MODELLING OF REACTIVE DISTILLATION COLUMN BY USING MOSAIC

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for the award of the degree of
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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Chemical Engineering.

Signature :
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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

Due to many advantages of reactive distillation column (RD) comparing to traditional method (reactors follows by distillation columns) in chemical synthesis, RD has been drawing attentions of researchers around the world to explore its potentials in chemical industries.

Modelling of RD can be made by many different modelling environments such as Matlab, Fortran and so on. However, it is a time consuming process and a lot of effort will be required in order to get the solutions of the model. Since the modelling is done by using their own programming languages, it has the poor readability. Thus, users prone to make the mistakes during coding and error identification will be difficult by using these modelling software.

In this study of RD modelling, a new modelling environment called MOSAIC will become the focus. MOSAIC is a web based modelling software and it introduces the new modelling approach in order to overcome what it seems as insufficient places of other modelling software. The key features of MOSAIC include modelling in the documentation level, reuse of model elements, code generation for other modelling environments and centralized cooperation on internet. (Kuntsche, Barz, Kraus, Arellano-Garcia, & Wozny, 2011)

Modelling of reactive distillation column is based on the steady state equilibrium model. It is assumed that the liquid and vapour phase behave ideally. Steady state equilibrium model can be described by MESH equations. MESH equations are material balance equation, phase equilibrium equation, summation equations and energy balance equation.

From the results, it can be seen that almost 100% conversion of reactants are achieved with 94% of MTBE purity. The temperature profile shows that the temperature is maintaining at 354K from condenser to feed stage. This is due to high purity of n-butene in each stages. After feed stage, the temperature increases rapidly until it reaches highest temperature of 424K at reboiler stage. This is caused by high mole fraction of MTBE from condenser to reboiler stage.

MOSAIC makes the modelling possible even without the knowledge of programming language. Latex documentary language is used by MOSAIC in documentation of modelling equations. High readability of Latex allows modelling using MOSAIC to be less errors and without much effort.

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NOMENCLATURE

a	Activity	-
F	Feed molar flow rate	mol/s
H	Enthalpy	J/mol
L	Liquid molar flow rate	mol/s
M_j	Molar liquid hold up on stage j	mol/s
P	Total pressure	Pa
P^o	Saturated vapour pressure	Pa
R	Reaction rate	mol/s
r	number of reactions	-
t	time	s
T	Temperature	K
V	Vapour molar flow rate	mol/s
W	Catalyst weight	kg
x	Liquid composition	-
y	Vapour composition	-
z	Feed composition	-
Greek letters		
δ	Parameter for reaction occurrence on stage j (0 or 1)	-
ϕ	Fugacity coefficient	-
γ	Activity coefficient	-
Subscripts		
i	Component number	
j	Stage number	
Superscripts		
c	Total number of components	
List of abbreviations		
EQ	Equilibrium model	
MeOH	Methanol	
MTBE	Methyl tert-butyl ether	
NEQ	Non-equilibrium model	
RD	Reactive distillation	

Chapter 1: Introduction

1.1 Motivation and statement of problem

RD technology has brought many advantages in chemical production, these include heat integration, elimination of azeotropes, 100% conversion of reactants with suppression of side products and lower capital cost. Although not all the chemical manufacturing are suitable by using RD, there are still a lot opportunity in application of RD technology in chemical industries. The production of MTBE is one of chemical processes can be fully benefited from RD technology.

The equation oriented modelling of RD has been done by many researchers by using different modelling environments, these include Matlab, FORTRAN and so on. Modelling of complex models will be time consuming process and it requires a lot of efforts especially to correct the errors during the coding. Besides that, modelling using of Matlab will experience the problem of readability since it is written based on its own programming language. Hence, it tends to cause modelling process to be difficult and frustrating. Other tools for the solution of models will be AspenPlus. Although the simulation can be done easily by using AspenPlus, it lacks in transparency of equations systems involved and it will never meet the requirement when a customized model is needed.

MOSAIC is a new modelling environment and it brings the new modelling approach. It is designed for minimization of modelling errors, minimization of programming effort, avoidance of errors and effort in documentation and encouragement of cooperative work. Some of the key features of MOSAIC are modelling in the documentation level, reuse of model elements, code generation for other modelling environments and centralized cooperation on internet. Furthermore, just like Matlab, it is designed to build a customized model as well. (Kuntsche et al., 2011)

1.2 Objective and Scopes

The objective of the research is to

- Explore the modelling of RD for MTBE production by using MOSAIC

1.3 The scopes of the research are

- Modelling of equilibrium(EQ) model of RD by using MOSAIC based on the given parameters of MTBE production
- Validation of the modelled RD with results from literature.
- Comparison between MOSAIC and other modelling environments.

Chapter 2: Literature Review

2.1 Reactive Distillation Column

2.1.1. General Introduction of RD

Although reactive distillation column (RD) was invented in 1921, the industrial application is only started to after 1980's. (Agreda, Partin, & Heise, 1990) RD consists of both reactor and distillation column under a single vessel. It have brought many advantages to chemical production especially for its high conversion and selectivity. Production of MTBE is one of chemicals that can be fully benefited from RD technology. However, not all the chemical production are suitable to use RD in manufacturing.

The introduction of in-situ reaction with distillation in a single vessel leads to the complex interactions between vapour- liquid equilibrium, vapour-liquid mass transfer, intra-catalyst diffusion (for heterogeneously catalysed process) and chemical kinetics. (Taylor & Krishna, 2000) This makes the design of these systems to be difficult.

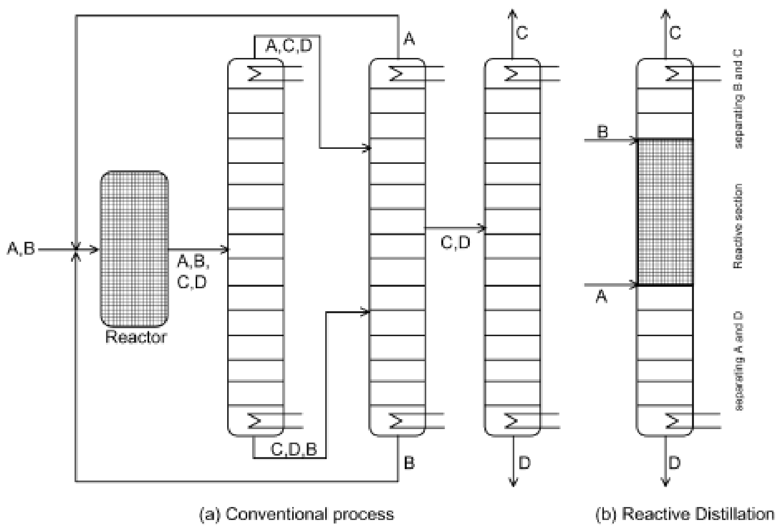

Figure 1:(a) Typical configuration of a conventional process consisting of a reactor followed by a distillation train. (b) The reactive distillation configuration. (Stichlmair & Frey, 1999)

From the Fig. 1(a), it shows the traditional method of chemical synthesis where the chemical reaction occurs in reactor and then the products are separated by distillation train. If the azeotropes are formed by the products, it will cause the separation of chemical components to be difficult and the distillation train will far more complicated than one shown in the figure above.

From the Fig. 1(b), the RD column consists of a reactive section in the middle with nonreactive rectifying and stripping sections at the top and bottom. For a properly designed RD column, virtually 100% conversion can be achieved. (Taylor & Krishna, 2000)

2.1.2. The advantages of RD

The RD is quite beneficial especially for the exothermic reaction. MTBE production is one of the exothermic reaction. The heat integration allows fully taking advantage of heat energy released from the chemical reaction. The heat released will be used in vaporization and reduce the duty of the reboiler. This will further decrease the risk of runaway reaction.

In addition, the formation of azeotropes can be avoided in RD. For the case of MTBE, by using traditional method where the reactor followed by distillation columns, extra 10% of methanol is required to feed into the reactor in order to reduce the mainly isobutylene dimmers by-product formation. (Elkanzi, 1996) The MTBE produced forms the azeotropes with the methanol and isobutylene. The reactant mixture leaving the reactor forms three minimum azeotropes (Taylor & Krishna, 2000) and it causes the separation of the mixture to be difficult. However, with the RD concept, it allows some of the azeotropes just “reacting away”. (Doherty & Buzad, 1992)

Moreover, the conversion of reactants can nearly achieve 100% with the suppression of the side reactions in RD. Thus, the selectivity of product is high. The limitation of chemical equilibrium can be overcome by RD by removing the product from reacting mixture. Therefore, the complete conversion can be achieved with the shifting of equilibrium to the right. For the case of MTBE, nearly 100% of conversion of isobutylene and methanol can be achieved along with suppression of the formation of the unwanted dimethyl ether by using RD. (Sundmacher, 1995)

Furthermore, the capital cost of RD in industrial production is lower than conventional method. The high number of required distillation columns can be avoided by using RD. The reduction of required pumps, instruments and piping also further decrease the capital cost. (Mohammed, 2009)

2.1.3. The constraints of RD

Although RD is a new technology and brings many advantages to the production of MTBE, not all the chemicals manufacturing are suitable by using RD. There are few constraints of RD. (Towler & Frey, 2002) The constraints could be the reactants and products may not have suitable volatility to maintain high concentration of reactants and low concentration of products in the reaction zone. Moreover, if the residence time is too long, a large column size and large tray hold-ups will be needed. Therefore, it may be more economical to use conventional method of reactor followed by distillation columns. Besides that, the optimum temperature and pressure of the reaction may not suitable under the optimal conditions of distillation. Furthermore, scale up to large flow rate is not suitable by using RD due to liquid distribution problems in packed RD columns.

2.2 MTBE

2.2.1. Background of MTBE production

In 1998, the worldwide production MTBE had achieved its records high with 6.6 billion gallons annually (Ahmed, 2001), with the US occupied the large portion of it, around 4.3 billion gallons per year. Besides that, MTBE was considered as one of the top 50 chemicals produced in the world. (WHO, 1998) However, the use of MTBE in US as gasoline additive gradually replaced by the ethanol, as the legislation favouring the ethanol. This is due the underground water and soil contamination caused by MTBE. (EIA, 2003b) It is estimated to cost 1 billion to 30 billion dollars to clean the aquifers and municipal water supplies and replacing leaky underground oil tanks. (Napoli, 2004) Nevertheless, the demand of MTBE is still growing in Asia as ethanol is less subject to subsidies.

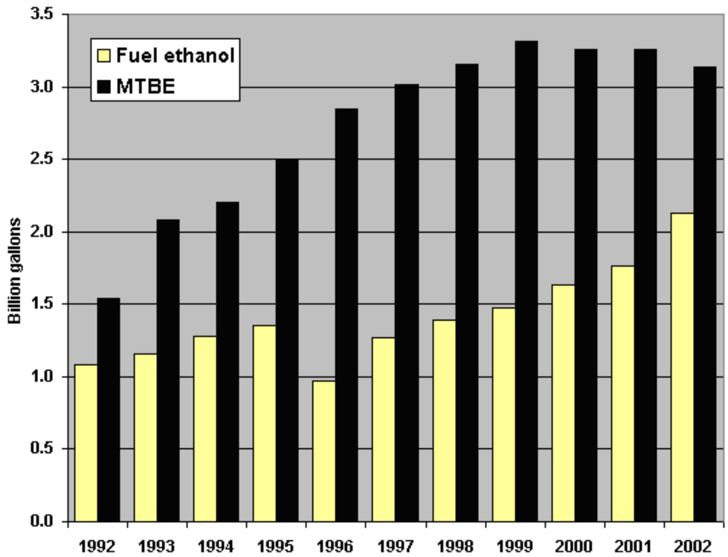

Figure 2: The bar chart shows the MTBE & ethanol production from 1992 until 2002 in US (EIA, 2003a)

Despite legislation of US in many states gradually phase out the use of MTBE as gasoline addictive, worldwide MTBE production is still remains constant due to the growth in Asian markets. The information from GIA shows that global market MTBE is expected to reach 19.2 million tons by the year 2017, this is driven primarily by the increased demand from developing countries such as Asia, particularly China, Middle East, and Latin America. The increasing automobile ownership in these countries and use of MTBE as an additive to improve quality of gasoline is expected to fuel consumption of MTBE. (GIA, 2011)

2.2.2. MTBE as Gasoline Additive

MTBE is widely used as the oxygenated compound in gasoline. The high oxygen content of MTBE will help in the complete combustion of the gasoline. In other words, with the sufficient amount of oxygen, the incomplete combustion of gasoline can be avoided and the released of carbon monoxide also can be eliminated. Besides that, another function of MTBE in gasoline is to increase the octane number of gasoline. MTBE is widely used as anti-knocking agent in gasoline to replace tetraethyl lead as gasoline additive.(Marceglia & Oriani, 1982) This is due to the environmental and health concerns of poisonous gas, lead and lead oxide which are released on combustion.

Other properties of MTBE such as low sulphur content, acceptable blending vapour pressure, high miscibility in gasoline, moderate boiling point, and stability in storage and lower cost compared to those of other high-octane components, made it the attractive choice as gasoline addictive. (Ziyang, Hidajat, & Ray, 2001)

2.2.3. MTBE Synthesis

Traditionally, the MTBE is produced by the reaction between the methanol and isobutylene using the acid ionic exchange resins in fixed bed reactor at the operating temperature between 313 and 353 K and under the pressure of 200 psig in order to maintain the reaction in liquid phase. The reaction is reversible and exothermic. (Ziyang et al., 2001) The chemical reaction can be shown as below:

$$(CH_3)_2CCH_2 + CH_3OH \Leftrightarrow (CH_3)_3COCH_3 \quad \Delta H = -37.3 kJ/mol$$

Normally, sulfonated acidic ion-exchange resin such as Lewatit SPC 118, Amberlyst 15 or Purolite CT-115 are used as catalyst in the reaction. (Ziyang et al., 2001) The isobutene can be taken from C4 streams of catalytic cracking processes for gasoline production and of ethylene manufacture. While the methanol is extensively produced by number of firms from inexpensive natural gas and other carbon sources. (Mitani, Keller, Bunton, Rinker, & Sandall, 2002)

2.3 Equilibrium Model of RD

2.3.1. RD Models

There are several models in designing of RD. (Richard Baur, 2000) They are listed as follows:

1. Steady-state equilibrium (EQ) stage model
2. Dynamic EQ stage model
3. Steady-state EQ stage model with stage efficiencies
4. Dynamic EQ stage model with stage efficiencies
5. Steady-state non-equilibrium (NEQ) stage model, where the interphase mass transfer is described by rigorous Maxwell-Stefan diffusion equations
6. Dynamic NEQ stage model
7. Steady-state NEQ cell model, developed by Higler (1999), in order to account for staging of the vapour and liquid phases during cross-current contacting on a distillation tray

In this study, modelling of RD by using MOSAIC will be based on steady state EQ model. In equilibrium (EQ) stage model, the vapour and liquid phases are assumed to be in thermodynamic equilibrium. (R Baur, Higler, Taylor, & Krishna, 2000)

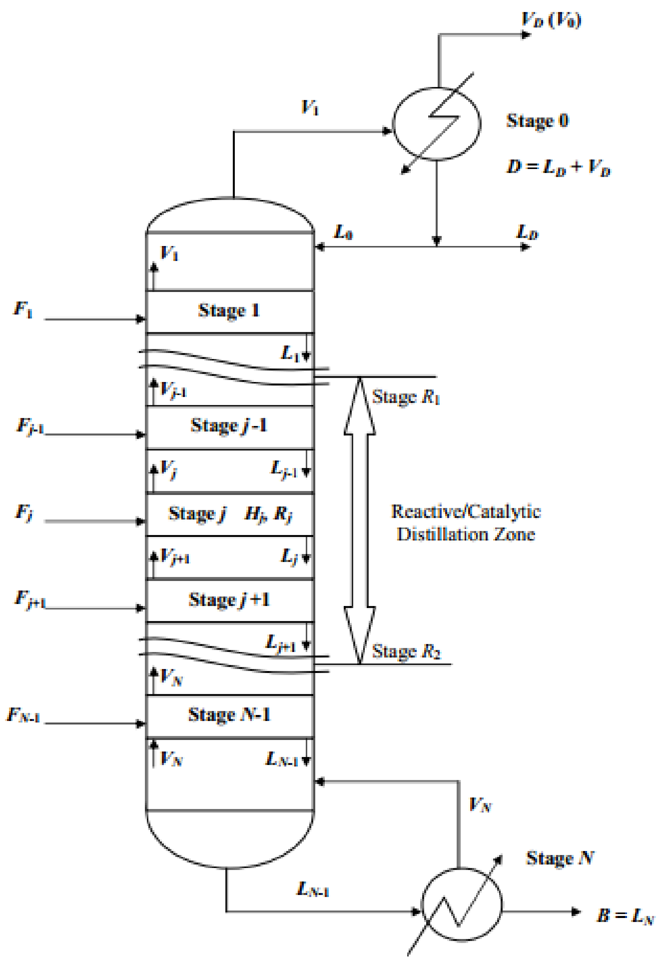

Figure 3: Schematic Representation of a Reactive Distillation Columns (Murat, Mohamed, & Bhatia, 2003)

2.3.2. Mathematical Modelling of EQ Model

The first step of modelling begins with mathematical modelling by formulation of equations to describe processes occurring in RD at the steady state. These formulated equations or just MESH equations will be required in finding solution of the model. The letters of MESH stand for material balance equations, phase equilibrium equations, summation equations and heat balance equations. The MESH equations shown below are modified from work of Murat et al. (2003).

Material balance equations

The material balance of every stages of RD can be represented by equation as follow:

Overall material balance

$$\frac{dM_j}{dt} = F_j - L_j - V_j + V_{j+1} + L_{j-1} + \delta_j R_j$$

Components material balance

$$\frac{dM_j x_{j,i}}{dt} = F_j z_{j,i} - L_j x_{j,i} - V_j y_{j,i} + V_{j+1} y_{j+1,i} + L_{j-1} x_{j-1,i} + \delta_j \sum_{r=1}^{R} \left(v_{i,r} r_{j,r}\right)$$

Since the model is assumed as steady state, and thus the derivative of material balance will be equal zero. Both j and i are subscripts to represent the stages numbers and components respectively. F represents feed flow rate, L represents liquid flow rate then V will represent vapour flow rate. x and y are the mole fraction of liquid and vapour respectively.

Furthermore, for integrated reactive part of equation, r represents the reaction rate and v represents the stoichiometry of chemical components. The value of δ will be either 0 or 1 to decide whether reaction occurring at the stages or not.

Phase equilibrium equations

$$y = \frac{\gamma P^o x}{\phi P}$$

Phase equilibrium relation equation describes the relationship between liquid mole fraction and vapour mole fraction of chemical components when vapour and liquid at equilibrium state. For the ideal condition, the value of activity coefficient, γ and fugacity, ϕ will be equal to 1. Saturated vapour pressure, P^o can be calculated using of Antoine equation and P is pressure of reactive distillation column.

Summation equations

$$\sum_{i}^{c} x_{j,i} = 1.0 \qquad \text{(Liquid phase)}$$

$$\sum_{i}^{c} y_{j,i} = 1.0 \qquad \text{(Vapour phase)}$$

From the summation equation, it states that sum of mole fraction of each components in liquid phase and vapour phase of each stages will be equal to 1.

Enthalpy balance equations.

The energy balance of each stages of RD can be described by equation as follow

$$\frac{dH_j}{dt} = F_j H^F + L_{j-1} H_{j-1}^L + V_{j+1} H_{j+1}^V - V_j H_j^V - \delta_j \sum_{r=1}^{R} \left(\Delta H_{j,r}^R \right) r_{j,r}$$

Again, for the steady state, the derivative of energy balance will be equal to zero. For the reactive part of the equation, ΔH is enthalpy change of chemical reaction, r is the rate of reaction and δ will decide whether the reaction taking place at each stages or not. For the case RD modelling for MTBE production, it assumes only a single reaction, and thus the summation of enthalpy change can be ignored.

2.4 *Kinetics model of MTBE Production*

For the production of MTBE, the kinetics model is obtained from work of Rehfinger and Hoffmann (1990) . The activity based rate model is shown as follow:

$$r_j = Wqk_f \left(\frac{a_i^{IB}}{a_i^{MeOH}} - \frac{a_i^{MTBE}}{K_{eq} a_i^{2\,MeOH}} \right)$$

where

$$a_i = \gamma_i x_i$$

$$k_f = 3.67 \times 10^{12} \exp(-\frac{11110}{T})$$

$$K_{eq} = 284 \exp[f(T)]$$

$$f(T) = A_1\left(\frac{1}{T} - \frac{1}{T_0}\right) + A_2 \ln\left(\frac{T}{T_0}\right) + A_3(T - T_0) + A_4\left(T_2 - T_0^2\right) + A_5\left(T^3 - T_0^3\right)A_6\left(T^4 - T_0^4\right)$$

T_0 = 298.15 K

A_1 = - 1.49277×10^3 K

A_2 = - 77.4002

A_3 = 0.507563 K^{-1}

A_4 = 9.12739×10^{-4} K^{-2}

A_5 = 1.10649×10^{-6} K^{-3}

A_6 = - 6.27996×10^{-10} K^{-4}

From the equation, W is weight of catalyst of each stages. q is the amount of acid groups on the resin per unit mass with value of 4.9 equiv/kg. The activity of each components is the product of its activity coefficient and liquid mole fraction. k_f is reaction rate constant and K_{eq} is equilibrium constant.

2.5 MOSAIC

2.5.1. Introduction of MOSAIC

MOSAIC is a web-based modelling software which brings the new modelling approach. It makes the modelling possible without knowing the programming language of modelling. It is designed for minimization of modelling errors, minimization of programming effort, avoidance of errors and effort in documentation and encouragement of cooperative work. (Kuntsche et al., 2011)

2.5.2. 4 Main Features of MOSAIC

One of the important features of MOSAIC is modelling at the documentation level. It means that MOSAIC can make the modelling at documentation level without any paperwork. The equations can be documented easily by MOSAIC using Latex documentary language. By using Latex, the documented equations have the same readability as documentation level. In addition, modelling can be done by MOSAIC even without knowing of modelling programming languages.

Besides that, MOSAIC is also designed for reuse of model elements effectively. In MOSAIC, modelling is done by creating of objects separately. These objects include notation object, equation objects, function objects, equation system object, evaluation object and parameter object. Each objects can be reused by another models. Thus, it will reduce the effort of modelling.

The next important features of MOSAIC is code generation for other modelling environments. MOSAIC itself can be a code generator and solver. However, MOSAIC is not designed to be a full solver as complicated models cannot solved by using MOSAIC. MOSAIC has more complete support of code generation for other modelling environments.

Moreover, MOSAIC also has the feature of centralized cooperation on internet. It allows users to share their models easily. The shared model can be read or write by another user on internet.

2.6 Summary

By introduction of RD technology in chemical industries, it brings numerous advantages by comparing with traditional chemical synthesis method. MTBE production is one of the chemical synthesis that can be fully benefited from RD technology. Those advantages include heat integration, elimination of azeotropes, 100% conversion of reactant with suppression of side products and the lower capital cost.

For the next chapter, procedure of modelling using MOSAIC based on the given parameters of MTBE production will be discussed.

