3, s_3) = 29.24\ °C$

⊞—Specific enthalpy of water (Region 1) as function of pressure and temperature

Specific enthalpy of feed water:

$h_3 := wspH1PT(p_3, T_3) = 134.4043\ \frac{kJ}{kg}$

Specific useful work of the turbine:

$l_p := h_3 - h_2 = 13.0007\ \frac{kJ}{kg}$

Spesific heat of the bouler

$q_0 := h_0 - h_3 = 3336.9854\ \frac{kJ}{kg}$

Thermal efficiency of the cycle:

$\eta_t := \frac{l_t - l_p}{q_0} = 0.4399$

International Association for the Properties of Water and Steam (IAPWS) is an international non-profit association of national organizations concerned with the properties of water and steam, particularly thermophysical properties, cycle chemistry guidelines, and other aspects of high-temperature steam, water and aqueous mixtures relevant to thermal power cycles and other industrial and scientific applications. IAPWS objectives are:

•To provide internationally accepted formulations for the properties of light and heavy steam, water and selected aqueous solutions for scientific and industrial applications.

•To provide technical guidance, obtained by international consensus of experts, on cycle chemistry and technology for steam power cycles in fossil and combined cycle plants and other industrial applications.

•To define research needs and promote and coordinate research on steam, water and selected aqueous systems important in thermal power cycles To collect and evaluate the resulting data, and to communicate and promulgate the findings

•To provide an international forum for exchange of experiences, ideas and results of research on high-temperature aqueous media

•To further these objectives, broaden the use of IAPWS formulations and to make power engineers around the world more productive by performing IAPWS calculations interactively online, we would like to include about 40 IAPWS formulations and several relevant calculation examples in the Knovel Interactive Equations.

The formulations will be converted into appropriate format and the calculation examples will be created by Prof. Valery Ochkov of the Moscow Power Engineering Institute (MPEI). Prof. Ochkov is a member of IAPWS and a world-renown expert who pioneered interactive engineering calculations online and has collaborated on a number of related projects with Knovel in the past. We plan to reference Knovel-based IAPWS formulations on our site (http://www.iapws.org/).

Prof. Ochkov has agreed, during a recent visit to Moscow by your associate, Mr. Sasha Gurke, to provide all the work gratis; and IAPWS would not require royalties or any other payments for its content.

International cooperation

http://www.rfbr.ru/rffi/eng/contests_international

RUSSIAN FOUNDATION FOR BASIC RESEARCH

Joint initiative research projects competition of the Russian Foundation for Basic research (RFBR) and the German Research Foundation (DFG)	«M_a»	31.12.2014 00:00	no data
Continuous joint competitions of the Russian Foundation for Basic research (RFBR) and Austrian Science Fund (FWF)	«M_a»	no data	no data
Continuous joint competitions of the Russian Foundation for Basic research (RFBR) and Austrian Science Fund (FWF)	«M_a»	no data	no data
Continuous Competition for Joint Russian and French Research Projects within the Framework of International Associated Laboratories (LIA) and International Joint Units (UMI)	«M_a»	no data	no data
Continuous competition of the Russian-German research projects within the framework of the program "International Research Training Groups"	«M_a»	no data	no data

Thanks!

Valery Ochkov

MPEI

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