Chapter 3: Methodology

3.1 Conditions of MTBE Production using RD

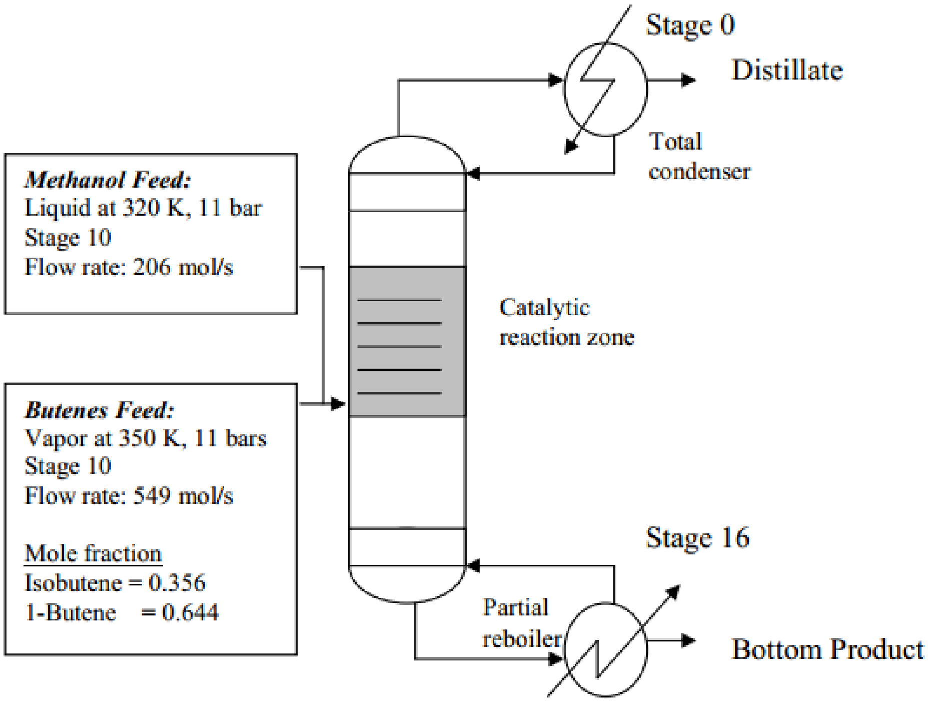

Figure 4: Column Configuration and Feed Specifications for MTBE synthesis (Murat et al., 2003)

3.1.1. Assumptions of Modelling

In this modelling, it was assumed that MTBE synthesis system only consists of main components, namely methanol, isobutylene, MTBE, and n-butene. However, in the actual situation, there are totally a minimum of 12 components with reactive components of methanol, isobutene and MTBE involve in the MTBE synthesis. Moreover, the inert C4 components can be assumed to be represented by n-butene since they have quite similar physical and chemical properties. The small quantities of by-products can be regarded as negligible.

3.1.2. Conditions of MTBE Synthesis

It is assumed that the production rate of MTBE to be 197 mol/s or 500,000 metric tons/year. 6400 kg of catalyst is used for 8 reactive trays with amount of 800kg catalyst each reactive tray. The reactive trays are located in the middle of column from the stage 3 until stage 10. There are totally 17 stages with condenser as stage 0 and partial reboiler as stage 16. The operating pressure is 11 bar or 10.87 atm. The reflux ratio is set to 7. There are two feed streams, methanol feed stream and mixed butenes feed stream with a small stoichiometric excess of methanol. (Nijhuis, Kerkhof, & Mak, 1993)

The feed synthesis specifications, column configuration and operating conditions for MTBE synthesis are summarized in the table below:

Table 1: The feed specifications of methanol and butenes & operating conditions for MTBE synthesis (Nijhuis et al., 1993)

Feed Streams	Methanol	Butenes	Units
Feed rate	206	549	mol/s
Phase	Liquid	Vapour	
Temperature	320	350	K
Pressure	11	11	bar
Feed stage	10	10	
x^{MeOH}	1.0	0.000	
x^{IB}	0.0	0.356	
$x^{n\text{-}butene}$	0.0	0.644	
Number of Stages, N	17		
Column Pressure, P	11		bar
Catalyst Weight, W	6400		kg
Reflux Ratio, r	7		
Bottom Flow, B	197		mol/s

3.2 Procedure of RD Modelling using MOSAIC

The process of RD modelling by using MOSAIC can be summarized by flowchart as shown below:

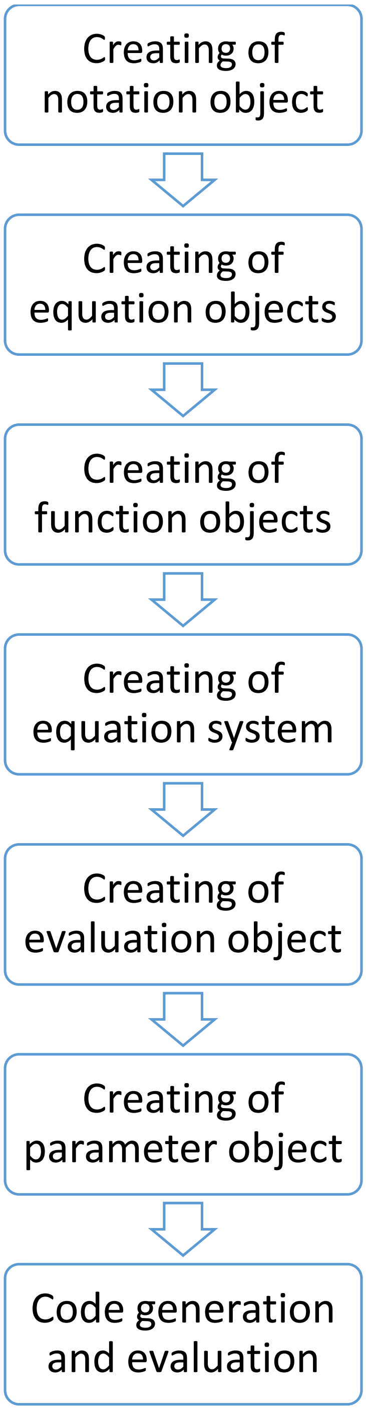

Figure 5: Procedure of modelling using MOSAIC

Step 1: Creating of notation

The symbols with description are created in notation to represent the variables of equations. Each variables can be represented by base name alone or together with subscripts and superscripts. By introducing of subscripts and superscripts, it allows two or more variables to have similar base name. Besides the creating of symbols for each variables, the indices required for modelling are created as well in notation. (Refer to **Appendix: I** for complete list of notation)

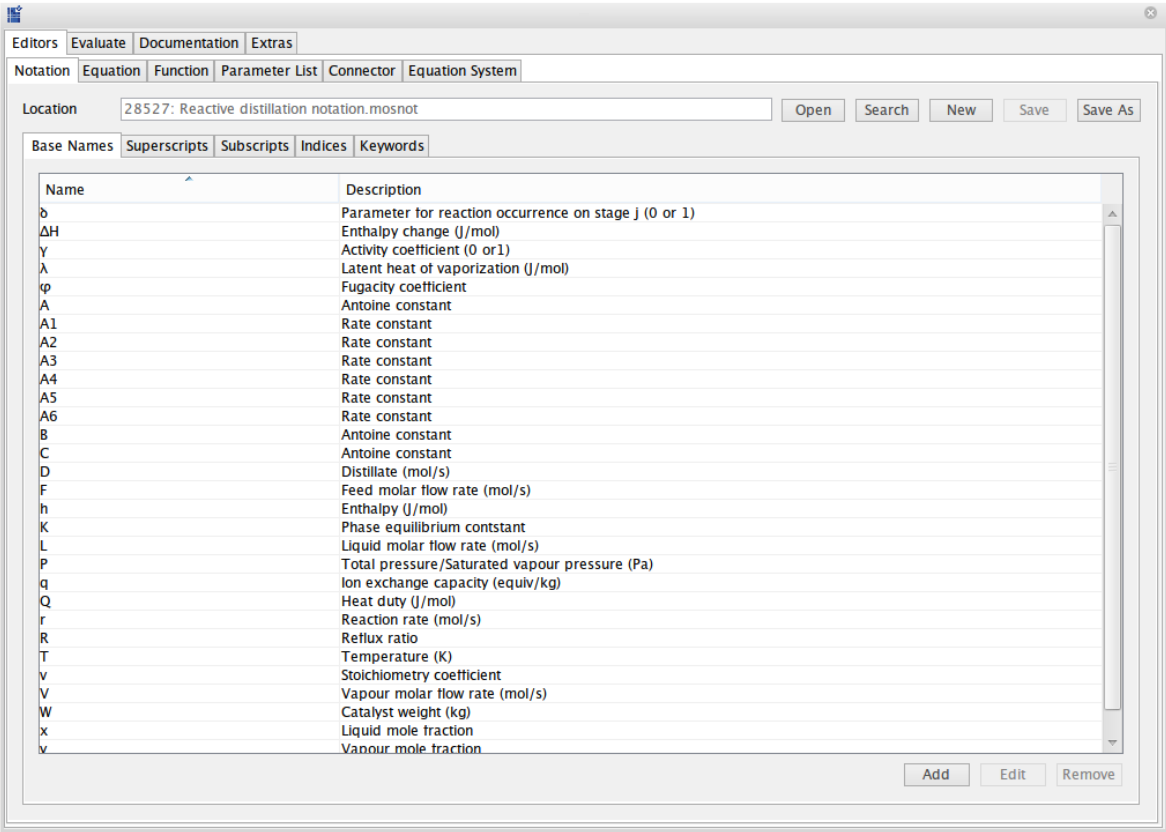

Figure 6: Creating of notation

Step 2: Creating of equation objects

The modelling equations can created by using of Latex. Latex is a documentary language which allows equations to be expressed in documentation level. (Refer to **Appendix: II** for complete list of equations)

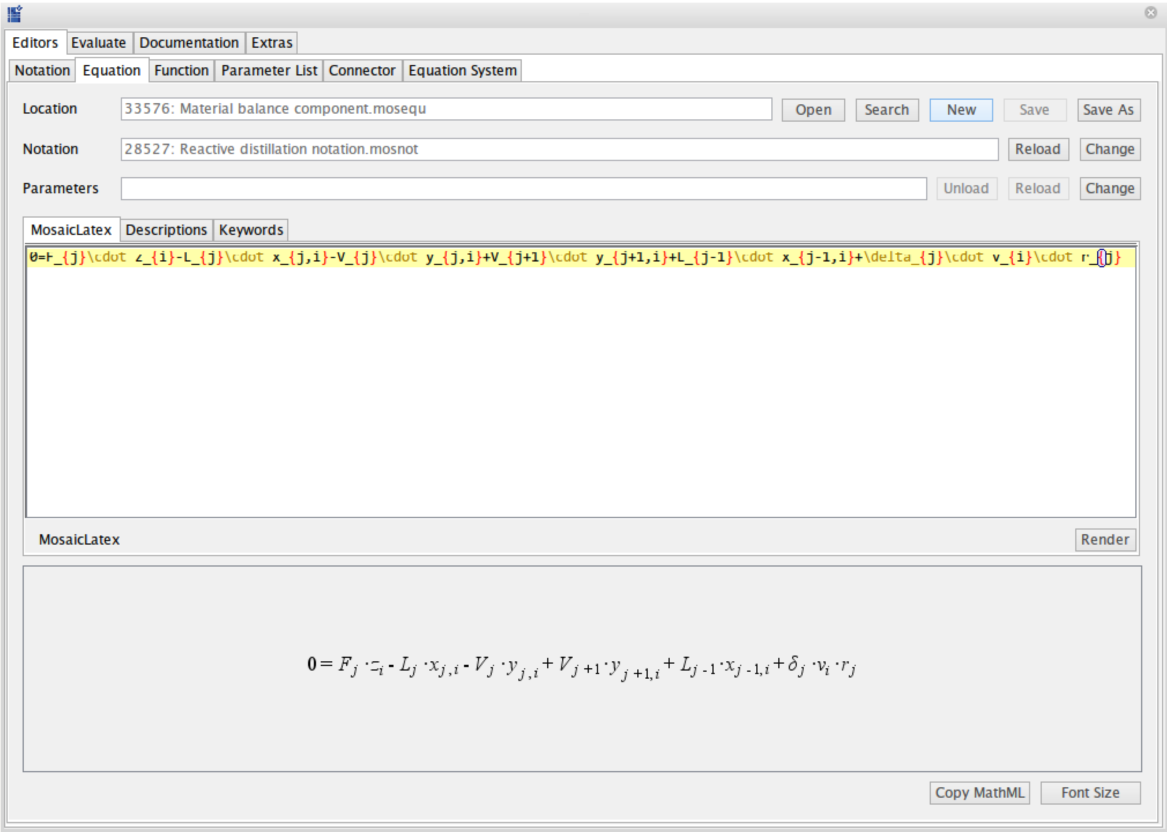

Figure 7: Creating of equations

Step 3: Creating of functions objects

Almost same as creating of equation objects, function objects are created by using Latex as well. However, the method of creating functions are not as simple as creating of equations. It may require creating of parameter list object if involving in parameter set index. Parameter set index allows users to set the index on output variable and parameters. The specification of output variable and input variables will be required. The output variable will be the variable that is calculated while the input variables are almost similar as design variables where the setting of its values will be required. Lastly, the formula which leads to output variable will be written in form Latex. (Refer to **Appendix III** for complete list of functions)

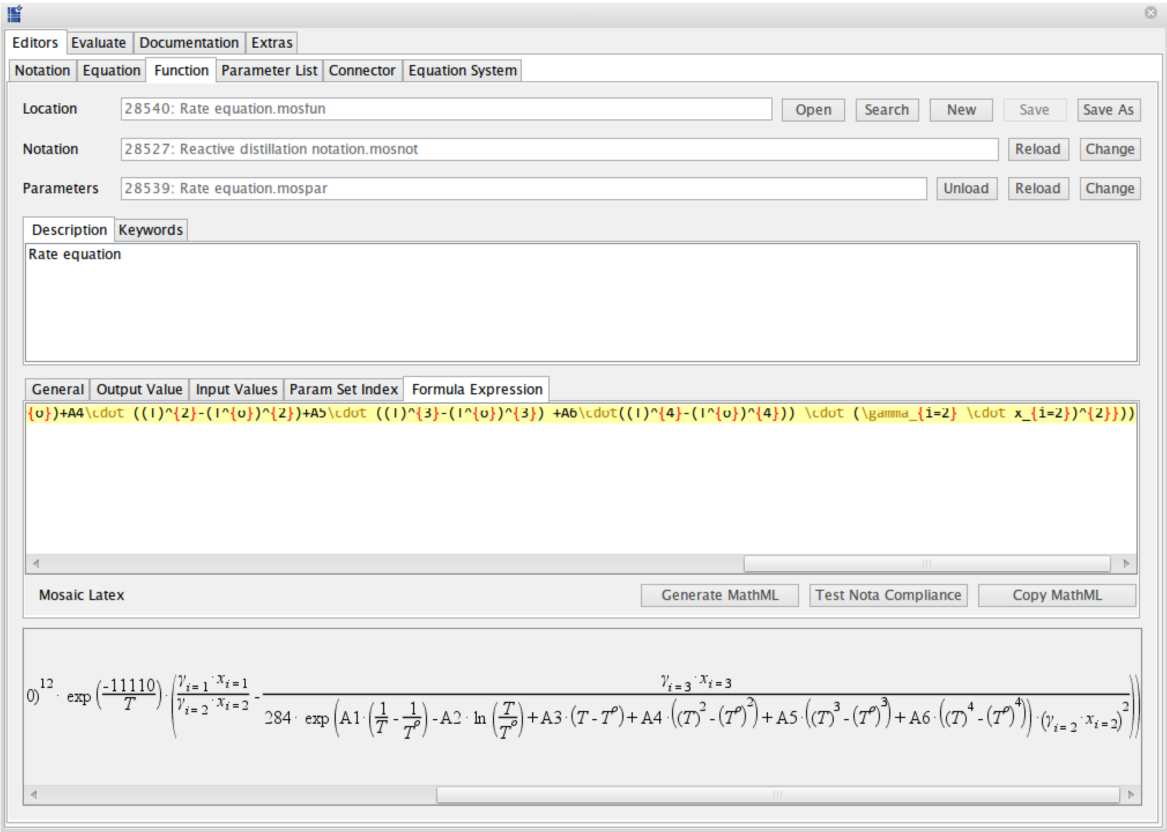

Figure 8: Creating of functions

Step 4: Creating of equation system

All equations and functions of a model are connected by equation system for evaluation. Adding of equations to equation system can be done easily, but for adding of functions, it is required to set the output variables and input variables. Preview of all the added equations and functions in equation system can be made.

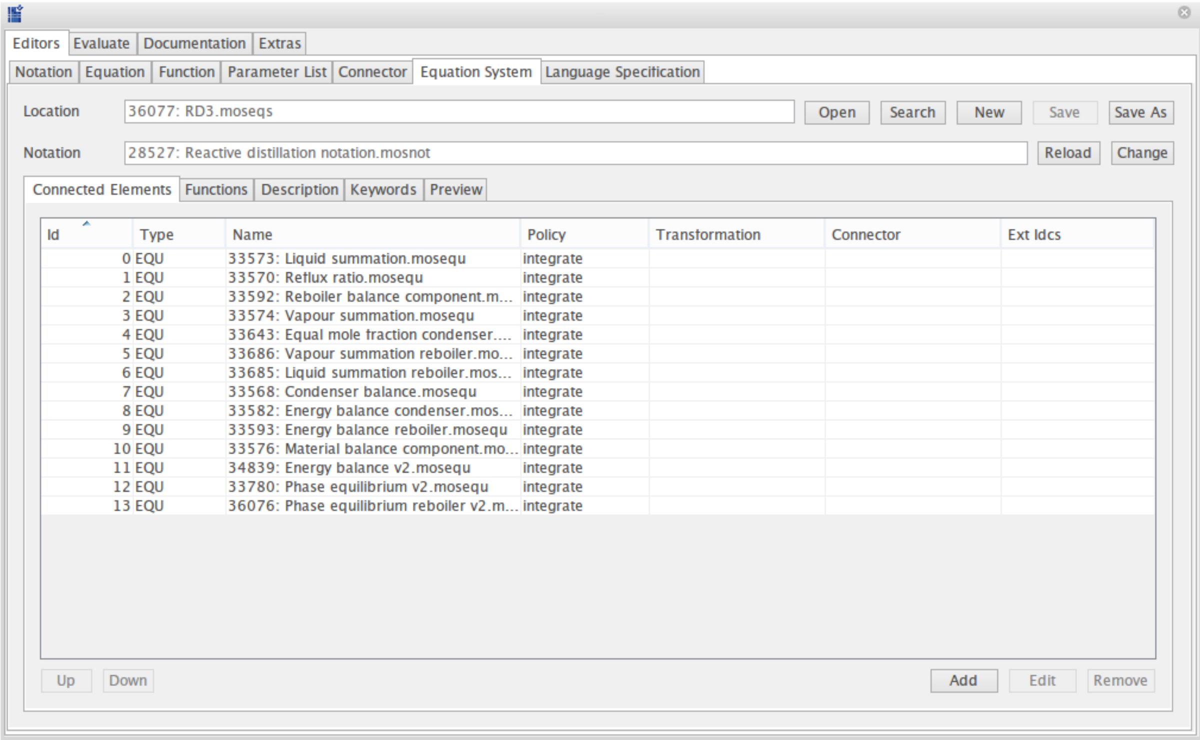

Figure 9: Adding of modelling equations

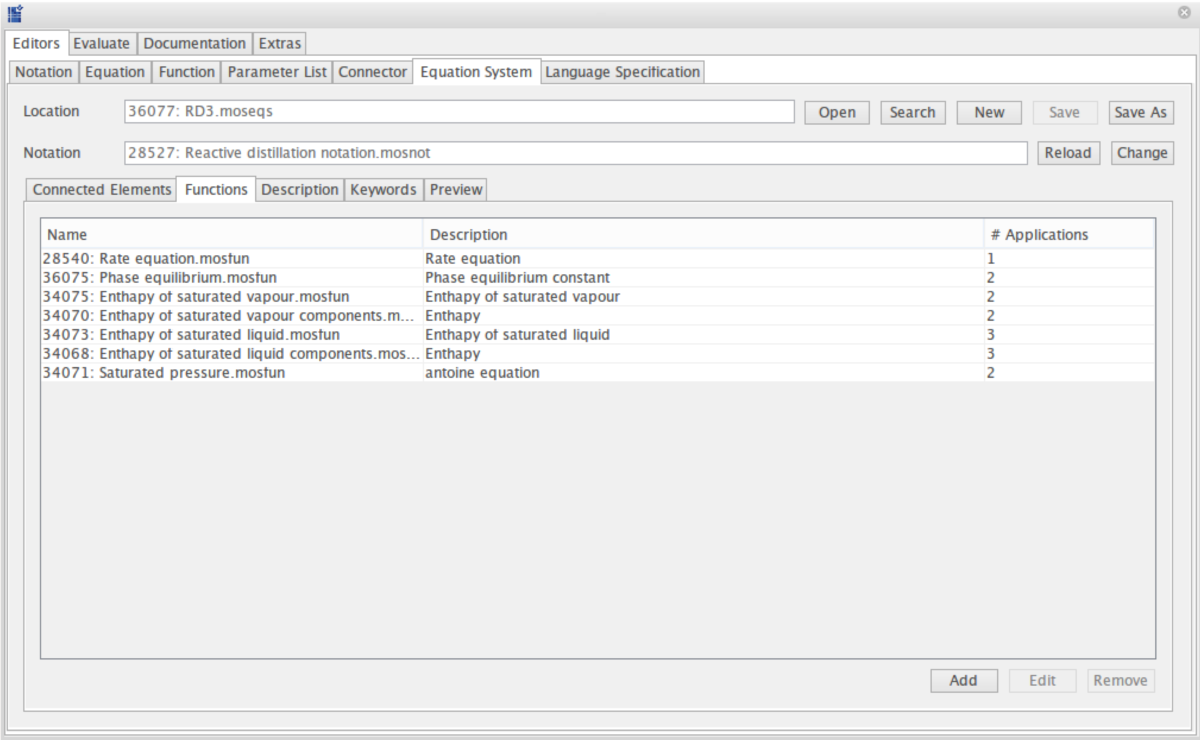

Figure 10: Adding of functions

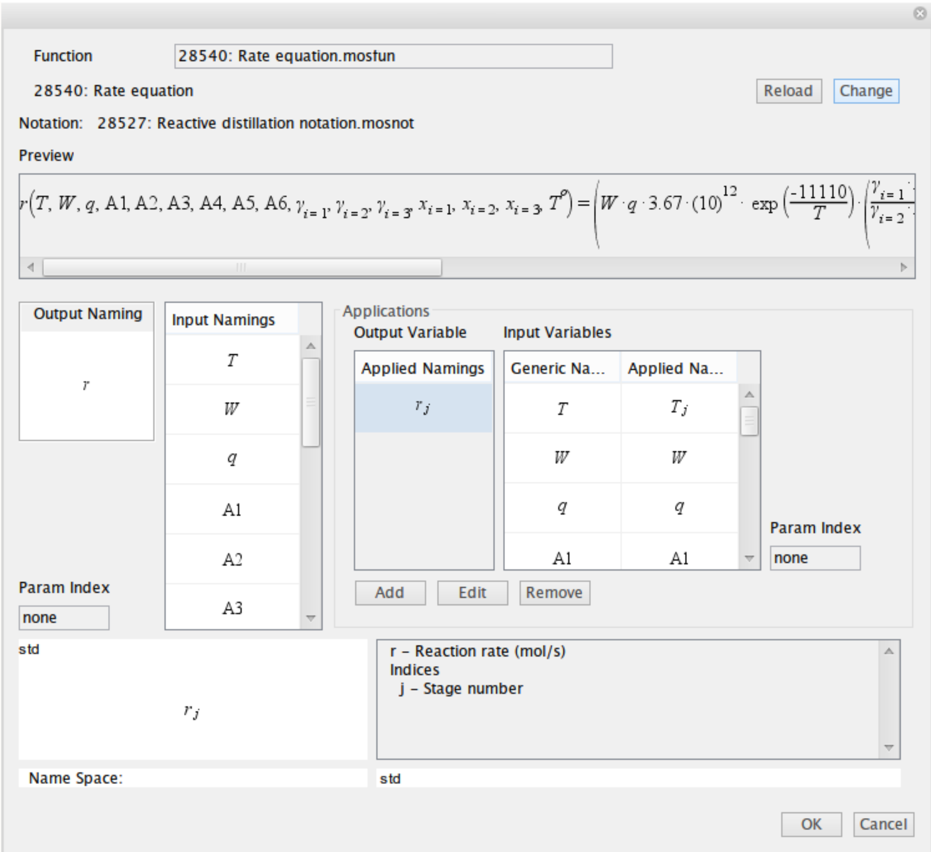

Figure 11: Adding of functions applications

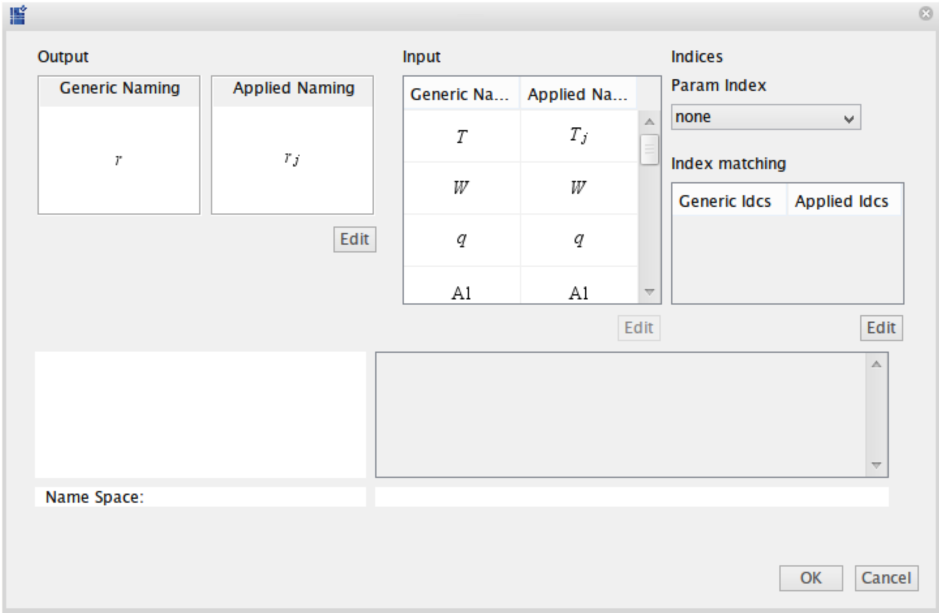

Figure 12: Setting of input variables

Step 5: Creating of evaluation object

In order to create the evaluation object, the equation system first has to be loaded. Once it is loaded, indexing can be made by specifying the max value of each indexes. After indexing, all the equations and functions involved in modelling can be displayed.

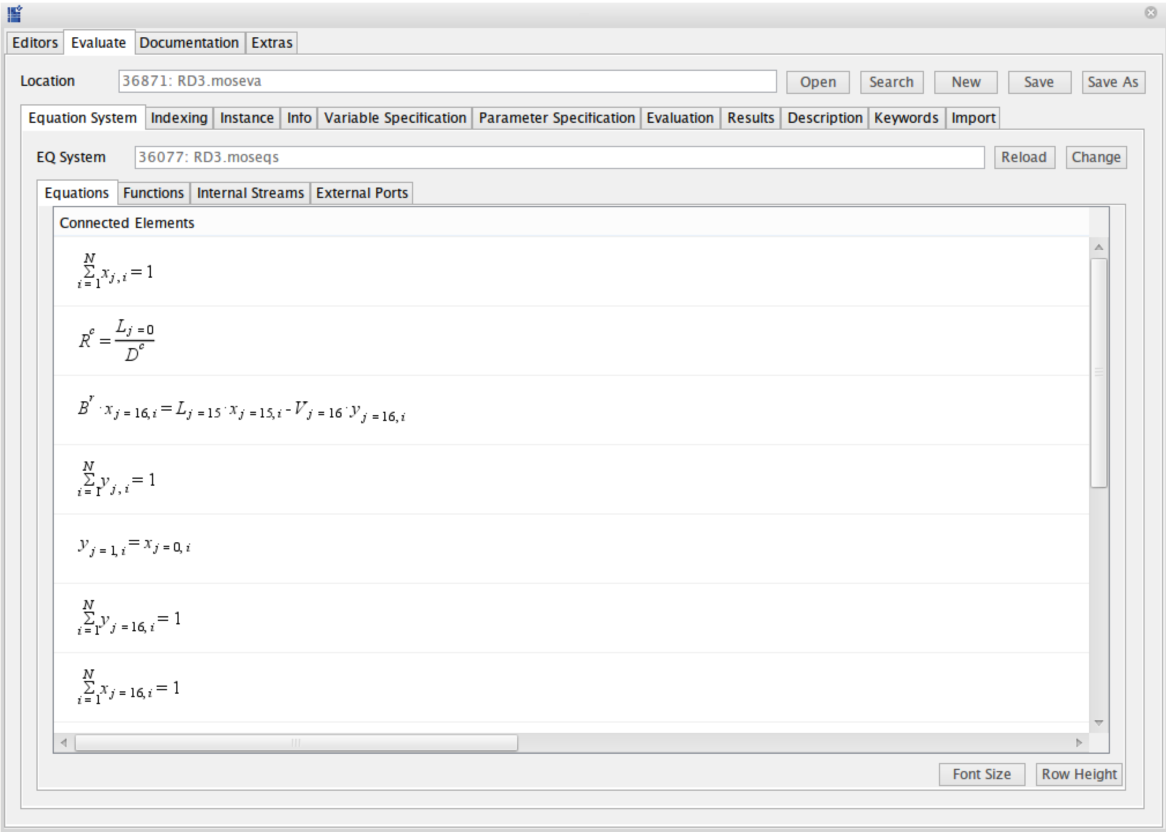

Figure 13: Preview of equation system

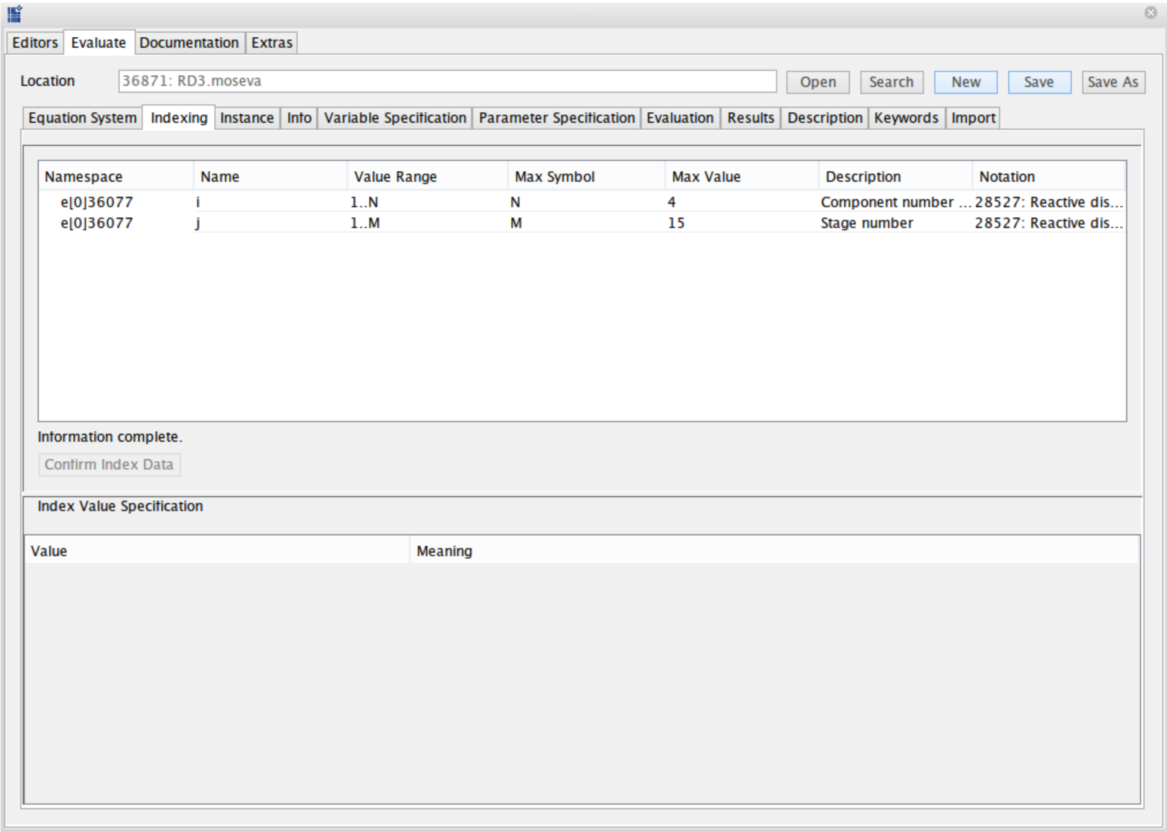

Figure 14: Setting of indexing number

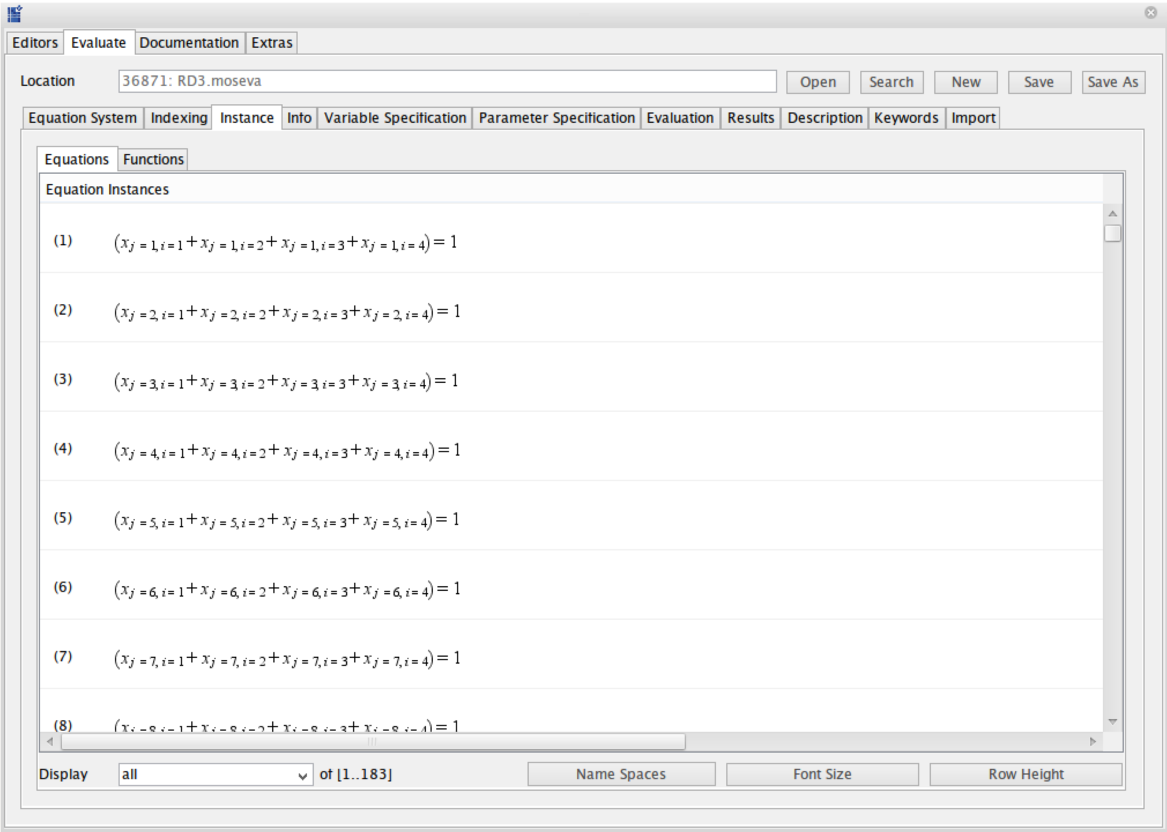

Figure 15: Preview of all modelling equations and functions after indexing

Step 6: Creating of parameter object

Specifications of variables are now ready to be made by assigning the variables as iteration variables or design variables. The degree of freedom will be automatically calculated when assigning of variables. In order to solve the model, degree of freedom must be zero. Once it is done, the value of each design variables is given for calculation. Furthermore, good initial values of iteration variables are important in solving of model. (Refer to **Appendix: IV** for specification of variables)

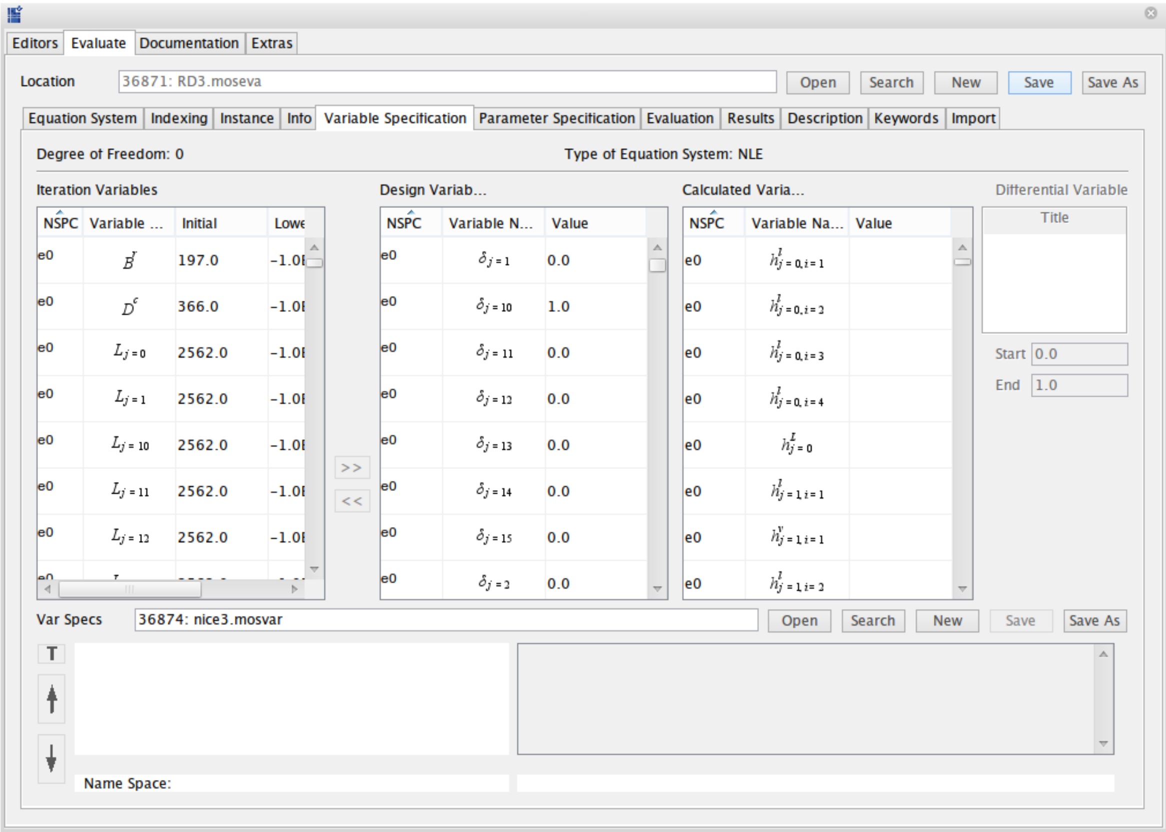

Figure 16: Variable specification

Step 7: Code generation and evaluation

Since MOSAIC is not designed to be full solver, it is not able to solve complex models. Hence, the solving of model can be made by code generation for other modelling environments. The generated codes can be run at their own environment for the solving of model. (Refer to **Appendix: V** for generated code of Matlab)

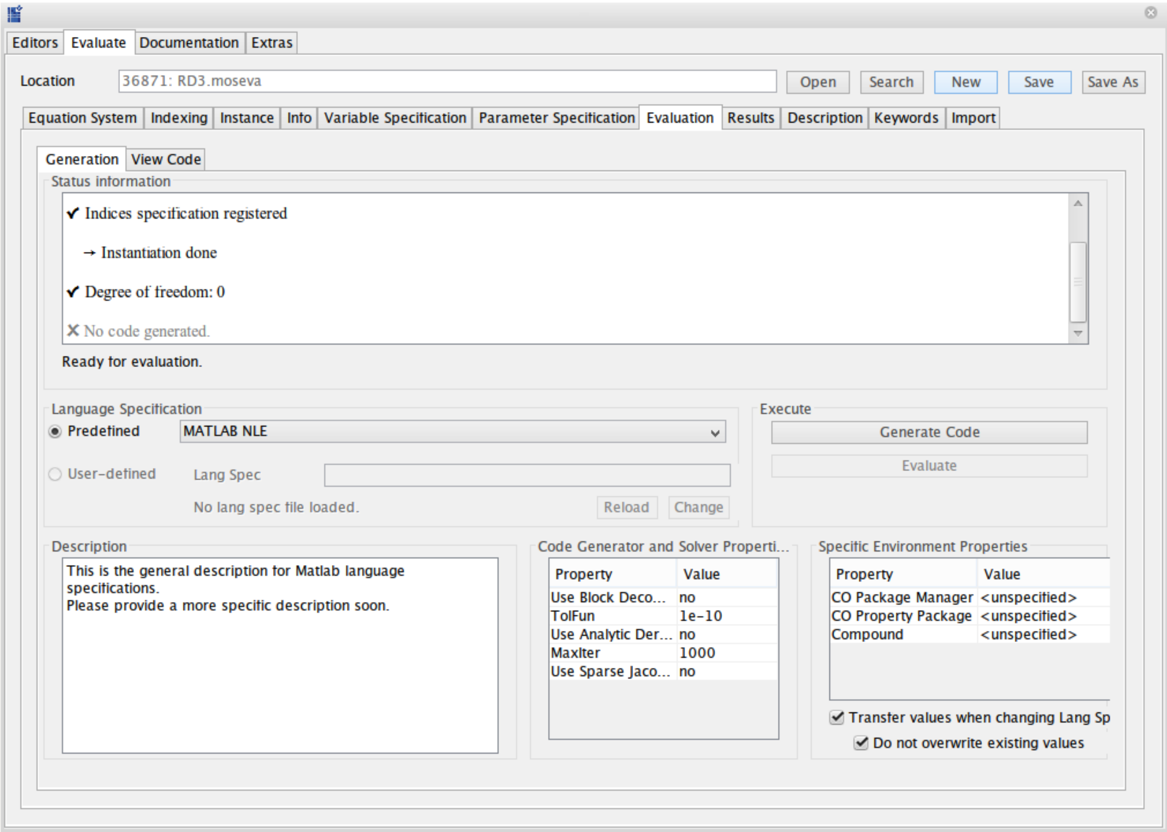

Figure 17: Code generation

Chapter 4: Results and Discussion

4.1 Results & Discussion

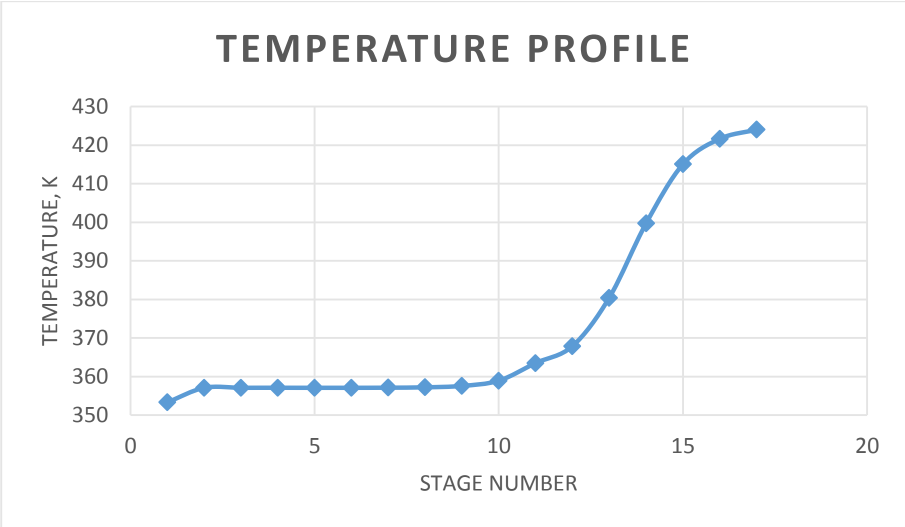

Figure 18: Temperature versus Stage number

From temperature profile, it can be seen that temperature is maintained at around 357K from condenser to feed stage. After the feed stage, the temperature starts to increase rapidly until it achieves the temperature of 424K at reboiler.

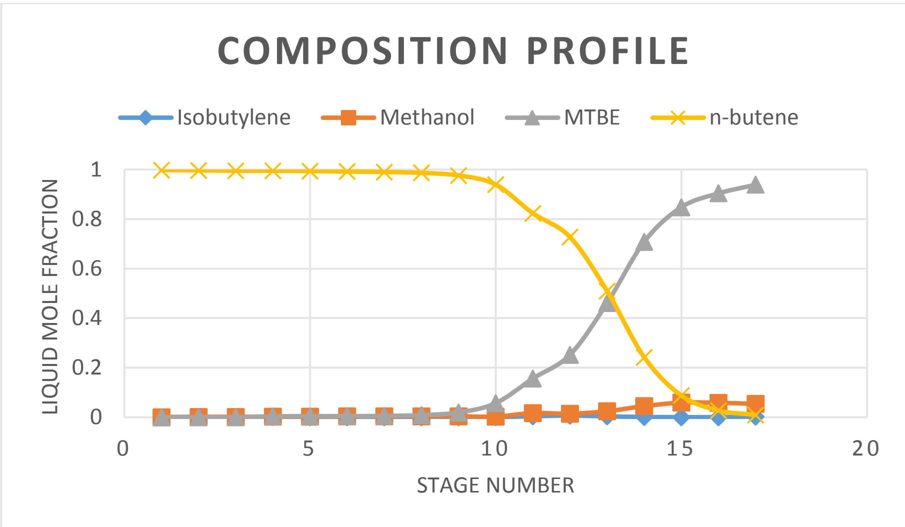

Figure 19: Liquid mole fraction of each components versus Stage number

For composition profile, nearly 100% purity of n-butene and MTBE are achieved at condenser stage and reboiler stage respectively. There is only significant drop of n-butene mole fraction only after feed stage. On the other hand, the mole fraction of MTBE shows increase in significant amount after feed stage.

The temperature of each stages is dependent on composition of each stages. Since the relative high mole fraction of isobutylene from condenser stage to feed stage, the temperature is maintaining at around boiling point of pure isobutylene (350K).

After the feed stages, the mole fraction of MTBE increases rapidly until it reaches nearly 100% purity of MTBE at reboiler stages. Thus, it causes the temperature of each stages to increase instantly until it hits the highest temperature of 424K which is nearly boiling point of pure MTBE.

4.2 Comparison with Expected Results

Table 2: Comparison of results between proposed model and Nijhuist's model

		Nijhuist's model		*Proposed model*	
Quantity	Units	Top	Bottom	Top	Bottom
x_{IB}		0.01	0.00	0.00	0.00
x_{MeOH}		0.04	0.00	0.01	0.05
x_{MTBE}		0.00	0.98	0.00	0.94
$x_{n\text{-}butene}$		0.95	0.02	0.99	0.01
Temperature	K	348	424	353	424
Product flow	mol/s	366	197	350	210
Heat duty	MW	49.7	35.1	48.1	35.1
MTBE purity	%	98		94	
Reflux flow	kmol/s	2.60		2.45	

From the table above, it can be seen that there are no significant differences in results between proposed model and Nijhuist's model, although it is assumed that liquid and vapour phase behave ideally in proposed model.

4.3 Comparison between MOSAIC and other modelling environments

Two Groups of Modelling Software

The software tools for the solution of models basically can be categorized into two group. The first group consists of readily made models with preprogramed equation systems and an appropriate numerical solution algorithm. They can be represented by AspenPlus and CHEMCAD. Solution of the models can be obtained easily, but it lacks in transparency of equations involved. Besides that, these software will never meet requirement whenever customized models are needed.

Second group provided the modelling environment based on their own programming languages. The users are free to define their own equation systems by using these tools. Moreover, these tools are readily for the creation of customized models. The examples of these tools are gProms, Aspen Custom Modeler (ACM), GAMS and Matlab. (Kuntsche et al., 2011)

Table 3: Comparison of MOSAIC with two groups of modelling tools

	MOSAIC	**Equation oriented modelling**	**Sequential approach modelling**	**Notes**
Modelling at documentation level	Available	Not available	-	Modelling by using MOSAIC can be done at documentation level. Since the equations are written in Latex documentary language, it has similar readability as documentation level. In addition, coding is not required for modelling using MOSAIC.
Reuse of model elements	Available	Partially available	-	The reuse of model elements by MOSAIC is more systematic and organized. The users can either reuse the notation, equations, functions and variables settings easily.
Code generation	Available	Not complete	-	Code generation of MOSAIC are much more complete. MOSAIC allows users to generate the code and run their model in many different environments.

Centralised internet database capability	Available	Not available	-	MOSAIC allows users to share their works on internet more easily. The shared work can be viewed or write by the person that users shared to.
Degree of freedom analysis	Available	Not available	-	Degree of freedom analysis can be done automatically by MOSAIC. In order to generate code for evaluation, degree of freedom must be zero. Hence, it is necessary for the model to have correct equations in equation system and all the errors must be corrected.
Error identification	Excellent	Difficult	-	Since modelling by MOSAIC is written in Latex documentary language, it has high readability. Hence, users can identify the errors more easily if they are making mistakes while key in modelling equations. In addition, coding is not required by MOSAIC, hence it results in less errors and less effort required.
Language	Documentary	Programing	-	MOSAIC is using Latex documentary language in writing of modelling equations. Latex has high readability, unlike programming language, it is difficult to read and understand the coding.
Readability	Excellent	Poor	-	Latex documentary language has much higher readability than programming language.
Difficulty	Medium	Hard	Easy	Although without knowledge of coding in modelling, MOSAIC still allows users to do modelling without a doubt. The stages of modelling using MOSAIC are creating of notation, creating of equations, creating of functions, creating of equation system, creating of parameter object and creating of evaluation object. The most difficult part will be creating of functions, however it can overcome easily once users know how it works.
Transparency of model	Excellent	Excellent	Poor	All equations involved in modelling are known for MOSAIC. Besides that, given value of variables also can be determined.
Building of customized model	Capable	Capable	Not capable	MOSAIC is similar to software like Matlab which is designed to build the customized model.

Chapter 5: Conclusion

Modelling by using MOSAIC can be done even without knowing of any modelling programming languages. MOSAIC uses the Latex documentary language in documentation of all modelling equations. Latex is much easier to learn than programming languages. Modelling equations created by using Latex almost have the same readability as documentation level. This is useful for error identification and it makes the modelling at documentation level to be possible.

Besides that, reuse of model elements can be done effectively by using MOSAIC. Since modelling by using MOSAIC is done by creating of objects separately, each objects can be reused by another model. Different models with different settings can be created easily. Thus, it is time saving and reducing the efforts of modelling.

Recommendation

In order to obtain accurate results, it is important to ensure all the errors and mistakes during modelling are corrected. MOSAIC definitely can help to identify the errors and mistakes more effectively. In addition, good initial values of iteration variables are important for solving of the model.

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Appendices

I. Notation of RD Model

Base names:	Description	Units
ΔH	Enthalpy change	J/mol
δ	Parameter for reaction occurrence on stage j (0 or 1)	
γ	Activity coefficient (0 or1)	
λ	Latent heat of vaporization	J/mol
φ	Fugacity coefficient	
A	Antoine constant	
A1	Rate constant	
A2	Rate constant	
A3	Rate constant	
A4	Rate constant	
A5	Rate constant	
A6	Rate constant	
B	Antoine constant	
C	Antoine constant	
D	Distillate	mol/s
F	Feed molar flow rate	mol/s
K	Phase equilibrium contstant	
L	Liquid molar flow rate	mol/s
P	Total pressure/Saturated vapour pressure	Pa
Q	Heat duty	J/mol
R	Reflux ratio	
T	Temperature	K
V	Vapour molar flow rate	mol/s
W	Catalyst weight	kg
h	Enthalpy	J/mol
q	Ion exchange capacity	equiv/kg
r	Reaction rate	mol/s
v	Stoichiometry coefficient	
x	Liquid mole fraction	
y	Vapour mole fraction	
z	Feed composition	

Superscripts:	
F	Feed
L	Liquid
V	Vapour
b	Normal latent heat of vaporization/boiling point
c	Condenser/Critical temperature
l	Component's liquid
o	Saturated / Initial
r	Reboiler
v	Component's vapour

Indices:	
i | maxVal: N	Component number (1=IB, 2=MeOH, 3=MTBE, 4=NB)
j | maxVal: M	Stage number

II. Equations of RD Model

Reflux ratio

$$R^{c}=\frac{L_{j=0}}{D^{c}}$$

MosaicLatex:

R^{c}=\frac{L_{j=0}}{D^{c}}

Equivalent of liquid and vapour mole fraction

$$y_{j=1,i}=x_{j=0,i}$$

MosaicLatex:

y_{j=1,i}=x_{j=0,i}

Phase equilibrium

$$y_{j,i}=K_{j,i}\cdot x_{j,i}$$

MosaicLatex:

y_{j,i}= K_{j,i} \cdot x_{j,i}

Phase equilibrium of reboiler

$$y_{j=16,i}=K_{j=16,i}\cdot x_{j=16,i}$$

MosaicLatex:

y_{j=16,i}=K_{j=16,i} \cdot x_{j=16,i}

Summation of vapour fraction

$$\sum_{i=1}^{N} y_{j,i}=1$$

MosaicLatex:

\sum_{i=1}^{N}{y_{j,i}}=1

Energy balance

$$0 = F_j \cdot h^F + L_{j-1} \cdot h_{j-1}^L + V_{j+1} \cdot h_{j+1}^V - \delta_j \cdot \Delta H \cdot r_j - V_j \cdot h_j^V - L_j \cdot h_j^L$$

MosaicLatex:

0=F_{j}\cdot h^{F}+L_{j-1}\cdot h_{j-1}^{L}+V_{j+1}\cdot h_{j+1}^{V}-\delta_{j}\cdot \Delta H\cdot r_{j}-V_{j}\cdot h_{j}^{V}- L_{j}\cdot h_{j}^{L}

Energy balance of reboiler

$$V_{j=1} \cdot h_{j=1}^V = h_{j=0}^L \cdot \left(L_{j=0} + D^c\right) + Q^c$$

MosaicLatex:

B^{r}\cdot h^{L}_{j=16}=L_{j=15}\cdot h^{L}_{j=15}-V_{j=16}\cdot h^{V}_{j=16}+Q^{r}

Material balance

$$0 = F_j \cdot z_i - L_j \cdot x_{j,i} - V_j \cdot y_{j,i} + V_{j+1} \cdot y_{j+1,i} + L_{j-1} \cdot x_{j-1,i} + \delta_j \cdot v_i \cdot r_j$$

MosaicLatex:

0=F_{j}\cdot z_{i}-L_{j}\cdot x_{j,i}-V_{j}\cdot y_{j,i}+V_{j+1}\cdot y_{j+1,i}+L_{j-1}\cdot x_{j-1,i}+\delta_{j}\cdot v_{i}\cdot r_{j}

Energy balance of condenser

$$V_{j=1} \cdot h_{j=1}^V = h_{j=0}^L \cdot \left(L_{j=0} + D^c\right) + Q^c$$

MosaicLatex:

V_{j=1}\cdot h^{V}_{j=1}=h^{L}_{j=0}\cdot (L_{j=0}+D^{c}) + Q^{c}

Summation of vapour fraction for reboiler

$$\sum_{i=1}^{N} y_{j=16,i} = 1$$

MosaicLatex:

\sum_{i=1}^{N}{y_{j=16,i}}=1

Material balance of reboiler

$$B^r \cdot x_{j=16,i} = L_{j=15} \cdot x_{j=15,i} - V_{j=16} \cdot y_{j=16,i}$$

MosaicLatex:

B^{r}\cdot x_{j=16,i}=L_{j=15}\cdot x_{j=15,i}-V_{j=16}\cdot y_{j=16,i}

Material balance of condenser

$$V_{j=1}=L_{j=0}+D^{c}$$

MosaicLatex:

V_{j=1}=L_{j=0}+D^{c}

Summation of liquid fraction

$$\sum_{i=1}^{N}x_{j,i}=1$$

MosaicLatex:

\sum_{i=1}^{N}{x_{j,i}}=1

Summation of liquid fraction for reboiler

$$\sum_{i=1}^{N}x_{j=16,i}=1$$

MosaicLatex:

\sum_{i=1}^{N}{x_{j=16,i}}=1

III. Functions of RD Model

Functions	Output Value	Input Value	Param Set Index
Rate equation	r	T, W, q, A1, A2, A3, A4, A5, A6, \gamma_{i=1}, \gamma_{i=2}, \gamma_{i=3}, x_{i=1}, x_{i=2}, x_{i=3}, T^{o}	none

$$\left(W \cdot q \cdot 3.67 \cdot (10)^{12} \cdot \exp\left(\frac{-11110}{T}\right) \cdot \left(\frac{\gamma_{i=1} \cdot x_{i=1}}{\gamma_{i=2} \cdot x_{i=2}} - \frac{\gamma_{i=3} \cdot x_{i=3}}{284 \cdot \exp\left(A1 \cdot \left(\frac{1}{T} - \frac{1}{T^{o}}\right) - A2 \cdot \ln\left(\frac{T}{T^{o}}\right) + A3 \cdot (T - T^{o}) + A4 \cdot \left((T)^{2} - (T^{o})^{2}\right) + A5 \cdot \left((T)^{3} - (T^{o})^{3}\right) + A6 \cdot \left((T)^{4} - (T^{o})^{4}\right)\right) \cdot (\gamma_{i=2} \cdot x_{i}}\right.\right.$$

Formula Expression

(W\cdot q\cdot 3.67\cdot (10)^{12}\cdot \exp(\frac{-11110}{T})\cdot(\frac{\gamma_{i=1} \cdot x_{i=1}}{\gamma_{i=2} \cdot x_{i=2}}-\frac{\gamma_{i=3} \cdot x_{i=3}}{284 \cdot \exp(A1\cdot (\frac{1}{T}-\frac{1}{T^{o}})-A2\cdot \ln(\frac{T}{T^{o}})+A3\cdot(T-T^{o})+A4\cdot ((T)^{2}-(T^{o})^{2})+A5\cdot ((T)^{3}-(T^{o})^{3}) +A6\cdot((T)^{4}-(T^{o})^{4})) \cdot (\gamma_{i=2} \cdot x_{i=2})^{2}}))

Applied as

r_{j}=(T_{j},W,q,A1,A2,A3,A4,A5,A6,\gamma_{j,i=1},\gamma_{j,i=2},\gamma_{j,i=3},x_{j,i=1},x_{j,i=2},x_{j,i=3},T^{o})

Functions	Output Value	Input Value	Param Set Index
Phase equilibrium constant	K	\gamma, P^{o}, P, \phi	none

$$\frac{P^{o} \cdot \gamma}{P \cdot \varphi}$$

Formula Expression

\frac{P^{o}\cdot \gamma}{P\cdot ϕ

Applied as

K_{j=16,i}=(\gamma_{j=16,i},P_{j=16,i}^{o},P,\phi)
K_{j,i}=(\gamma_{j,i},P_{j,i}^{o},P,\phi)

Functions	Output Value	Input Value	Param Set Index
Enthapy of saturated vapour	h^{V}	h_{i=1}^{v}, h_{i=3}^{v}, h_{i=2}^{v}, h_{i=4}^{v}, y_{i=1}, y_{i=2}, y_{i=3}, y_{i=4}	none

$$h^{v}_{i=1} \cdot y_{i=1} + h^{v}_{i=2} \cdot y_{i=2} + h^{v}_{i=3} \cdot y_{i=3} + h^{v}_{i=4} \cdot y_{i=4}$$

Formula Expression

h^{v}_{i=1}\cdot y_{i=1}+h^{v}_{i=2}\cdot y_{i=2}+h^{v}_{i=3}\cdot y_{i=3}+h^{v}_{i=4}\cdot y_{i=4}

Applied as

h_{j}^{V}=(h_{j,i=1}^{v},h_{j,i=3}^{v},h_{j,i=2}^{v},h_{j,i=4}^{v},y_{j,i=1},y_{j,i=2},y_{j,i=3},y_{j,i=4})
h_{j=16}^{V}=(h_{j=16,i=1}^{v},h_{j=16,i=3}^{v},h_{j=16,i=2}^{v},h_{j=16,i=4}^{v},y_{j=16,i=1},y_{j=16,i=2},y_{j=16,i=3},y_{j=16,i=4})

Enthapy of saturated vapour for components	h^{v}	T, \lambda^{b}, A^{L}, B^{L}, C^{L}, T^{b}, T^{c}	none

$$\left(A^{L}\cdot T+\frac{B^{L}}{2}\cdot(T)^{2}+\frac{C^{L}}{3}\cdot(T)^{3}\right)-\left(A^{L}\cdot 298+\frac{B^{L}}{2}\cdot(298)^{2}+\frac{C^{L}}{3}\cdot(298)^{3}\right)+\lambda^{b}\cdot\left(\frac{T^{c}-T}{T^{c}-T^{b}}\right)^{0.38}$$

Formula Expression

(A^{L}\cdot T + \frac{B^{L}}{2}\cdot (T)^{2} + \frac{C^{L}}{3}\cdot (T)^{3})-(A^{L}\cdot 298 + \frac{B^{L}}{2}\cdot (298)^{2} + \frac{C^{L}}{3}\cdot (298)^{3})+\lambda^{b} \cdot (\frac{T^{c}-T}{T^{c}-T^{b}})^{0.38}

Applied as

h_{j=16,i}^{v}=(T_{j=16},\lambda_{i}^{b},A_{i}^{L},B_{i}^{L},C_{i}^{L},T_{i}^{b},T_{i}^{c})
h_{j,i}^{v}=(T_{j},\lambda_{i}^{b},A_{i}^{L},B_{i}^{L},C_{i}^{L},T_{i}^{b},T_{i}^{c})

Enthapy of saturated liquid for components	h^{l}	T, C^{L}, B^{L}, A^{L}	none

$$\left(A^{L}\cdot T+\frac{B^{L}}{2}\cdot(T)^{2}+\frac{C^{L}}{3}\cdot(T)^{3}\right)-\left(A^{L}\cdot 298+\frac{B^{L}}{2}\cdot(298)^{2}+\frac{C^{L}}{3}\cdot(298)^{3}\right)$$

Formula Expression

(A^{L}\cdot T + \frac{B^{L}}{2}\cdot (T)^{2} + \frac{C^{L}}{3}\cdot (T)^{3})-(A^{L}\cdot 298 + \frac{B^{L}}{2}\cdot (298)^{2} + \frac{C^{L}}{3}\cdot (298)^{3})

Applied as

h_{j=16,i}^{l}=(T_{j=16},C_{i}^{L},B_{i}^{L},A_{i}^{L})
h_{j=0,i}^{l}=(T_{j=0},C_{i}^{L},B_{i}^{L},A_{i}^{L})
h_{j,i}^{l}=(T_{j},C_{i}^{L},B_{i}^{L},A_{i}^{L})

Enthapy of saturated liquid	h^{L}	h_{i=1}^{l}, h_{i=2}^{l}, h_{i=3}^{l}, h_{i=4}^{l}, x_{i=1}, x_{i=2}, x_{i=3}, x_{i=4}	none

$$:h^{l}_{i=1}\cdot x_{i=1}+h^{l}_{i=2}\cdot x_{i=2}+h^{l}_{i=3}\cdot x_{i=3}+h^{l}_{i=4}\cdot x_{i=4}$$

Formula Expression

h^{l}_{i=1}\cdot x_{i=1}+h^{l}_{i=2}\cdot x_{i=2}+h^{l}_{i=3}\cdot x_{i=3}+h^{l}_{i=4}\cdot x_{i=4}

Applied as

h_{j}^{L}=(h_{j,i=1}^{l},h_{j,i=2}^{l},h_{j,i=3}^{l},h_{j,i=4}^{l},x_{j,i=1},x_{j,i=2},x_{j,i=3},x_{j,i=4})
h_{j=16}^{L}=(h_{j=16,i=1}^{l},h_{j=16,i=2}^{l},h_{j=16,i=3}^{l},h_{j=16,i=4}^{l},x_{j=16,i=1},x_{j=16,i=2},x_{j=16,i=3},x_{j=16,i=4})
h_{j=0}^{L}=(h_{j=0,i=1}^{l},h_{j=0,i=2}^{l},h_{j=0,i=3}^{l},h_{j=0,i=4}^{l},x_{j=0,i=1},x_{j=0,i=2},x_{j=0,i=3},x_{j=0,i=4})

Antoine equation	P^{o}	T, C, B, A	none

$$P^{o}(T, C, B, A) = 100000\cdot\exp\left(A+\frac{B}{T+C}\right)$$

Formula Expression

100000\cdot \exp(A+\frac{B}{T+C})

Applied as

P_{j=16,i}^{o}=(T_{j=16},C_{i},B_{i},A_{i})
P_{j,i}^{o}=(T_{j},C_{i},B_{i},A_{i})

IV. Variable Specification

Iteration variables:	Value	Design variables:	Value
B^{r}	197.0	ΔH	37700.0
D^{c}	366.0	A1	-1492.77
L_{j=0}	2562.0	A2	-77.4002
L_{j=10}	2562.0	A3	0.507563
L_{j=11}	2562.0	A4	-9.12739E-4
L_{j=12}	2562.0	A5	1.10649E-6
L_{j=13}	2562.0	A6	-6.27996E-10
L_{j=14}	2562.0	A_{i=1}^{L}	113.1346
L_{j=15}	2562.0	A_{i=1}	9.132635
L_{j=1}	2562.0	A_{i=2}^{L}	74.86274
L_{j=2}	2562.0	A_{i=2}	11.986965
L_{j=3}	2562.0	A_{i=3}^{L}	162.0418
L_{j=4}	2562.0	A_{i=3}	9.203235
L_{j=5}	2562.0	A_{i=4}^{L}	103.2326
L_{j=6}	2562.0	A_{i=4}	9.382695
L_{j=7}	2562.0	B_{i=1}^{L}	-0.0361507
L_{j=8}	2562.0	B_{i=1}	-2125.74886
L_{j=9}	2562.0	B_{i=2}^{L}	-0.102315
Q^{c}	4.97E7	B_{i=2}	-3643.31362
T_{j=0}	355.0	B_{i=3}^{L}	-0.173412
T_{j=10}	354.0	B_{i=3}	-2571.5846
T_{j=11}	354.0	B_{i=4}^{L}	-0.009500675
T_{j=12}	370.0	B_{i=4}	-2320.5167
T_{j=13}	380.0	C_{i=1}^{L}	3.01275E-4
T_{j=14}	390.0	C_{i=1}	-33.16
T_{j=15}	400.0	C_{i=2}^{L}	4.066567E-4
T_{j=1}	354.0	C_{i=2}	-33.434
T_{j=2}	354.0	C_{i=3}^{L}	7.826743E-4
T_{j=3}	354.0	C_{i=3}	-48.406
T_{j=4}	354.0	C_{i=4}^{L}	2.335311E-4
T_{j=5}	354.0	C_{i=4}	-24.932
T_{j=6}	354.0	F_{j=10}	755.0
T_{j=7}	354.0	F_{j=11}	0.0
T_{j=8}	354.0	F_{j=12}	0.0
T_{j=9}	354.0	F_{j=13}	0.0
V_{j=10}	2928.0	F_{j=14}	0.0
V_{j=11}	2928.0	F_{j=15}	0.0
V_{j=12}	2928.0	F_{j=1}	0.0
V_{j=13}	2928.0	F_{j=2}	0.0
V_{j=14}	2928.0	F_{j=3}	0.0
V_{j=15}	2928.0	F_{j=4}	0.0
V_{j=16}	2928.0	F_{j=5}	0.0
V_{j=1}	2928.0	F_{j=6}	0.0
V_{j=2}	2928.0	F_{j=7}	0.0
V_{j=3}	2928.0	F_{j=8}	0.0
V_{j=4}	2928.0	F_{j=9}	0.0
V_{j=5}	2928.0	P	1100000.0
V_{j=6}	2928.0	Q^{r}	3.51E7
V_{j=7}	2928.0	R^{c}	7.0
V_{j=8}	2928.0	T^{o}	298.15
V_{j=9}	2928.0	T_{i=1}^{b}	266.25
x_{j=0,i=1}	0.003	T_{i=1}^{c}	425.0
x_{j=0,i=2}	0.032	T_{i=2}^{b}	337.75
x_{j=0,i=3}	0.0	T_{i=2}^{c}	513.15
x_{j=0,i=4}	0.965	T_{i=3}^{b}	328.3
x_{j=1,i=1}	0.0105	T_{i=3}^{c}	497.14
x_{j=1,i=2}	0.0338	T_{i=4}^{b}	272.65
x_{j=1,i=3}	0.0083	T_{i=4}^{c}	425.18
x_{j=1,i=4}	0.9474	T_{j=16}	424.0
x_{j=10,i=1}	0.0776	W	800.0
x_{j=10,i=2}	0.05	\delta_{j=10}	1.0
x_{j=10,i=3}	0.0833	\delta_{j=11}	0.0
x_{j=10,i=4	0.7891	\delta_{j=12}	0.0

x_{j=11,i=1}	0.0851	\delta_{j=13}	0.0
x_{j=11,i=2}	0.0417	\delta_{j=14}	0.0
x_{j=11,i=3}	0.0917	\delta_{j=15}	0.0
x_{j=11,i=4}	0.7816	\delta_{j=1}	0.0
x_{j=12,i=1}	0.0925	\delta_{j=2}	0.0
x_{j=12,i=2}	0.0333	\delta_{j=3}	1.0
x_{j=12,i=3}	0.1	\delta_{j=4}	1.0
x_{j=12,i=4}	0.7741	\delta_{j=5}	1.0
x_{j=13,i=1}	0.1	\delta_{j=6}	1.0
x_{j=13,i=2}	0.025	\delta_{j=7}	1.0
x_{j=13,i=3}	0.3257	\delta_{j=8}	1.0
x_{j=13,i=4}	0.5493	\delta_{j=9}	1.0
x_{j=14,i=1}	0.0667	\gamma_{j=1,i=1}	1.0
x_{j=14,i=2}	0.0167	\gamma_{j=1,i=2}	1.0
x_{j=14,i=3}	0.5513	\gamma_{j=1,i=3}	1.0
x_{j=14,i=4}	0.3653	\gamma_{j=1,i=4}	1.0
x_{j=15,i=1}	0.0333	\gamma_{j=10,i=1}	1.0
x_{j=15,i=2}	0.0083	\gamma_{j=10,i=2}	1.0
x_{j=15,i=3}	0.777	\gamma_{j=10,i=3}	1.0
x_{j=15,i=4}	0.1813	\gamma_{j=10,i=4}	1.0
x_{j=16,i=1}	0.0	\gamma_{j=11,i=1}	1.0
x_{j=16,i=2}	0.0	\gamma_{j=11,i=2}	1.0
x_{j=16,i=3}	0.986	\gamma_{j=11,i=3}	1.0
x_{j=16,i=4}	0.014	\gamma_{j=11,i=4}	1.0
x_{j=2,i=1}	0.0179	\gamma_{j=12,i=1}	1.0
x_{j=2,i=2}	0.0356	\gamma_{j=12,i=2}	1.0
x_{j=2,i=3}	0.0167	\gamma_{j=12,i=3}	1.0
x_{j=2,i=4}	0.9298	\gamma_{j=12,i=4}	1.0
x_{j=3,i=1}	0.0254	\gamma_{j=13,i=1}	1.0
x_{j=3,i=2}	0.0374	\gamma_{j=13,i=2}	1.0
x_{j=3,i=3}	0.025	\gamma_{j=13,i=3}	1.0
x_{j=3,i=4}	0.9122	\gamma_{j=13,i=4}	1.0
x_{j=4,i=1}	0.0328	\gamma_{j=14,i=1}	1.0
x_{j=4,i=2}	0.0392	\gamma_{j=14,i=2}	1.0
x_{j=4,i=3}	0.0333	\gamma_{j=14,i=3}	1.0
x_{j=4,i=4}	0.8946	\gamma_{j=14,i=4}	1.0
x_{j=5,i=1}	0.0403	\gamma_{j=15,i=1}	1.0
x_{j=5,i=2}	0.041	\gamma_{j=15,i=2}	1.0
x_{j=5,i=3}	0.0417	\gamma_{j=15,i=3}	1.0
x_{j=5,i=4}	0.877	\gamma_{j=15,i=4}	1.0
x_{j=6,i=1}	0.0478	\gamma_{j=16,i=1}	1.0
x_{j=6,i=2}	0.0428	\gamma_{j=16,i=2}	1.0
x_{j=6,i=3}	0.05	\gamma_{j=16,i=3}	1.0
x_{j=6,i=4}	0.8594	\gamma_{j=16,i=4}	1.0
x_{j=7,i=1}	0.0552	\gamma_{j=2,i=1}	1.0
x_{j=7,i=2}	0.0446	\gamma_{j=2,i=2}	1.0
x_{j=7,i=3}	0.0583	\gamma_{j=2,i=3}	1.0
x_{j=7,i=4}	0.8418	\gamma_{j=2,i=4}	1.0
x_{j=8,i=1}	0.0627	\gamma_{j=3,i=1}	1.0
x_{j=8,i=2}	0.0464	\gamma_{j=3,i=2}	1.0
x_{j=8,i=3}	0.0667	\gamma_{j=3,i=3}	1.0
x_{j=8,i=4}	0.8242	\gamma_{j=3,i=4}	1.0
x_{j=9,i=1}	0.0702	\gamma_{j=4,i=1}	1.0
x_{j=9,i=2}	0.0482	\gamma_{j=4,i=2}	1.0
x_{j=9,i=3}	0.075	\gamma_{j=4,i=3}	1.0
x_{j=9,i=4}	0.8066	\gamma_{j=4,i=4}	1.0
y_{j=1,i=1}	0.0	\gamma_{j=5,i=1}	1.0
y_{j=1,i=2}	0.0	\gamma_{j=5,i=2}	1.0
y_{j=1,i=3}	0.0	\gamma_{j=5,i=3}	1.0
y_{j=1,i=4}	0.0	\gamma_{j=5,i=4}	1.0
y_{j=10,i=1}	0.0	\gamma_{j=6,i=1}	1.0
y_{j=10,i=2}	0.0	\gamma_{j=6,i=2}	1.0
y_{j=10,i=3}	0.0	\gamma_{j=6,i=3}	1.0
y_{j=10,i=4}	0.0	\gamma_{j=6,i=4}	1.0
y_{j=11,i=1}	0.0	\gamma_{j=7,i=1}	1.0
y_{j=11,i=2}	0.0	\gamma_{j=7,i=2}	1.0
y_{j=11,i=3}	0.0	\gamma_{j=7,i=3}	1.0

y_{j=11,i=4}	0.0
y_{j=12,i=1}	0.0
y_{j=12,i=2}	0.0
y_{j=12,i=3}	0.0
y_{j=12,i=4}	0.0
y_{j=13,i=1}	0.0
y_{j=13,i=2}	0.0
y_{j=13,i=3}	0.0
y_{j=13,i=4}	0.0
y_{j=14,i=1}	0.0
y_{j=14,i=2}	0.0
y_{j=14,i=3}	0.0
y_{j=14,i=4}	0.0
y_{j=15,i=1}	0.0
y_{j=15,i=2}	0.0
y_{j=15,i=3}	0.0
y_{j=15,i=4}	0.0
y_{j=16,i=1}	0.0
y_{j=16,i=2}	0.0
y_{j=16,i=3}	0.0
y_{j=16,i=4}	0.0
y_{j=2,i=1}	0.0
y_{j=2,i=2}	0.0
y_{j=2,i=3}	0.0
y_{j=2,i=4}	0.0
y_{j=3,i=1}	0.0
y_{j=3,i=2}	0.0
y_{j=3,i=3}	0.0
y_{j=3,i=4}	0.0
y_{j=4,i=1}	0.0
y_{j=4,i=2}	0.0
y_{j=4,i=3}	0.0
y_{j=4,i=4}	0.0
y_{j=5,i=1}	0.0
y_{j=5,i=2}	0.0
y_{j=5,i=3}	0.0
y_{j=5,i=4}	0.0
y_{j=6,i=1}	0.0
y_{j=6,i=2}	0.0
y_{j=6,i=3}	0.0
y_{j=6,i=4}	0.0
y_{j=7,i=1}	0.0
y_{j=7,i=2}	0.0
y_{j=7,i=3}	0.0
y_{j=7,i=4}	0.0
y_{j=8,i=1}	0.0
y_{j=8,i=2}	0.0
y_{j=8,i=3}	0.0
y_{j=8,i=4}	0.0
y_{j=9,i=1}	0.0
y_{j=9,i=2}	0.0
y_{j=9,i=3}	0.0
y_{j=9,i=4}	0.0

\gamma_{j=7,i=4}	1.0
\gamma_{j=8,i=1}	1.0
\gamma_{j=8,i=2}	1.0
\gamma_{j=8,i=3}	1.0
\gamma_{j=8,i=4}	1.0
\gamma_{j=9,i=1}	1.0
\gamma_{j=9,i=2}	1.0
\gamma_{j=9,i=3}	1.0
\gamma_{j=9,i=4}	1.0
\lambda_{i=1}^{b}	22131.0
\lambda_{i=2}^{b}	35278.0
\lambda_{i=3}^{b}	30522.0
\lambda_{i=4}^{b}	22408.0
\phi	1.0
h^{F}	17300.0
q	4.9
v_{i=1}	-1.0
v_{i=2}	-1.0
v_{i=3}	1.0
v_{i=4}	0.0
z_{i=1}	0.259
z_{i=2}	0.273
z_{i=3}	0.0
z_{i=4}	0.468

V. Generated Code of Matlab

```
%**********************************************************
% The namespaces have been normalized. The following
% table shows the attribution.
% Normalized Name --> Original Name
% ================================
% e0 --> e[0]36077
%**********************************************************

%**********************************************************
% The variables are named according to the notation
% provided in the Mosaic model.
%
% The variable names can be read as follows:
% ==========================================
%   e0_greek_DeltaH
%       &Delta;H: Enthapy change
%
%   e0_greek_delta_j##
%       &delta;: Parameter for reaction occurrence on stage j (0 or 1)
%       Indices
%           j: Stage number
%
%   e0_B_i#
%       B: Constant for Antoine/Bottom
%       Indices
%           i: Component number
%
%   e0_B_L_i#
%       B: Constant for Antoine/Bottom
%       Superscripts
%           L: Liquid
%       Indices
%           i: Component number
%
%   e0_C_i#
%       C: Constant for Antoine
%       Indices
%           i: Component number
%
%   e0_C_L_i#
%       C: Constant for Antoine
%       Superscripts
%           L: Liquid
%       Indices
%           i: Component number
%
%   e0_D_c
%       D: Distillate
%       Superscripts
%           c: condenser/critical temperature
%
%   e0_F_j##
%       F: Feed molar flow rate
%       Indices
%           j: Stage number
%
%   e0_L_j#
%       L: Liquid molar flow rate
%       Indices
%           j: Stage number
%
%   e0_P
%       P: Total pressure/Saturated vapour pressure
%
%   e0_Q_c
%       Q: heat released
%       Superscripts
%           c: condenser/critical temperature
%
%   e0_Q_r
%       Q: heat released
%       Superscripts
%           r: reboiler
%
%   e0_R_c
%       R: Total numbers of moles generated or disappear/Reflux ratio
%       Superscripts
%           c: condenser/critical temperature
%
%   e0_T_o
%       T: Temperature
%       Superscripts
%           o: Saturated
%
%   e0_T_b_i#
%       T: Temperature
%       Superscripts
%           b: normal latent heat of vaporization/boiling point
%       Indices
%           i: Component number
%
%   e0_T_c_i#
%       T: Temperature
%       Superscripts
%           c: condenser/critical temperature
```

```
%      Indices
%          i: Component number
%
%   e0_greek_gamma_j#_i#
%      &gamma;: Activity coefficient
%      Indices
%          j: Stage number
%          i: Component number
%
%   e0_T_j#
%      T: Temperature
%      Indices
%          j: Stage number
%
%   e0_V_j##
%      V: Vapour molar flow rate
%      Indices
%          j: Stage number
%
%   e0_W
%      W: Catalyst weight
%
%   e0_h_F
%      h: Partial molar enthapy
%      Superscripts
%          F: Feed
%
%   e0_q
%      q: Ion exchange capacity
%
%   e0_v_i#
%      v: Stoichiometry coefficient
%      Indices
%          i: Component number
%
%   e0_x_j#_i#
%      x: Liquid mole fraction
%      Indices
%          j: Stage number
%          i: Component number
%
%   e0_y_j#_i#
%      y: Vapour mole fraction
%      Indices
%          j: Stage number
%          i: Component number
%
%   e0_z_i#
%      z: Feed composition
%      Indices
%          i: Component number
%
%   e0_greek_lambda_b_i#
%      &lambda;: Latent heat of vaporization
%      Superscripts
%          b: normal latent heat of vaporization/boiling point
%      Indices
%          i: Component number
%
%   e0_greek_phi
%      &phi;: Fugacity coefficient
%
%   e0_A#
%      A1: A1
%
%   e0_A#
%      A2: A2
%
%   e0_A#
%      A3: A3
%
%   e0_A#
%      A4: A4
%
%   e0_A#
%      A5: A5
%
%   e0_A#
%      A6: A6
%
%   e0_A_i#
%      A: Constant for Antoine
%      Indices
%          i: Component number
%
%   e0_A_L_i#
%      A: Constant for Antoine
%      Superscripts
%          L: Liquid
%      Indices
%          i: Component number
%
%   e0_B_r
%      B: Constant for Antoine/Bottom
%      Superscripts
%          r: reboiler
%
%*******************************************************

function[ROOTS]=solveEquationSystem()
```

```
% load variable init values
X_ITER(1) = 197.0;      % e0_B_r
X_ITER(2) = 366.0;      % e0_D_c
X_ITER(3) = 2562.0;     % e0_L_j0
X_ITER(4) = 2562.0;     % e0_L_j10
X_ITER(5) = 2562.0;     % e0_L_j11
X_ITER(6) = 2562.0;     % e0_L_j12
X_ITER(7) = 2562.0;     % e0_L_j13
X_ITER(8) = 2562.0;     % e0_L_j14
X_ITER(9) = 2562.0;     % e0_L_j15
X_ITER(10) = 2562.0;    % e0_L_j1
X_ITER(11) = 2562.0;    % e0_L_j2
X_ITER(12) = 2562.0;    % e0_L_j3
X_ITER(13) = 2562.0;    % e0_L_j4
X_ITER(14) = 2562.0;    % e0_L_j5
X_ITER(15) = 2562.0;    % e0_L_j6
X_ITER(16) = 2562.0;    % e0_L_j7
X_ITER(17) = 2562.0;    % e0_L_j8
X_ITER(18) = 2562.0;    % e0_L_j9
X_ITER(19) = 4.97E7;    % e0_Q_c
X_ITER(20) = 355.0;     % e0_T_j0
X_ITER(21) = 354.0;     % e0_T_j10
X_ITER(22) = 354.0;     % e0_T_j11
X_ITER(23) = 370.0;     % e0_T_j12
X_ITER(24) = 380.0;     % e0_T_j13
X_ITER(25) = 390.0;     % e0_T_j14
X_ITER(26) = 400.0;     % e0_T_j15
X_ITER(27) = 354.0;     % e0_T_j1
X_ITER(28) = 354.0;     % e0_T_j2
X_ITER(29) = 354.0;     % e0_T_j3
X_ITER(30) = 354.0;     % e0_T_j4
X_ITER(31) = 354.0;     % e0_T_j5
X_ITER(32) = 354.0;     % e0_T_j6
X_ITER(33) = 354.0;     % e0_T_j7
X_ITER(34) = 354.0;     % e0_T_j8
X_ITER(35) = 354.0;     % e0_T_j9
X_ITER(36) = 2928.0;    % e0_V_j10
X_ITER(37) = 2928.0;    % e0_V_j11
X_ITER(38) = 2928.0;    % e0_V_j12
X_ITER(39) = 2928.0;    % e0_V_j13
X_ITER(40) = 2928.0;    % e0_V_j14
X_ITER(41) = 2928.0;    % e0_V_j15
X_ITER(42) = 2928.0;    % e0_V_j16
X_ITER(43) = 2928.0;    % e0_V_j1
X_ITER(44) = 2928.0;    % e0_V_j2
X_ITER(45) = 2928.0;    % e0_V_j3
X_ITER(46) = 2928.0;    % e0_V_j4
X_ITER(47) = 2928.0;    % e0_V_j5
X_ITER(48) = 2928.0;    % e0_V_j6
X_ITER(49) = 2928.0;    % e0_V_j7
X_ITER(50) = 2928.0;    % e0_V_j8
X_ITER(51) = 2928.0;    % e0_V_j9
X_ITER(52) = 0.003;     % e0_x_j0_i1
X_ITER(53) = 0.032;     % e0_x_j0_i2
X_ITER(54) = 0.0;   % e0_x_j0_i3
X_ITER(55) = 0.965;     % e0_x_j0_i4
X_ITER(56) = 0.0105;    % e0_x_j1_i1
X_ITER(57) = 0.0338;    % e0_x_j1_i2
X_ITER(58) = 0.0083;    % e0_x_j1_i3
X_ITER(59) = 0.9474;    % e0_x_j1_i4
X_ITER(60) = 0.0776;    % e0_x_j10_i1
X_ITER(61) = 0.05;      % e0_x_j10_i2
X_ITER(62) = 0.0833;    % e0_x_j10_i3
X_ITER(63) = 0.7891;    % e0_x_j10_i4
X_ITER(64) = 0.0851;    % e0_x_j11_i1
X_ITER(65) = 0.0417;    % e0_x_j11_i2
X_ITER(66) = 0.0917;    % e0_x_j11_i3
X_ITER(67) = 0.7816;    % e0_x_j11_i4
X_ITER(68) = 0.0925;    % e0_x_j12_i1
X_ITER(69) = 0.0333;    % e0_x_j12_i2
X_ITER(70) = 0.1;   % e0_x_j12_i3
X_ITER(71) = 0.7741;    % e0_x_j12_i4
X_ITER(72) = 0.1;   % e0_x_j13_i1
X_ITER(73) = 0.025;     % e0_x_j13_i2
X_ITER(74) = 0.3257;    % e0_x_j13_i3
X_ITER(75) = 0.5493;    % e0_x_j13_i4
X_ITER(76) = 0.0667;    % e0_x_j14_i1
X_ITER(77) = 0.0167;    % e0_x_j14_i2
X_ITER(78) = 0.5513;    % e0_x_j14_i3
X_ITER(79) = 0.3653;    % e0_x_j14_i4
X_ITER(80) = 0.0333;    % e0_x_j15_i1
X_ITER(81) = 0.0083;    % e0_x_j15_i2
X_ITER(82) = 0.777;     % e0_x_j15_i3
X_ITER(83) = 0.1813;    % e0_x_j15_i4
X_ITER(84) = 0.0;   % e0_x_j16_i1
X_ITER(85) = 0.0;   % e0_x_j16_i2
X_ITER(86) = 0.986;     % e0_x_j16_i3
X_ITER(87) = 0.014;     % e0_x_j16_i4
X_ITER(88) = 0.0179;    % e0_x_j2_i1
X_ITER(89) = 0.0356;    % e0_x_j2_i2
X_ITER(90) = 0.0167;    % e0_x_j2_i3
X_ITER(91) = 0.9298;    % e0_x_j2_i4
X_ITER(92) = 0.0254;    % e0_x_j3_i1
X_ITER(93) = 0.0374;    % e0_x_j3_i2
X_ITER(94) = 0.025;     % e0_x_j3_i3
X_ITER(95) = 0.9122;    % e0_x_j3_i4
X_ITER(96) = 0.0328;    % e0_x_j4_i1
X_ITER(97) = 0.0392;    % e0_x_j4_i2
X_ITER(98) = 0.0333;    % e0_x_j4_i3
X_ITER(99) = 0.8946;    % e0_x_j4_i4
X_ITER(100) = 0.0403;   % e0_x_j5_i1
```

```
X_ITER(101) = 0.041;    % e0_x_j5_i2
X_ITER(102) = 0.0417;   % e0_x_j5_i3
X_ITER(103) = 0.877;    % e0_x_j5_i4
X_ITER(104) = 0.0478;   % e0_x_j6_i1
X_ITER(105) = 0.0428;   % e0_x_j6_i2
X_ITER(106) = 0.05;     % e0_x_j6_i3
X_ITER(107) = 0.8594;   % e0_x_j6_i4
X_ITER(108) = 0.0552;   % e0_x_j7_i1
X_ITER(109) = 0.0446;   % e0_x_j7_i2
X_ITER(110) = 0.0583;   % e0_x_j7_i3
X_ITER(111) = 0.8418;   % e0_x_j7_i4
X_ITER(112) = 0.0627;   % e0_x_j8_i1
X_ITER(113) = 0.0464;   % e0_x_j8_i2
X_ITER(114) = 0.0667;   % e0_x_j8_i3
X_ITER(115) = 0.8242;   % e0_x_j8_i4
X_ITER(116) = 0.0702;   % e0_x_j9_i1
X_ITER(117) = 0.0482;   % e0_x_j9_i2
X_ITER(118) = 0.075;    % e0_x_j9_i3
X_ITER(119) = 0.8066;   % e0_x_j9_i4
X_ITER(120) = 0.0;      % e0_y_j1_i1
X_ITER(121) = 0.0;      % e0_y_j1_i2
X_ITER(122) = 0.0;      % e0_y_j1_i3
X_ITER(123) = 0.0;      % e0_y_j1_i4
X_ITER(124) = 0.0;      % e0_y_j10_i1
X_ITER(125) = 0.0;      % e0_y_j10_i2
X_ITER(126) = 0.0;      % e0_y_j10_i3
X_ITER(127) = 0.0;      % e0_y_j10_i4
X_ITER(128) = 0.0;      % e0_y_j11_i1
X_ITER(129) = 0.0;      % e0_y_j11_i2
X_ITER(130) = 0.0;      % e0_y_j11_i3
X_ITER(131) = 0.0;      % e0_y_j11_i4
X_ITER(132) = 0.0;      % e0_y_j12_i1
X_ITER(133) = 0.0;      % e0_y_j12_i2
X_ITER(134) = 0.0;      % e0_y_j12_i3
X_ITER(135) = 0.0;      % e0_y_j12_i4
X_ITER(136) = 0.0;      % e0_y_j13_i1
X_ITER(137) = 0.0;      % e0_y_j13_i2
X_ITER(138) = 0.0;      % e0_y_j13_i3
X_ITER(139) = 0.0;      % e0_y_j13_i4
X_ITER(140) = 0.0;      % e0_y_j14_i1
X_ITER(141) = 0.0;      % e0_y_j14_i2
X_ITER(142) = 0.0;      % e0_y_j14_i3
X_ITER(143) = 0.0;      % e0_y_j14_i4
X_ITER(144) = 0.0;      % e0_y_j15_i1
X_ITER(145) = 0.0;      % e0_y_j15_i2
X_ITER(146) = 0.0;      % e0_y_j15_i3
X_ITER(147) = 0.0;      % e0_y_j15_i4
X_ITER(148) = 0.0;      % e0_y_j16_i1
X_ITER(149) = 0.0;      % e0_y_j16_i2
X_ITER(150) = 0.0;      % e0_y_j16_i3
X_ITER(151) = 0.0;      % e0_y_j16_i4
X_ITER(152) = 0.0;      % e0_y_j2_i1
X_ITER(153) = 0.0;      % e0_y_j2_i2
X_ITER(154) = 0.0;      % e0_y_j2_i3
X_ITER(155) = 0.0;      % e0_y_j2_i4
X_ITER(156) = 0.0;      % e0_y_j3_i1
X_ITER(157) = 0.0;      % e0_y_j3_i2
X_ITER(158) = 0.0;      % e0_y_j3_i3
X_ITER(159) = 0.0;      % e0_y_j3_i4
X_ITER(160) = 0.0;      % e0_y_j4_i1
X_ITER(161) = 0.0;      % e0_y_j4_i2
X_ITER(162) = 0.0;      % e0_y_j4_i3
X_ITER(163) = 0.0;      % e0_y_j4_i4
X_ITER(164) = 0.0;      % e0_y_j5_i1
X_ITER(165) = 0.0;      % e0_y_j5_i2
X_ITER(166) = 0.0;      % e0_y_j5_i3
X_ITER(167) = 0.0;      % e0_y_j5_i4
X_ITER(168) = 0.0;      % e0_y_j6_i1
X_ITER(169) = 0.0;      % e0_y_j6_i2
X_ITER(170) = 0.0;      % e0_y_j6_i3
X_ITER(171) = 0.0;      % e0_y_j6_i4
X_ITER(172) = 0.0;      % e0_y_j7_i1
X_ITER(173) = 0.0;      % e0_y_j7_i2
X_ITER(174) = 0.0;      % e0_y_j7_i3
X_ITER(175) = 0.0;      % e0_y_j7_i4
X_ITER(176) = 0.0;      % e0_y_j8_i1
X_ITER(177) = 0.0;      % e0_y_j8_i2
X_ITER(178) = 0.0;      % e0_y_j8_i3
X_ITER(179) = 0.0;      % e0_y_j8_i4
X_ITER(180) = 0.0;      % e0_y_j9_i1
X_ITER(181) = 0.0;      % e0_y_j9_i2
X_ITER(182) = 0.0;      % e0_y_j9_i3
X_ITER(183) = 0.0;      % e0_y_j9_i4

% load parameters
PARAMS(1) = 1.0;    % e0_greek_gamma_j9_i3
PARAMS(2) = 1.0;    % e0_greek_gamma_j9_i4
PARAMS(3) = 425.18;     % e0_T_c_i4
PARAMS(4) = 337.75;     % e0_T_b_i2
PARAMS(5) = 513.15;     % e0_T_c_i2
PARAMS(6) = 266.25;     % e0_T_b_i1
PARAMS(7) = 425.0;      % e0_T_c_i1
PARAMS(8) = 272.65;     % e0_T_b_i4
PARAMS(9) = 328.3;      % e0_T_b_i3
PARAMS(10) = 497.14;    % e0_T_c_i3
PARAMS(11) = 1.0;   % e0_greek_gamma_j9_i2
PARAMS(12) = 1.0;   % e0_greek_gamma_j9_i1
PARAMS(13) = 1.0;   % e0_greek_gamma_j8_i4
PARAMS(14) = 1.0;   % e0_greek_gamma_j8_i3
PARAMS(15) = 1.0;   % e0_greek_gamma_j8_i2
PARAMS(16) = 1.0;   % e0_greek_gamma_j8_i1
```

```
PARAMS(17) = 1.0;   % e0_greek_gamma_j7_i4
PARAMS(18) = 1.0;   % e0_greek_gamma_j7_i3
PARAMS(19) = 1.0;   % e0_greek_gamma_j6_i4
PARAMS(20) = 1.0;   % e0_greek_gamma_j7_i1
PARAMS(21) = 1.0;   % e0_greek_gamma_j7_i2
PARAMS(22) = 3.51E7;    % e0_Q_r
PARAMS(23) = 298.15;    % e0_T_o
PARAMS(24) = 7.0;   % e0_R_c
PARAMS(25) = 1100000.0;     % e0_P
PARAMS(26) = 1.0;   % e0_greek_gamma_j6_i1
PARAMS(27) = 1.0;   % e0_greek_gamma_j5_i4
PARAMS(28) = 1.0;   % e0_greek_gamma_j6_i3
PARAMS(29) = 1.0;   % e0_greek_gamma_j6_i2
PARAMS(30) = 1.0;   % e0_greek_gamma_j5_i1
PARAMS(31) = 1.0;   % e0_greek_gamma_j5_i3
PARAMS(32) = 1.0;   % e0_greek_gamma_j5_i2
PARAMS(33) = 9.132635;      % e0_A_i1
PARAMS(34) = -6.27996E-10;      % e0_A6
PARAMS(35) = 9.203235;      % e0_A_i3
PARAMS(36) = 74.86274;      % e0_A_L_i2
PARAMS(37) = 11.986965;     % e0_A_i2
PARAMS(38) = 113.1346;      % e0_A_L_i1
PARAMS(39) = 103.2326;      % e0_A_L_i4
PARAMS(40) = 9.382695;      % e0_A_i4
PARAMS(41) = 162.0418;      % e0_A_L_i3
PARAMS(42) = 1.10649E-6;    % e0_A5
PARAMS(43) = 1.0;   % e0_greek_delta_j5
PARAMS(44) = 1.0;   % e0_greek_delta_j4
PARAMS(45) = 424.0;     % e0_T_j16
PARAMS(46) = 1.0;   % e0_greek_delta_j6
PARAMS(47) = 1.0;   % e0_greek_delta_j7
PARAMS(48) = 1.0;   % e0_greek_delta_j8
PARAMS(49) = 1.0;   % e0_greek_delta_j9
PARAMS(50) = 1.0;   % e0_greek_gamma_j1_i1
PARAMS(51) = 1.0;   % e0_greek_gamma_j1_i2
PARAMS(52) = 1.0;   % e0_greek_gamma_j1_i3
PARAMS(53) = 22131.0;   % e0_greek_lambda_b_i1
PARAMS(54) = 1.0;   % e0_greek_gamma_j1_i4
PARAMS(55) = 30522.0;   % e0_greek_lambda_b_i3
PARAMS(56) = 35278.0;   % e0_greek_lambda_b_i2
PARAMS(57) = 1.0;   % e0_greek_phi
PARAMS(58) = 22408.0;   % e0_greek_lambda_b_i4
PARAMS(59) = -77.4002;      % e0_A2
PARAMS(60) = -1492.77;      % e0_A1
PARAMS(61) = -9.12739E-4;   % e0_A4
PARAMS(62) = 0.507563;      % e0_A3
PARAMS(63) = 0.0;   % e0_F_j11
PARAMS(64) = 1.0;   % e0_greek_gamma_j10_i2
PARAMS(65) = 755.0;     % e0_F_j10
PARAMS(66) = 1.0;   % e0_greek_gamma_j10_i3
PARAMS(67) = 0.0;   % e0_F_j12
PARAMS(68) = 1.0;   % e0_greek_gamma_j10_i1
PARAMS(69) = -33.434;   % e0_C_i2
PARAMS(70) = -48.406;   % e0_C_i3
PARAMS(71) = 4.066567E-4;   % e0_C_L_i2
PARAMS(72) = -24.932;   % e0_C_i4
PARAMS(73) = 7.826743E-4;   % e0_C_L_i3
PARAMS(74) = 2.335311E-4;   % e0_C_L_i4
PARAMS(75) = 1.0;   % e0_v_i3
PARAMS(76) = 1.0;   % e0_greek_gamma_j12_i2
PARAMS(77) = -1.0;      % e0_v_i2
PARAMS(78) = 1.0;   % e0_greek_gamma_j12_i1
PARAMS(79) = -1.0;      % e0_v_i1
PARAMS(80) = 1.0;   % e0_greek_gamma_j11_i4
PARAMS(81) = 0.0;   % e0_v_i4
PARAMS(82) = 1.0;   % e0_greek_gamma_j11_i3
PARAMS(83) = 1.0;   % e0_greek_gamma_j11_i2
PARAMS(84) = 1.0;   % e0_greek_gamma_j11_i1
PARAMS(85) = 1.0;   % e0_greek_gamma_j10_i4
PARAMS(86) = 3.01275E-4;    % e0_C_L_i1
PARAMS(87) = 1.0;   % e0_greek_gamma_j12_i3
PARAMS(88) = -33.16;    % e0_C_i1
PARAMS(89) = 1.0;   % e0_greek_gamma_j12_i4
PARAMS(90) = -0.009500675;      % e0_B_L_i4
PARAMS(91) = 1.0;   % e0_greek_gamma_j13_i1
PARAMS(92) = -2320.5167;    % e0_B_i4
PARAMS(93) = 1.0;   % e0_greek_gamma_j13_i2
PARAMS(94) = 800.0;     % e0_W
PARAMS(95) = 17300.0;   % e0_h_F
PARAMS(96) = 4.9;   % e0_q
PARAMS(97) = -0.0361507;    % e0_B_L_i1
PARAMS(98) = -2125.74886;   % e0_B_i1
PARAMS(99) = -0.173412;     % e0_B_L_i3
PARAMS(100) = -2571.5846;   % e0_B_i3
PARAMS(101) = -0.102315;    % e0_B_L_i2
PARAMS(102) = -3643.31362;      % e0_B_i2
PARAMS(103) = 1.0;      % e0_greek_gamma_j14_i4
PARAMS(104) = 1.0;      % e0_greek_gamma_j14_i3
PARAMS(105) = 1.0;      % e0_greek_gamma_j13_i4
PARAMS(106) = 1.0;      % e0_greek_gamma_j13_i3
PARAMS(107) = 1.0;      % e0_greek_gamma_j14_i2
PARAMS(108) = 1.0;      % e0_greek_gamma_j14_i1
PARAMS(109) = 0.0;      % e0_greek_delta_j13
PARAMS(110) = 1.0;      % e0_greek_gamma_j15_i1
PARAMS(111) = 0.0;      % e0_greek_delta_j12
PARAMS(112) = 0.0;      % e0_greek_delta_j15
PARAMS(113) = 0.0;      % e0_greek_delta_j14
PARAMS(114) = 1.0;      % e0_greek_gamma_j15_i4
PARAMS(115) = -37700.0;     % e0_greek_DeltaH
PARAMS(116) = 1.0;      % e0_greek_gamma_j16_i1
PARAMS(117) = 1.0;      % e0_greek_gamma_j15_i2
```

```
    PARAMS(118) = 0.0;      % e0_greek_delta_j11
    PARAMS(119) = 1.0;      % e0_greek_gamma_j15_i3
    PARAMS(120) = 1.0;      % e0_greek_delta_j10
    PARAMS(121) = 0.0;      % e0_greek_delta_j2
    PARAMS(122) = 0.0;      % e0_F_j9
    PARAMS(123) = 0.0;      % e0_greek_delta_j1
    PARAMS(124) = 1.0;      % e0_greek_delta_j3
    PARAMS(125) = 1.0;      % e0_greek_gamma_j2_i1
    PARAMS(126) = 1.0;      % e0_greek_gamma_j16_i4
    PARAMS(127) = 1.0;      % e0_greek_gamma_j16_i3
    PARAMS(128) = 1.0;      % e0_greek_gamma_j16_i2
    PARAMS(129) = 1.0;      % e0_greek_gamma_j2_i2
    PARAMS(130) = 1.0;      % e0_greek_gamma_j2_i3
    PARAMS(131) = 1.0;      % e0_greek_gamma_j2_i4
    PARAMS(132) = 1.0;      % e0_greek_gamma_j3_i1
    PARAMS(133) = 1.0;      % e0_greek_gamma_j3_i2
    PARAMS(134) = 0.0;      % e0_F_j7
    PARAMS(135) = 1.0;      % e0_greek_gamma_j3_i3
    PARAMS(136) = 0.0;      % e0_F_j6
    PARAMS(137) = 1.0;      % e0_greek_gamma_j3_i4
    PARAMS(138) = 0.0;      % e0_F_j5
    PARAMS(139) = 0.0;      % e0_F_j4
    PARAMS(140) = 0.0;      % e0_F_j3
    PARAMS(141) = 0.0;      % e0_F_j2
    PARAMS(142) = 0.0;      % e0_F_j1
    PARAMS(143) = 0.0;      % e0_F_j15
    PARAMS(144) = 0.0;      % e0_F_j14
    PARAMS(145) = 0.0;      % e0_F_j13
    PARAMS(146) = 0.273;    % e0_z_i2
    PARAMS(147) = 0.259;    % e0_z_i1
    PARAMS(148) = 0.0;      % e0_F_j8
    PARAMS(149) = 0.468;    % e0_z_i4
    PARAMS(150) = 0.0;      % e0_z_i3
    PARAMS(151) = 1.0;      % e0_greek_gamma_j4_i2
    PARAMS(152) = 1.0;      % e0_greek_gamma_j4_i1
    PARAMS(153) = 1.0;      % e0_greek_gamma_j4_i4
    PARAMS(154) = 1.0;      % e0_greek_gamma_j4_i3

    options = optimset('MaxIter',1000,'TolFun',1e-10,'Display','Iter');
    RES = fsolve (@( x_iter )getFunVal(x_iter,PARAMS),X_ITER,options);

    ROOTS = getFunVal(RES,PARAMS);
    ROOTS = ROOTS';

    displayResults(RES);

end


function[Y] = getFunVal(X_ITER,PARAMS)

%
% Calculate the function value of a normalized equation system.
%
    % read out variables
    e0_B_r = X_ITER(1);
    e0_D_c = X_ITER(2);
    e0_L_j0 = X_ITER(3);
    e0_L_j10 = X_ITER(4);
    e0_L_j11 = X_ITER(5);
    e0_L_j12 = X_ITER(6);
    e0_L_j13 = X_ITER(7);
    e0_L_j14 = X_ITER(8);
    e0_L_j15 = X_ITER(9);
    e0_L_j1 = X_ITER(10);
    e0_L_j2 = X_ITER(11);
    e0_L_j3 = X_ITER(12);
    e0_L_j4 = X_ITER(13);
    e0_L_j5 = X_ITER(14);
    e0_L_j6 = X_ITER(15);
    e0_L_j7 = X_ITER(16);
    e0_L_j8 = X_ITER(17);
    e0_L_j9 = X_ITER(18);
    e0_Q_c = X_ITER(19);
    e0_T_j0 = X_ITER(20);
    e0_T_j10 = X_ITER(21);
    e0_T_j11 = X_ITER(22);
    e0_T_j12 = X_ITER(23);
    e0_T_j13 = X_ITER(24);
    e0_T_j14 = X_ITER(25);
    e0_T_j15 = X_ITER(26);
    e0_T_j1 = X_ITER(27);
    e0_T_j2 = X_ITER(28);
    e0_T_j3 = X_ITER(29);
    e0_T_j4 = X_ITER(30);
    e0_T_j5 = X_ITER(31);
    e0_T_j6 = X_ITER(32);
    e0_T_j7 = X_ITER(33);
    e0_T_j8 = X_ITER(34);
    e0_T_j9 = X_ITER(35);
    e0_V_j10 = X_ITER(36);
    e0_V_j11 = X_ITER(37);
    e0_V_j12 = X_ITER(38);
    e0_V_j13 = X_ITER(39);
    e0_V_j14 = X_ITER(40);
    e0_V_j15 = X_ITER(41);
    e0_V_j16 = X_ITER(42);
    e0_V_j1 = X_ITER(43);
    e0_V_j2 = X_ITER(44);
```

```
e0_V_j3 = X_ITER(45);
e0_V_j4 = X_ITER(46);
e0_V_j5 = X_ITER(47);
e0_V_j6 = X_ITER(48);
e0_V_j7 = X_ITER(49);
e0_V_j8 = X_ITER(50);
e0_V_j9 = X_ITER(51);
e0_x_j0_i1 = X_ITER(52);
e0_x_j0_i2 = X_ITER(53);
e0_x_j0_i3 = X_ITER(54);
e0_x_j0_i4 = X_ITER(55);
e0_x_j1_i1 = X_ITER(56);
e0_x_j1_i2 = X_ITER(57);
e0_x_j1_i3 = X_ITER(58);
e0_x_j1_i4 = X_ITER(59);
e0_x_j10_i1 = X_ITER(60);
e0_x_j10_i2 = X_ITER(61);
e0_x_j10_i3 = X_ITER(62);
e0_x_j10_i4 = X_ITER(63);
e0_x_j11_i1 = X_ITER(64);
e0_x_j11_i2 = X_ITER(65);
e0_x_j11_i3 = X_ITER(66);
e0_x_j11_i4 = X_ITER(67);
e0_x_j12_i1 = X_ITER(68);
e0_x_j12_i2 = X_ITER(69);
e0_x_j12_i3 = X_ITER(70);
e0_x_j12_i4 = X_ITER(71);
e0_x_j13_i1 = X_ITER(72);
e0_x_j13_i2 = X_ITER(73);
e0_x_j13_i3 = X_ITER(74);
e0_x_j13_i4 = X_ITER(75);
e0_x_j14_i1 = X_ITER(76);
e0_x_j14_i2 = X_ITER(77);
e0_x_j14_i3 = X_ITER(78);
e0_x_j14_i4 = X_ITER(79);
e0_x_j15_i1 = X_ITER(80);
e0_x_j15_i2 = X_ITER(81);
e0_x_j15_i3 = X_ITER(82);
e0_x_j15_i4 = X_ITER(83);
e0_x_j16_i1 = X_ITER(84);
e0_x_j16_i2 = X_ITER(85);
e0_x_j16_i3 = X_ITER(86);
e0_x_j16_i4 = X_ITER(87);
e0_x_j2_i1 = X_ITER(88);
e0_x_j2_i2 = X_ITER(89);
e0_x_j2_i3 = X_ITER(90);
e0_x_j2_i4 = X_ITER(91);
e0_x_j3_i1 = X_ITER(92);
e0_x_j3_i2 = X_ITER(93);
e0_x_j3_i3 = X_ITER(94);
e0_x_j3_i4 = X_ITER(95);
e0_x_j4_i1 = X_ITER(96);
e0_x_j4_i2 = X_ITER(97);
e0_x_j4_i3 = X_ITER(98);
e0_x_j4_i4 = X_ITER(99);
e0_x_j5_i1 = X_ITER(100);
e0_x_j5_i2 = X_ITER(101);
e0_x_j5_i3 = X_ITER(102);
e0_x_j5_i4 = X_ITER(103);
e0_x_j6_i1 = X_ITER(104);
e0_x_j6_i2 = X_ITER(105);
e0_x_j6_i3 = X_ITER(106);
e0_x_j6_i4 = X_ITER(107);
e0_x_j7_i1 = X_ITER(108);
e0_x_j7_i2 = X_ITER(109);
e0_x_j7_i3 = X_ITER(110);
e0_x_j7_i4 = X_ITER(111);
e0_x_j8_i1 = X_ITER(112);
e0_x_j8_i2 = X_ITER(113);
e0_x_j8_i3 = X_ITER(114);
e0_x_j8_i4 = X_ITER(115);
e0_x_j9_i1 = X_ITER(116);
e0_x_j9_i2 = X_ITER(117);
e0_x_j9_i3 = X_ITER(118);
e0_x_j9_i4 = X_ITER(119);
e0_y_j1_i1 = X_ITER(120);
e0_y_j1_i2 = X_ITER(121);
e0_y_j1_i3 = X_ITER(122);
e0_y_j1_i4 = X_ITER(123);
e0_y_j10_i1 = X_ITER(124);
e0_y_j10_i2 = X_ITER(125);
e0_y_j10_i3 = X_ITER(126);
e0_y_j10_i4 = X_ITER(127);
e0_y_j11_i1 = X_ITER(128);
e0_y_j11_i2 = X_ITER(129);
e0_y_j11_i3 = X_ITER(130);
e0_y_j11_i4 = X_ITER(131);
e0_y_j12_i1 = X_ITER(132);
e0_y_j12_i2 = X_ITER(133);
e0_y_j12_i3 = X_ITER(134);
e0_y_j12_i4 = X_ITER(135);
e0_y_j13_i1 = X_ITER(136);
e0_y_j13_i2 = X_ITER(137);
e0_y_j13_i3 = X_ITER(138);
e0_y_j13_i4 = X_ITER(139);
e0_y_j14_i1 = X_ITER(140);
e0_y_j14_i2 = X_ITER(141);
e0_y_j14_i3 = X_ITER(142);
e0_y_j14_i4 = X_ITER(143);
e0_y_j15_i1 = X_ITER(144);
e0_y_j15_i2 = X_ITER(145);
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e0_y_j15_i3 = X_ITER(146);
e0_y_j15_i4 = X_ITER(147);
e0_y_j16_i1 = X_ITER(148);
e0_y_j16_i2 = X_ITER(149);
e0_y_j16_i3 = X_ITER(150);
e0_y_j16_i4 = X_ITER(151);
e0_y_j2_i1 = X_ITER(152);
e0_y_j2_i2 = X_ITER(153);
e0_y_j2_i3 = X_ITER(154);
e0_y_j2_i4 = X_ITER(155);
e0_y_j3_i1 = X_ITER(156);
e0_y_j3_i2 = X_ITER(157);
e0_y_j3_i3 = X_ITER(158);
e0_y_j3_i4 = X_ITER(159);
e0_y_j4_i1 = X_ITER(160);
e0_y_j4_i2 = X_ITER(161);
e0_y_j4_i3 = X_ITER(162);
e0_y_j4_i4 = X_ITER(163);
e0_y_j5_i1 = X_ITER(164);
e0_y_j5_i2 = X_ITER(165);
e0_y_j5_i3 = X_ITER(166);
e0_y_j5_i4 = X_ITER(167);
e0_y_j6_i1 = X_ITER(168);
e0_y_j6_i2 = X_ITER(169);
e0_y_j6_i3 = X_ITER(170);
e0_y_j6_i4 = X_ITER(171);
e0_y_j7_i1 = X_ITER(172);
e0_y_j7_i2 = X_ITER(173);
e0_y_j7_i3 = X_ITER(174);
e0_y_j7_i4 = X_ITER(175);
e0_y_j8_i1 = X_ITER(176);
e0_y_j8_i2 = X_ITER(177);
e0_y_j8_i3 = X_ITER(178);
e0_y_j8_i4 = X_ITER(179);
e0_y_j9_i1 = X_ITER(180);
e0_y_j9_i2 = X_ITER(181);
e0_y_j9_i3 = X_ITER(182);
e0_y_j9_i4 = X_ITER(183);

% read out parameters
e0_greek_gamma_j9_i3 = PARAMS(1);
e0_greek_gamma_j9_i4 = PARAMS(2);
e0_T_c_i4 = PARAMS(3);
e0_T_b_i2 = PARAMS(4);
e0_T_c_i2 = PARAMS(5);
e0_T_b_i1 = PARAMS(6);
e0_T_c_i1 = PARAMS(7);
e0_T_b_i4 = PARAMS(8);
e0_T_b_i3 = PARAMS(9);
e0_T_c_i3 = PARAMS(10);
e0_greek_gamma_j9_i2 = PARAMS(11);
e0_greek_gamma_j9_i1 = PARAMS(12);
e0_greek_gamma_j8_i4 = PARAMS(13);
e0_greek_gamma_j8_i3 = PARAMS(14);
e0_greek_gamma_j8_i2 = PARAMS(15);
e0_greek_gamma_j8_i1 = PARAMS(16);
e0_greek_gamma_j7_i4 = PARAMS(17);
e0_greek_gamma_j7_i3 = PARAMS(18);
e0_greek_gamma_j6_i4 = PARAMS(19);
e0_greek_gamma_j7_i1 = PARAMS(20);
e0_greek_gamma_j7_i2 = PARAMS(21);
e0_Q_r = PARAMS(22);
e0_T_o = PARAMS(23);
e0_R_c = PARAMS(24);
e0_P = PARAMS(25);
e0_greek_gamma_j6_i1 = PARAMS(26);
e0_greek_gamma_j5_i4 = PARAMS(27);
e0_greek_gamma_j6_i3 = PARAMS(28);
e0_greek_gamma_j6_i2 = PARAMS(29);
e0_greek_gamma_j5_i1 = PARAMS(30);
e0_greek_gamma_j5_i3 = PARAMS(31);
e0_greek_gamma_j5_i2 = PARAMS(32);
e0_A_i1 = PARAMS(33);
e0_A6 = PARAMS(34);
e0_A_i3 = PARAMS(35);
e0_A_L_i2 = PARAMS(36);
e0_A_i2 = PARAMS(37);
e0_A_L_i1 = PARAMS(38);
e0_A_L_i4 = PARAMS(39);
e0_A_i4 = PARAMS(40);
e0_A_L_i3 = PARAMS(41);
e0_A5 = PARAMS(42);
e0_greek_delta_j5 = PARAMS(43);
e0_greek_delta_j4 = PARAMS(44);
e0_T_j16 = PARAMS(45);
e0_greek_delta_j6 = PARAMS(46);
e0_greek_delta_j7 = PARAMS(47);
e0_greek_delta_j8 = PARAMS(48);
e0_greek_delta_j9 = PARAMS(49);
e0_greek_gamma_j1_i1 = PARAMS(50);
e0_greek_gamma_j1_i2 = PARAMS(51);
e0_greek_gamma_j1_i3 = PARAMS(52);
e0_greek_lambda_b_i1 = PARAMS(53);
e0_greek_gamma_j1_i4 = PARAMS(54);
e0_greek_lambda_b_i3 = PARAMS(55);
e0_greek_lambda_b_i2 = PARAMS(56);
e0_greek_phi = PARAMS(57);
e0_greek_lambda_b_i4 = PARAMS(58);
e0_A2 = PARAMS(59);
e0_A1 = PARAMS(60);
e0_A4 = PARAMS(61);
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e0_A3 = PARAMS(62);
e0_F_j11 = PARAMS(63);
e0_greek_gamma_j10_i2 = PARAMS(64);
e0_F_j10 = PARAMS(65);
e0_greek_gamma_j10_i3 = PARAMS(66);
e0_F_j12 = PARAMS(67);
e0_greek_gamma_j10_i1 = PARAMS(68);
e0_C_i2 = PARAMS(69);
e0_C_i3 = PARAMS(70);
e0_C_L_i2 = PARAMS(71);
e0_C_i4 = PARAMS(72);
e0_C_L_i3 = PARAMS(73);
e0_C_L_i4 = PARAMS(74);
e0_v_i3 = PARAMS(75);
e0_greek_gamma_j12_i2 = PARAMS(76);
e0_v_i2 = PARAMS(77);
e0_greek_gamma_j12_i1 = PARAMS(78);
e0_v_i1 = PARAMS(79);
e0_greek_gamma_j11_i4 = PARAMS(80);
e0_v_i4 = PARAMS(81);
e0_greek_gamma_j11_i3 = PARAMS(82);
e0_greek_gamma_j11_i2 = PARAMS(83);
e0_greek_gamma_j11_i1 = PARAMS(84);
e0_greek_gamma_j10_i4 = PARAMS(85);
e0_C_L_i1 = PARAMS(86);
e0_greek_gamma_j12_i3 = PARAMS(87);
e0_C_i1 = PARAMS(88);
e0_greek_gamma_j12_i4 = PARAMS(89);
e0_B_L_i4 = PARAMS(90);
e0_greek_gamma_j13_i1 = PARAMS(91);
e0_B_i4 = PARAMS(92);
e0_greek_gamma_j13_i2 = PARAMS(93);
e0_W = PARAMS(94);
e0_h_F = PARAMS(95);
e0_q = PARAMS(96);
e0_B_L_i1 = PARAMS(97);
e0_B_i1 = PARAMS(98);
e0_B_L_i3 = PARAMS(99);
e0_B_i3 = PARAMS(100);
e0_B_L_i2 = PARAMS(101);
e0_B_i2 = PARAMS(102);
e0_greek_gamma_j14_i4 = PARAMS(103);
e0_greek_gamma_j14_i3 = PARAMS(104);
e0_greek_gamma_j13_i4 = PARAMS(105);
e0_greek_gamma_j13_i3 = PARAMS(106);
e0_greek_gamma_j14_i2 = PARAMS(107);
e0_greek_gamma_j14_i1 = PARAMS(108);
e0_greek_delta_j13 = PARAMS(109);
e0_greek_gamma_j15_i1 = PARAMS(110);
e0_greek_delta_j12 = PARAMS(111);
e0_greek_delta_j15 = PARAMS(112);
e0_greek_delta_j14 = PARAMS(113);
e0_greek_gamma_j15_i4 = PARAMS(114);
e0_greek_DeltaH = PARAMS(115);
e0_greek_gamma_j16_i1 = PARAMS(116);
e0_greek_gamma_j15_i2 = PARAMS(117);
e0_greek_delta_j11 = PARAMS(118);
e0_greek_gamma_j15_i3 = PARAMS(119);
e0_greek_delta_j10 = PARAMS(120);
e0_greek_delta_j2 = PARAMS(121);
e0_F_j9 = PARAMS(122);
e0_greek_delta_j1 = PARAMS(123);
e0_greek_delta_j3 = PARAMS(124);
e0_greek_gamma_j2_i1 = PARAMS(125);
e0_greek_gamma_j16_i4 = PARAMS(126);
e0_greek_gamma_j16_i3 = PARAMS(127);
e0_greek_gamma_j16_i2 = PARAMS(128);
e0_greek_gamma_j2_i2 = PARAMS(129);
e0_greek_gamma_j2_i3 = PARAMS(130);
e0_greek_gamma_j2_i4 = PARAMS(131);
e0_greek_gamma_j3_i1 = PARAMS(132);
e0_greek_gamma_j3_i2 = PARAMS(133);
e0_F_j7 = PARAMS(134);
e0_greek_gamma_j3_i3 = PARAMS(135);
e0_F_j6 = PARAMS(136);
e0_greek_gamma_j3_i4 = PARAMS(137);
e0_F_j5 = PARAMS(138);
e0_F_j4 = PARAMS(139);
e0_F_j3 = PARAMS(140);
e0_F_j2 = PARAMS(141);
e0_F_j1 = PARAMS(142);
e0_F_j15 = PARAMS(143);
e0_F_j14 = PARAMS(144);
e0_F_j13 = PARAMS(145);
e0_z_i2 = PARAMS(146);
e0_z_i1 = PARAMS(147);
e0_F_j8 = PARAMS(148);
e0_z_i4 = PARAMS(149);
e0_z_i3 = PARAMS(150);
e0_greek_gamma_j4_i2 = PARAMS(151);
e0_greek_gamma_j4_i1 = PARAMS(152);
e0_greek_gamma_j4_i4 = PARAMS(153);
e0_greek_gamma_j4_i3 = PARAMS(154);

% perform direct function calls
e0_h_l_j10_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j10,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_P_o_j5_i4 = fun_34071__saturated_pressure(e0_T_j5,e0_C_i4,e0_B_i4,e0_A_i4) ;
e0_P_o_j8_i2 = fun_34071__saturated_pressure(e0_T_j8,e0_C_i2,e0_B_i2,e0_A_i2) ;
e0_P_o_j6_i4 = fun_34071__saturated_pressure(e0_T_j6,e0_C_i4,e0_B_i4,e0_A_i4) ;
e0_P_o_j8_i1 = fun_34071__saturated_pressure(e0_T_j8,e0_C_i1,e0_B_i1,e0_A_i1) ;
e0_P_o_j3_i2 = fun_34071__saturated_pressure(e0_T_j3,e0_C_i2,e0_B_i2,e0_A_i2) ;
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e0_h_l_j1_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j1,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_h_v_j14_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j14,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
e0_P_o_j15_i3 = fun_34071__saturated_pressure(e0_T_j15,e0_C_i3,e0_B_i3,e0_A_i3) ;
e0_h_v_j10_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j10,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
e0_h_l_j15_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j15,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_h_l_j11_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j11,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_h_l_j0_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j0,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
e0_h_l_j12_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j12,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
e0_P_o_j12_i1 = fun_34071__saturated_pressure(e0_T_j12,e0_C_i1,e0_B_i1,e0_A_i1) ;
e0_P_o_j4_i3 = fun_34071__saturated_pressure(e0_T_j4,e0_C_i3,e0_B_i3,e0_A_i3) ;
e0_h_l_j9_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j9,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
e0_P_o_j11_i2 = fun_34071__saturated_pressure(e0_T_j11,e0_C_i2,e0_B_i2,e0_A_i2) ;
e0_P_o_j16_i2 = fun_34071__saturated_pressure(e0_T_j16,e0_C_i2,e0_B_i2,e0_A_i2) ;
e0_P_o_j8_i4 = fun_34071__saturated_pressure(e0_T_j8,e0_C_i4,e0_B_i4,e0_A_i4) ;
e0_h_l_j8_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j8,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
e0_h_l_j4_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j4,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
e0_h_l_j14_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j14,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
e0_h_l_j16_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j16,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
e0_h_l_j13_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j13,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
e0_h_v_j5_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j5,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
e0_h_v_j7_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j7,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
e0_h_v_j12_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j12,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
e0_P_o_j4_i1 = fun_34071__saturated_pressure(e0_T_j4,e0_C_i1,e0_B_i1,e0_A_i1) ;
e0_P_o_j2_i3 = fun_34071__saturated_pressure(e0_T_j2,e0_C_i3,e0_B_i3,e0_A_i3) ;
e0_P_o_j12_i2 = fun_34071__saturated_pressure(e0_T_j12,e0_C_i2,e0_B_i2,e0_A_i2) ;
e0_P_o_j1_i4 = fun_34071__saturated_pressure(e0_T_j1,e0_C_i4,e0_B_i4,e0_A_i4) ;
e0_h_l_j4_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j4,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
e0_r_j12 =
fun_28540__rate_equation(e0_T_j12,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j12_i1,e0_greek_gamma_j12_i2,e0_greek_gamma_j12_i3,e0_x
_j12_i1,e0_x_j12_i2,e0_x_j12_i3,e0_T_o) ;
e0_h_v_j13_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j13,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
e0_P_o_j6_i3 = fun_34071__saturated_pressure(e0_T_j6,e0_C_i3,e0_B_i3,e0_A_i3) ;
e0_h_l_j5_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j5,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
e0_r_j13 =
fun_28540__rate_equation(e0_T_j13,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j13_i1,e0_greek_gamma_j13_i2,e0_greek_gamma_j13_i3,e0_x
_j13_i1,e0_x_j13_i2,e0_x_j13_i3,e0_T_o) ;
e0_h_l_j14_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j14,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
e0_h_v_j15_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j15,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
e0_P_o_j7_i2 = fun_34071__saturated_pressure(e0_T_j7,e0_C_i2,e0_B_i2,e0_A_i2) ;
e0_h_v_j11_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j11,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
e0_P_o_j7_i3 = fun_34071__saturated_pressure(e0_T_j7,e0_C_i3,e0_B_i3,e0_A_i3) ;
e0_h_l_j16_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j16,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
e0_h_l_j2_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j2,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
e0_h_v_j16_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j16,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
e0_P_o_j9_i1 = fun_34071__saturated_pressure(e0_T_j9,e0_C_i1,e0_B_i1,e0_A_i1) ;
e0_h_l_j9_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j9,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
e0_h_l_j8_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j8,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_h_l_j6_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j6,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
e0_h_v_j15_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j15,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
e0_h_l_j4_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j4,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_h_l_j6_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j6,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_h_l_j6_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j6,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
e0_h_v_j15_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j15,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
e0_h_v_j10_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j10,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
e0_P_o_j16_i4 = fun_34071__saturated_pressure(e0_T_j16,e0_C_i4,e0_B_i4,e0_A_i4) ;
e0_h_v_j7_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j7,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
e0_h_l_j9_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j9,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_r_j7 =
fun_28540__rate_equation(e0_T_j7,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j7_i1,e0_greek_gamma_j7_i2,e0_greek_gamma_j7_i3,e0_x_j7_i
1,e0_x_j7_i2,e0_x_j7_i3,e0_T_o) ;
e0_h_v_j9_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j9,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
e0_h_v_j6_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j6,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
e0_h_v_j14_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j14,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
e0_h_l_j3_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j3,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_P_o_j10_i4 = fun_34071__saturated_pressure(e0_T_j10,e0_C_i4,e0_B_i4,e0_A_i4) ;
e0_h_v_j16_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j16,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
e0_h_v_j2_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j2,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
e0_h_l_j11_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j11,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
e0_h_v_j5_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j5,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
e0_r_j6 =
fun_28540__rate_equation(e0_T_j6,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j6_i1,e0_greek_gamma_j6_i2,e0_greek_gamma_j6_i3,e0_x_j6_i
1,e0_x_j6_i2,e0_x_j6_i3,e0_T_o) ;
e0_h_v_j3_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j3,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
e0_P_o_j4_i4 = fun_34071__saturated_pressure(e0_T_j4,e0_C_i4,e0_B_i4,e0_A_i4) ;
e0_h_v_j8_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j8,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
e0_h_l_j14_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j14,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
e0_h_l_j3_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j3,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
e0_P_o_j1_i1 = fun_34071__saturated_pressure(e0_T_j1,e0_C_i1,e0_B_i1,e0_A_i1) ;
e0_h_l_j7_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j7,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
e0_h_v_j11_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j11,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
e0_h_v_j3_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j3,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
e0_h_l_j8_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j8,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
e0_h_v_j14_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j14,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
e0_h_v_j1_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j1,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
e0_r_j11 =
fun_28540__rate_equation(e0_T_j11,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j11_i1,e0_greek_gamma_j11_i2,e0_greek_gamma_j11_i3,e0_x
_j11_i1,e0_x_j11_i2,e0_x_j11_i3,e0_T_o) ;
e0_P_o_j3_i4 = fun_34071__saturated_pressure(e0_T_j3,e0_C_i4,e0_B_i4,e0_A_i4) ;
e0_h_l_j4_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j4,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
e0_h_l_j2_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j2,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
e0_r_j1 =
fun_28540__rate_equation(e0_T_j1,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j1_i1,e0_greek_gamma_j1_i2,e0_greek_gamma_j1_i3,e0_x_j1_i
1,e0_x_j1_i2,e0_x_j1_i3,e0_T_o) ;
e0_h_l_j1_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j1,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
e0_h_l_j13_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j13,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
e0_h_l_j12_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j12,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
e0_P_o_j5_i1 = fun_34071__saturated_pressure(e0_T_j5,e0_C_i1,e0_B_i1,e0_A_i1) ;
e0_P_o_j16_i3 = fun_34071__saturated_pressure(e0_T_j16,e0_C_i3,e0_B_i3,e0_A_i3) ;
e0_h_v_j16_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j16,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
e0_h_v_j13_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j13,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
e0_h_l_j7_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j7,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
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   e0_P_o_j14_i4 = fun_34071__saturated_pressure(e0_T_j14,e0_C_i4,e0_B_i4,e0_A_i4) ;
   e0_P_o_j15_i4 = fun_34071__saturated_pressure(e0_T_j15,e0_C_i4,e0_B_i4,e0_A_i4) ;
   e0_h_l_j10_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j10,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
   e0_h_v_j14_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j14,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_r_j4 =
fun_28540__rate_equation(e0_T_j4,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j4_i1,e0_greek_gamma_j4_i2,e0_greek_gamma_j4_i3,e0_x_j4_i
1,e0_x_j4_i2,e0_x_j4_i3,e0_T_o) ;
   e0_h_l_j15_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j15,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
   e0_h_v_j3_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j3,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_h_v_j2_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j2,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
   e0_P_o_j1_i2 = fun_34071__saturated_pressure(e0_T_j1,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_h_l_j10_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j10,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
   e0_h_l_j9_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j9,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
   e0_h_v_j9_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j9,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_h_l_j16_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j16,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
   e0_P_o_j4_i2 = fun_34071__saturated_pressure(e0_T_j4,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_P_o_j3_i3 = fun_34071__saturated_pressure(e0_T_j3,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_h_v_j3_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j3,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
   e0_h_v_j12_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j12,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_h_l_j7_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j7,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
   e0_h_l_j5_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j5,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
   e0_P_o_j11_i1 = fun_34071__saturated_pressure(e0_T_j11,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_h_v_j4_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j4,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_h_l_j0_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j0,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
   e0_h_l_j3_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j3,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
   e0_P_o_j13_i2 = fun_34071__saturated_pressure(e0_T_j13,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_P_o_j5_i2 = fun_34071__saturated_pressure(e0_T_j5,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_P_o_j12_i3 = fun_34071__saturated_pressure(e0_T_j12,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_h_v_j4_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j4,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
   e0_h_l_j1_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j1,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
   e0_h_l_j2_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j2,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
   e0_h_v_j7_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j7,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
   e0_h_l_j5_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j5,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
   e0_h_v_j2_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j2,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
   e0_h_v_j4_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j4,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_h_l_j11_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j11,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
   e0_h_v_j1_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j1,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
   e0_P_o_j9_i4 = fun_34071__saturated_pressure(e0_T_j9,e0_C_i4,e0_B_i4,e0_A_i4) ;
   e0_P_o_j10_i3 = fun_34071__saturated_pressure(e0_T_j10,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_h_l_j1_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j1,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
   e0_h_v_j4_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j4,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
   e0_h_l_j0_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j0,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
   e0_P_o_j11_i4 = fun_34071__saturated_pressure(e0_T_j11,e0_C_i4,e0_B_i4,e0_A_i4) ;
   e0_P_o_j14_i1 = fun_34071__saturated_pressure(e0_T_j14,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_h_v_j10_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j10,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_h_v_j13_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j13,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
   e0_h_v_j15_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j15,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_h_l_j2_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j2,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
   e0_h_v_j12_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j12,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
   e0_P_o_j2_i1 = fun_34071__saturated_pressure(e0_T_j2,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_P_o_j6_i2 = fun_34071__saturated_pressure(e0_T_j6,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_h_l_j13_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j13,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
   e0_h_v_j8_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j8,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
   e0_P_o_j16_i1 = fun_34071__saturated_pressure(e0_T_j16,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_h_v_j1_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j1,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_P_o_j13_i1 = fun_34071__saturated_pressure(e0_T_j13,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_P_o_j13_i4 = fun_34071__saturated_pressure(e0_T_j13,e0_C_i4,e0_B_i4,e0_A_i4) ;
   e0_r_j10 =
fun_28540__rate_equation(e0_T_j10,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j10_i1,e0_greek_gamma_j10_i2,e0_greek_gamma_j10_i3,e0_x
_j10_i1,e0_x_j10_i2,e0_x_j10_i3,e0_T_o) ;
   e0_h_v_j1_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j1,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_r_j8 =
fun_28540__rate_equation(e0_T_j8,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j8_i1,e0_greek_gamma_j8_i2,e0_greek_gamma_j8_i3,e0_x_j8_i
1,e0_x_j8_i2,e0_x_j8_i3,e0_T_o) ;
   e0_h_v_j10_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j10,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_P_o_j8_i3 = fun_34071__saturated_pressure(e0_T_j8,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_h_v_j2_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j2,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_h_l_j12_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j12,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
   e0_h_v_j7_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j7,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
   e0_h_v_j9_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j9,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
   e0_r_j3 =
fun_28540__rate_equation(e0_T_j3,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j3_i1,e0_greek_gamma_j3_i2,e0_greek_gamma_j3_i3,e0_x_j3_i
1,e0_x_j3_i2,e0_x_j3_i3,e0_T_o) ;
   e0_P_o_j7_i4 = fun_34071__saturated_pressure(e0_T_j7,e0_C_i4,e0_B_i4,e0_A_i4) ;
   e0_h_v_j11_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j11,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_P_o_j14_i3 = fun_34071__saturated_pressure(e0_T_j14,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_P_o_j10_i1 = fun_34071__saturated_pressure(e0_T_j10,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_P_o_j7_i1 = fun_34071__saturated_pressure(e0_T_j7,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_P_o_j5_i3 = fun_34071__saturated_pressure(e0_T_j5,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_h_v_j12_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j12,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_P_o_j1_i3 = fun_34071__saturated_pressure(e0_T_j1,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_h_l_j5_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j5,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
   e0_r_j15 =
fun_28540__rate_equation(e0_T_j15,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j15_i1,e0_greek_gamma_j15_i2,e0_greek_gamma_j15_i3,e0_x
_j15_i1,e0_x_j15_i2,e0_x_j15_i3,e0_T_o) ;
   e0_h_l_j14_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j14,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
   e0_h_l_j8_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j8,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
   e0_P_o_j14_i2 = fun_34071__saturated_pressure(e0_T_j14,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_P_o_j2_i2 = fun_34071__saturated_pressure(e0_T_j2,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_h_l_j3_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j3,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
   e0_P_o_j11_i3 = fun_34071__saturated_pressure(e0_T_j11,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_h_l_j10_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j10,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
   e0_r_j14 =
fun_28540__rate_equation(e0_T_j14,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j14_i1,e0_greek_gamma_j14_i2,e0_greek_gamma_j14_i3,e0_x
_j14_i1,e0_x_j14_i2,e0_x_j14_i3,e0_T_o) ;
   e0_h_l_j11_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j11,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
   e0_h_v_j8_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j8,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
   e0_P_o_j15_i1 = fun_34071__saturated_pressure(e0_T_j15,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_P_o_j13_i3 = fun_34071__saturated_pressure(e0_T_j13,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_P_o_j3_i1 = fun_34071__saturated_pressure(e0_T_j3,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_P_o_j12_i4 = fun_34071__saturated_pressure(e0_T_j12,e0_C_i4,e0_B_i4,e0_A_i4) ;
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   e0_P_o_j6_i1 = fun_34071__saturated_pressure(e0_T_j6,e0_C_i1,e0_B_i1,e0_A_i1) ;
   e0_P_o_j9_i3 = fun_34071__saturated_pressure(e0_T_j9,e0_C_i3,e0_B_i3,e0_A_i3) ;
   e0_h_l_j6_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j6,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
   e0_P_o_j9_i2 = fun_34071__saturated_pressure(e0_T_j9,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_h_l_j7_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j7,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
   e0_h_v_j13_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j13,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_h_l_j15_i1 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j15,e0_C_L_i1,e0_B_L_i1,e0_A_L_i1) ;
   e0_h_l_j13_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j13,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
   e0_h_l_j12_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j12,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
   e0_h_v_j9_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j9,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_h_v_j16_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j16,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
   e0_P_o_j15_i2 = fun_34071__saturated_pressure(e0_T_j15,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_h_v_j11_i3 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j11,e0_greek_lambda_b_i3,e0_A_L_i3,e0_B_L_i3,e0_C_L_i3,e0_T_b_i3,e0_T_c_i3) ;
   e0_h_v_j6_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j6,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_h_l_j15_i4 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j15,e0_C_L_i4,e0_B_L_i4,e0_A_L_i4) ;
   e0_r_j5 =
fun_28540__rate_equation(e0_T_j5,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j5_i1,e0_greek_gamma_j5_i2,e0_greek_gamma_j5_i3,e0_x_j5_i
1,e0_x_j5_i2,e0_x_j5_i3,e0_T_o) ;
   e0_h_l_j16_i3 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j16,e0_C_L_i3,e0_B_L_i3,e0_A_L_i3) ;
   e0_h_v_j6_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j6,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_h_v_j6_i4 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j6,e0_greek_lambda_b_i4,e0_A_L_i4,e0_B_L_i4,e0_C_L_i4,e0_T_b_i4,e0_T_c_i4) ;
   e0_h_v_j8_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j8,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_h_v_j5_i2 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j5,e0_greek_lambda_b_i2,e0_A_L_i2,e0_B_L_i2,e0_C_L_i2,e0_T_b_i2,e0_T_c_i2) ;
   e0_P_o_j2_i4 = fun_34071__saturated_pressure(e0_T_j2,e0_C_i4,e0_B_i4,e0_A_i4) ;
   e0_r_j2 =
fun_28540__rate_equation(e0_T_j2,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j2_i1,e0_greek_gamma_j2_i2,e0_greek_gamma_j2_i3,e0_x_j2_i
1,e0_x_j2_i2,e0_x_j2_i3,e0_T_o) ;
   e0_r_j9 =
fun_28540__rate_equation(e0_T_j9,e0_W,e0_q,e0_A1,e0_A2,e0_A3,e0_A4,e0_A5,e0_A6,e0_greek_gamma_j9_i1,e0_greek_gamma_j9_i2,e0_greek_gamma_j9_i3,e0_x_j9_i
1,e0_x_j9_i2,e0_x_j9_i3,e0_T_o) ;
   e0_h_l_j0_i2 = fun_34068__enthapy_of_saturated_liquid_components(e0_T_j0,e0_C_L_i2,e0_B_L_i2,e0_A_L_i2) ;
   e0_h_v_j5_i1 = fun_34070__enthapy_of_saturated_vapour_components(e0_T_j5,e0_greek_lambda_b_i1,e0_A_L_i1,e0_B_L_i1,e0_C_L_i1,e0_T_b_i1,e0_T_c_i1) ;
   e0_P_o_j10_i2 = fun_34071__saturated_pressure(e0_T_j10,e0_C_i2,e0_B_i2,e0_A_i2) ;
   e0_h_L_j14 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j14_i1,e0_h_l_j14_i2,e0_h_l_j14_i3,e0_h_l_j14_i4,e0_x_j14_i1,e0_x_j14_i2,e0_x_j14_i3,e0_x_j14_i4) ;
   e0_K_j5_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j5_i3,e0_P_o_j5_i3,e0_P,e0_greek_phi) ;
   e0_K_j7_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j7_i1,e0_P_o_j7_i1,e0_P,e0_greek_phi) ;
   e0_K_j10_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j10_i2,e0_P_o_j10_i2,e0_P,e0_greek_phi) ;
   e0_h_V_j4 = fun_34075__enthapy_of_saturated_vapour(e0_h_v_j4_i1,e0_h_v_j4_i3,e0_h_v_j4_i2,e0_h_v_j4_i4,e0_y_j4_i1,e0_y_j4_i2,e0_y_j4_i3,e0_y_j4_i4) ;
   e0_K_j1_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j1_i1,e0_P_o_j1_i1,e0_P,e0_greek_phi) ;
   e0_K_j9_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j9_i3,e0_P_o_j9_i3,e0_P,e0_greek_phi) ;
   e0_h_L_j11 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j11_i1,e0_h_l_j11_i2,e0_h_l_j11_i3,e0_h_l_j11_i4,e0_x_j11_i1,e0_x_j11_i2,e0_x_j11_i3,e0_x_j11_i4) ;
   e0_h_L_j9 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j9_i1,e0_h_l_j9_i2,e0_h_l_j9_i3,e0_h_l_j9_i4,e0_x_j9_i1,e0_x_j9_i2,e0_x_j9_i3,e0_x_j9_i4) ;
   e0_K_j8_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j8_i4,e0_P_o_j8_i4,e0_P,e0_greek_phi) ;
   e0_K_j2_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j2_i1,e0_P_o_j2_i1,e0_P,e0_greek_phi) ;
   e0_h_V_j8 = fun_34075__enthapy_of_saturated_vapour(e0_h_v_j8_i1,e0_h_v_j8_i3,e0_h_v_j8_i2,e0_h_v_j8_i4,e0_y_j8_i1,e0_y_j8_i2,e0_y_j8_i3,e0_y_j8_i4) ;
   e0_K_j14_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j14_i1,e0_P_o_j14_i1,e0_P,e0_greek_phi) ;
   e0_K_j11_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j11_i4,e0_P_o_j11_i4,e0_P,e0_greek_phi) ;
   e0_h_V_j11 =
fun_34075__enthapy_of_saturated_vapour(e0_h_v_j11_i1,e0_h_v_j11_i3,e0_h_v_j11_i2,e0_h_v_j11_i4,e0_y_j11_i1,e0_y_j11_i2,e0_y_j11_i3,e0_y_j11_i4) ;
   e0_K_j10_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j10_i3,e0_P_o_j10_i3,e0_P,e0_greek_phi) ;
   e0_K_j1_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j1_i2,e0_P_o_j1_i2,e0_P,e0_greek_phi) ;
   e0_K_j9_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j9_i4,e0_P_o_j9_i4,e0_P,e0_greek_phi) ;
   e0_K_j12_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j12_i3,e0_P_o_j12_i3,e0_P,e0_greek_phi) ;
   e0_h_L_j7 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j7_i1,e0_h_l_j7_i2,e0_h_l_j7_i3,e0_h_l_j7_i4,e0_x_j7_i1,e0_x_j7_i2,e0_x_j7_i3,e0_x_j7_i4) ;
   e0_h_L_j12 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j12_i1,e0_h_l_j12_i2,e0_h_l_j12_i3,e0_h_l_j12_i4,e0_x_j12_i1,e0_x_j12_i2,e0_x_j12_i3,e0_x_j12_i4) ;
   e0_h_V_j5 = fun_34075__enthapy_of_saturated_vapour(e0_h_v_j5_i1,e0_h_v_j5_i3,e0_h_v_j5_i2,e0_h_v_j5_i4,e0_y_j5_i1,e0_y_j5_i2,e0_y_j5_i3,e0_y_j5_i4) ;
   e0_K_j13_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j13_i2,e0_P_o_j13_i2,e0_P,e0_greek_phi) ;
   e0_K_j16_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j16_i2,e0_P_o_j16_i2,e0_P,e0_greek_phi) ;
   e0_K_j15_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j15_i3,e0_P_o_j15_i3,e0_P,e0_greek_phi) ;
   e0_K_j16_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j16_i4,e0_P_o_j16_i4,e0_P,e0_greek_phi) ;
   e0_h_L_j13 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j13_i1,e0_h_l_j13_i2,e0_h_l_j13_i3,e0_h_l_j13_i4,e0_x_j13_i1,e0_x_j13_i2,e0_x_j13_i3,e0_x_j13_i4) ;
   e0_h_V_j6 = fun_34075__enthapy_of_saturated_vapour(e0_h_v_j6_i1,e0_h_v_j6_i3,e0_h_v_j6_i2,e0_h_v_j6_i4,e0_y_j6_i1,e0_y_j6_i2,e0_y_j6_i3,e0_y_j6_i4) ;
   e0_K_j10_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j10_i4,e0_P_o_j10_i4,e0_P,e0_greek_phi) ;
   e0_h_L_j0 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j0_i1,e0_h_l_j0_i2,e0_h_l_j0_i3,e0_h_l_j0_i4,e0_x_j0_i1,e0_x_j0_i2,e0_x_j0_i3,e0_x_j0_i4) ;
   e0_K_j5_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j5_i1,e0_P_o_j5_i1,e0_P,e0_greek_phi) ;
   e0_K_j6_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j6_i3,e0_P_o_j6_i3,e0_P,e0_greek_phi) ;
   e0_K_j14_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j14_i4,e0_P_o_j14_i4,e0_P,e0_greek_phi) ;
   e0_h_L_j10 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j10_i1,e0_h_l_j10_i2,e0_h_l_j10_i3,e0_h_l_j10_i4,e0_x_j10_i1,e0_x_j10_i2,e0_x_j10_i3,e0_x_j10_i4) ;
   e0_K_j11_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j11_i2,e0_P_o_j11_i2,e0_P,e0_greek_phi) ;
   e0_h_V_j2 = fun_34075__enthapy_of_saturated_vapour(e0_h_v_j2_i1,e0_h_v_j2_i3,e0_h_v_j2_i2,e0_h_v_j2_i4,e0_y_j2_i1,e0_y_j2_i2,e0_y_j2_i3,e0_y_j2_i4) ;
   e0_K_j12_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j12_i1,e0_P_o_j12_i1,e0_P,e0_greek_phi) ;
   e0_K_j3_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j3_i1,e0_P_o_j3_i1,e0_P,e0_greek_phi) ;
   e0_K_j11_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j11_i3,e0_P_o_j11_i3,e0_P,e0_greek_phi) ;
   e0_h_V_j3 = fun_34075__enthapy_of_saturated_vapour(e0_h_v_j3_i1,e0_h_v_j3_i3,e0_h_v_j3_i2,e0_h_v_j3_i4,e0_y_j3_i1,e0_y_j3_i2,e0_y_j3_i3,e0_y_j3_i4) ;
   e0_h_L_j5 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j5_i1,e0_h_l_j5_i2,e0_h_l_j5_i3,e0_h_l_j5_i4,e0_x_j5_i1,e0_x_j5_i2,e0_x_j5_i3,e0_x_j5_i4) ;
   e0_h_V_j16 =
fun_34075__enthapy_of_saturated_vapour(e0_h_v_j16_i1,e0_h_v_j16_i3,e0_h_v_j16_i2,e0_h_v_j16_i4,e0_y_j16_i1,e0_y_j16_i2,e0_y_j16_i3,e0_y_j16_i4) ;
   e0_K_j2_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j2_i2,e0_P_o_j2_i2,e0_P,e0_greek_phi) ;
   e0_h_V_j12 =
fun_34075__enthapy_of_saturated_vapour(e0_h_v_j12_i1,e0_h_v_j12_i3,e0_h_v_j12_i2,e0_h_v_j12_i4,e0_y_j12_i1,e0_y_j12_i2,e0_y_j12_i3,e0_y_j12_i4) ;
   e0_h_V_j7 = fun_34075__enthapy_of_saturated_vapour(e0_h_v_j7_i1,e0_h_v_j7_i3,e0_h_v_j7_i2,e0_h_v_j7_i4,e0_y_j7_i1,e0_y_j7_i2,e0_y_j7_i3,e0_y_j7_i4) ;
   e0_K_j4_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j4_i4,e0_P_o_j4_i4,e0_P,e0_greek_phi) ;
   e0_K_j1_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j1_i3,e0_P_o_j1_i3,e0_P,e0_greek_phi) ;
   e0_K_j5_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j5_i2,e0_P_o_j5_i2,e0_P,e0_greek_phi) ;
   e0_K_j6_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j6_i1,e0_P_o_j6_i1,e0_P,e0_greek_phi) ;
   e0_K_j7_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j7_i3,e0_P_o_j7_i3,e0_P,e0_greek_phi) ;
   e0_K_j5_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j5_i4,e0_P_o_j5_i4,e0_P,e0_greek_phi) ;
   e0_h_L_j8 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j8_i1,e0_h_l_j8_i2,e0_h_l_j8_i3,e0_h_l_j8_i4,e0_x_j8_i1,e0_x_j8_i2,e0_x_j8_i3,e0_x_j8_i4) ;
   e0_K_j15_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j15_i1,e0_P_o_j15_i1,e0_P,e0_greek_phi) ;
   e0_K_j13_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j13_i3,e0_P_o_j13_i3,e0_P,e0_greek_phi) ;
   e0_h_L_j1 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j1_i1,e0_h_l_j1_i2,e0_h_l_j1_i3,e0_h_l_j1_i4,e0_x_j1_i1,e0_x_j1_i2,e0_x_j1_i3,e0_x_j1_i4) ;
   e0_K_j12_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j12_i4,e0_P_o_j12_i4,e0_P,e0_greek_phi) ;
   e0_h_L_j6 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j6_i1,e0_h_l_j6_i2,e0_h_l_j6_i3,e0_h_l_j6_i4,e0_x_j6_i1,e0_x_j6_i2,e0_x_j6_i3,e0_x_j6_i4) ;
   e0_K_j16_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j16_i3,e0_P_o_j16_i3,e0_P,e0_greek_phi) ;
   e0_K_j11_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j11_i1,e0_P_o_j11_i1,e0_P,e0_greek_phi) ;
   e0_K_j14_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j14_i2,e0_P_o_j14_i2,e0_P,e0_greek_phi) ;
   e0_K_j15_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j15_i4,e0_P_o_j15_i4,e0_P,e0_greek_phi) ;
   e0_K_j7_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j7_i2,e0_P_o_j7_i2,e0_P,e0_greek_phi) ;
   e0_K_j8_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j8_i1,e0_P_o_j8_i1,e0_P,e0_greek_phi) ;
   e0_K_j9_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j9_i1,e0_P_o_j9_i1,e0_P,e0_greek_phi) ;
   e0_K_j6_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j6_i4,e0_P_o_j6_i4,e0_P,e0_greek_phi) ;
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    e0_K_j8_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j8_i2,e0_P_o_j8_i2,e0_P,e0_greek_phi) ;
    e0_K_j3_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j3_i2,e0_P_o_j3_i2,e0_P,e0_greek_phi) ;
    e0_K_j4_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j4_i3,e0_P_o_j4_i3,e0_P,e0_greek_phi) ;
    e0_h_V_j15 =
fun_34075__enthapy_of_saturated_vapour(e0_h_v_j15_i1,e0_h_v_j15_i3,e0_h_v_j15_i2,e0_h_v_j15_i4,e0_y_j15_i1,e0_y_j15_i2,e0_y_j15_i3,e0_y_j15_i4) ;
    e0_K_j14_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j14_i3,e0_P_o_j14_i3,e0_P,e0_greek_phi) ;
    e0_K_j10_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j10_i1,e0_P_o_j10_i1,e0_P,e0_greek_phi) ;
    e0_h_L_j2 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j2_i1,e0_h_l_j2_i2,e0_h_l_j2_i3,e0_h_l_j2_i4,e0_x_j2_i1,e0_x_j2_i2,e0_x_j2_i3,e0_x_j2_i4) ;
    e0_h_L_j4 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j4_i1,e0_h_l_j4_i2,e0_h_l_j4_i3,e0_h_l_j4_i4,e0_x_j4_i1,e0_x_j4_i2,e0_x_j4_i3,e0_x_j4_i4) ;
    e0_K_j3_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j3_i4,e0_P_o_j3_i4,e0_P,e0_greek_phi) ;
    e0_h_L_j3 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j3_i1,e0_h_l_j3_i2,e0_h_l_j3_i3,e0_h_l_j3_i4,e0_x_j3_i1,e0_x_j3_i2,e0_x_j3_i3,e0_x_j3_i4) ;
    e0_K_j9_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j9_i2,e0_P_o_j9_i2,e0_P,e0_greek_phi) ;
    e0_K_j4_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j4_i2,e0_P_o_j4_i2,e0_P,e0_greek_phi) ;
    e0_K_j3_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j3_i3,e0_P_o_j3_i3,e0_P,e0_greek_phi) ;
    e0_h_V_j10 =
fun_34075__enthapy_of_saturated_vapour(e0_h_v_j10_i1,e0_h_v_j10_i3,e0_h_v_j10_i2,e0_h_v_j10_i4,e0_y_j10_i1,e0_y_j10_i2,e0_y_j10_i3,e0_y_j10_i4) ;
    e0_K_j2_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j2_i3,e0_P_o_j2_i3,e0_P,e0_greek_phi) ;
    e0_K_j4_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j4_i1,e0_P_o_j4_i1,e0_P,e0_greek_phi) ;
    e0_h_V_j9 = fun_34075__enthapy_of_saturated_vapour(e0_h_v_j9_i1,e0_h_v_j9_i3,e0_h_v_j9_i2,e0_h_v_j9_i4,e0_y_j9_i1,e0_y_j9_i2,e0_y_j9_i3,e0_y_j9_i4) ;
    e0_K_j12_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j12_i2,e0_P_o_j12_i2,e0_P,e0_greek_phi) ;
    e0_K_j1_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j1_i4,e0_P_o_j1_i4,e0_P,e0_greek_phi) ;
    e0_K_j2_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j2_i4,e0_P_o_j2_i4,e0_P,e0_greek_phi) ;
    e0_h_L_j16 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j16_i1,e0_h_l_j16_i2,e0_h_l_j16_i3,e0_h_l_j16_i4,e0_x_j16_i1,e0_x_j16_i2,e0_x_j16_i3,e0_x_j16_i4) ;
    e0_K_j15_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j15_i2,e0_P_o_j15_i2,e0_P,e0_greek_phi) ;
    e0_K_j8_i3 = fun_36075__phase_equilibrium(e0_greek_gamma_j8_i3,e0_P_o_j8_i3,e0_P,e0_greek_phi) ;
    e0_h_V_j1 = fun_34075__enthapy_of_saturated_vapour(e0_h_v_j1_i1,e0_h_v_j1_i3,e0_h_v_j1_i2,e0_h_v_j1_i4,e0_y_j1_i1,e0_y_j1_i2,e0_y_j1_i3,e0_y_j1_i4) ;
    e0_K_j7_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j7_i4,e0_P_o_j7_i4,e0_P,e0_greek_phi) ;
    e0_h_V_j14 =
fun_34075__enthapy_of_saturated_vapour(e0_h_v_j14_i1,e0_h_v_j14_i3,e0_h_v_j14_i2,e0_h_v_j14_i4,e0_y_j14_i1,e0_y_j14_i2,e0_y_j14_i3,e0_y_j14_i4) ;
    e0_K_j6_i2 = fun_36075__phase_equilibrium(e0_greek_gamma_j6_i2,e0_P_o_j6_i2,e0_P,e0_greek_phi) ;
    e0_K_j16_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j16_i1,e0_P_o_j16_i1,e0_P,e0_greek_phi) ;
    e0_h_V_j13 =
fun_34075__enthapy_of_saturated_vapour(e0_h_v_j13_i1,e0_h_v_j13_i3,e0_h_v_j13_i2,e0_h_v_j13_i4,e0_y_j13_i1,e0_y_j13_i2,e0_y_j13_i3,e0_y_j13_i4) ;
    e0_K_j13_i1 = fun_36075__phase_equilibrium(e0_greek_gamma_j13_i1,e0_P_o_j13_i1,e0_P,e0_greek_phi) ;
    e0_K_j13_i4 = fun_36075__phase_equilibrium(e0_greek_gamma_j13_i4,e0_P_o_j13_i4,e0_P,e0_greek_phi) ;
    e0_h_L_j15 = fun_34073__enthapy_of_saturated_liquid(e0_h_l_j15_i1,e0_h_l_j15_i2,e0_h_l_j15_i3,e0_h_l_j15_i4,e0_x_j15_i1,e0_x_j15_i2,e0_x_j15_i3,e0_x_j15_i4) ;

    % evaluate the function values
    Y(1) = ( e0_x_j1_i1 + e0_x_j1_i2 + e0_x_j1_i3 + e0_x_j1_i4 ) - ( 1.0 );
    Y(2) = ( e0_x_j2_i1 + e0_x_j2_i2 + e0_x_j2_i3 + e0_x_j2_i4 ) - ( 1.0 );
    Y(3) = ( e0_x_j3_i1 + e0_x_j3_i2 + e0_x_j3_i3 + e0_x_j3_i4 ) - ( 1.0 );
    Y(4) = ( e0_x_j4_i1 + e0_x_j4_i2 + e0_x_j4_i3 + e0_x_j4_i4 ) - ( 1.0 );
    Y(5) = ( e0_x_j5_i1 + e0_x_j5_i2 + e0_x_j5_i3 + e0_x_j5_i4 ) - ( 1.0 );
    Y(6) = ( e0_x_j6_i1 + e0_x_j6_i2 + e0_x_j6_i3 + e0_x_j6_i4 ) - ( 1.0 );
    Y(7) = ( e0_x_j7_i1 + e0_x_j7_i2 + e0_x_j7_i3 + e0_x_j7_i4 ) - ( 1.0 );
    Y(8) = ( e0_x_j8_i1 + e0_x_j8_i2 + e0_x_j8_i3 + e0_x_j8_i4 ) - ( 1.0 );
    Y(9) = ( e0_x_j9_i1 + e0_x_j9_i2 + e0_x_j9_i3 + e0_x_j9_i4 ) - ( 1.0 );
    Y(10) = ( e0_x_j10_i1 + e0_x_j10_i2 + e0_x_j10_i3 + e0_x_j10_i4 ) - ( 1.0 );
    Y(11) = ( e0_x_j11_i1 + e0_x_j11_i2 + e0_x_j11_i3 + e0_x_j11_i4 ) - ( 1.0 );
    Y(12) = ( e0_x_j12_i1 + e0_x_j12_i2 + e0_x_j12_i3 + e0_x_j12_i4 ) - ( 1.0 );
    Y(13) = ( e0_x_j13_i1 + e0_x_j13_i2 + e0_x_j13_i3 + e0_x_j13_i4 ) - ( 1.0 );
    Y(14) = ( e0_x_j14_i1 + e0_x_j14_i2 + e0_x_j14_i3 + e0_x_j14_i4 ) - ( 1.0 );
    Y(15) = ( e0_x_j15_i1 + e0_x_j15_i2 + e0_x_j15_i3 + e0_x_j15_i4 ) - ( 1.0 );
    Y(16) = e0_R_c - ( ( e0_L_j0 )/( e0_D_c ) );
    Y(17) = e0_B_r * e0_x_j16_i1 - ( e0_L_j15 * e0_x_j15_i1 - e0_V_j16 * e0_y_j16_i1 );
    Y(18) = e0_B_r * e0_x_j16_i2 - ( e0_L_j15 * e0_x_j15_i2 - e0_V_j16 * e0_y_j16_i2 );
    Y(19) = e0_B_r * e0_x_j16_i3 - ( e0_L_j15 * e0_x_j15_i3 - e0_V_j16 * e0_y_j16_i3 );
    Y(20) = e0_B_r * e0_x_j16_i4 - ( e0_L_j15 * e0_x_j15_i4 - e0_V_j16 * e0_y_j16_i4 );
    Y(21) = ( e0_y_j1_i1 + e0_y_j1_i2 + e0_y_j1_i3 + e0_y_j1_i4 ) - ( 1.0 );
    Y(22) = ( e0_y_j2_i1 + e0_y_j2_i2 + e0_y_j2_i3 + e0_y_j2_i4 ) - ( 1.0 );
    Y(23) = ( e0_y_j3_i1 + e0_y_j3_i2 + e0_y_j3_i3 + e0_y_j3_i4 ) - ( 1.0 );
    Y(24) = ( e0_y_j4_i1 + e0_y_j4_i2 + e0_y_j4_i3 + e0_y_j4_i4 ) - ( 1.0 );
    Y(25) = ( e0_y_j5_i1 + e0_y_j5_i2 + e0_y_j5_i3 + e0_y_j5_i4 ) - ( 1.0 );
    Y(26) = ( e0_y_j6_i1 + e0_y_j6_i2 + e0_y_j6_i3 + e0_y_j6_i4 ) - ( 1.0 );
    Y(27) = ( e0_y_j7_i1 + e0_y_j7_i2 + e0_y_j7_i3 + e0_y_j7_i4 ) - ( 1.0 );
    Y(28) = ( e0_y_j8_i1 + e0_y_j8_i2 + e0_y_j8_i3 + e0_y_j8_i4 ) - ( 1.0 );
    Y(29) = ( e0_y_j9_i1 + e0_y_j9_i2 + e0_y_j9_i3 + e0_y_j9_i4 ) - ( 1.0 );
    Y(30) = ( e0_y_j10_i1 + e0_y_j10_i2 + e0_y_j10_i3 + e0_y_j10_i4 ) - ( 1.0 );
    Y(31) = ( e0_y_j11_i1 + e0_y_j11_i2 + e0_y_j11_i3 + e0_y_j11_i4 ) - ( 1.0 );
    Y(32) = ( e0_y_j12_i1 + e0_y_j12_i2 + e0_y_j12_i3 + e0_y_j12_i4 ) - ( 1.0 );
    Y(33) = ( e0_y_j13_i1 + e0_y_j13_i2 + e0_y_j13_i3 + e0_y_j13_i4 ) - ( 1.0 );
    Y(34) = ( e0_y_j14_i1 + e0_y_j14_i2 + e0_y_j14_i3 + e0_y_j14_i4 ) - ( 1.0 );
    Y(35) = ( e0_y_j15_i1 + e0_y_j15_i2 + e0_y_j15_i3 + e0_y_j15_i4 ) - ( 1.0 );
    Y(36) = e0_y_j1_i1 - ( e0_x_j0_i1 );
    Y(37) = e0_y_j1_i2 - ( e0_x_j0_i2 );
    Y(38) = e0_y_j1_i3 - ( e0_x_j0_i3 );
    Y(39) = e0_y_j1_i4 - ( e0_x_j0_i4 );
    Y(40) = ( e0_y_j16_i1 + e0_y_j16_i2 + e0_y_j16_i3 + e0_y_j16_i4 ) - ( 1.0 );
    Y(41) = ( e0_x_j16_i1 + e0_x_j16_i2 + e0_x_j16_i3 + e0_x_j16_i4 ) - ( 1.0 );
    Y(42) = e0_V_j1 - ( e0_L_j0 + e0_D_c );
    Y(43) = e0_V_j1 * e0_h_V_j1 - ( e0_h_L_j0 * ( e0_L_j0 + e0_D_c ) + e0_Q_c );
    Y(44) = e0_B_r * e0_h_L_j16 - ( e0_L_j15 * e0_h_L_j15 - e0_V_j16 * e0_h_V_j16 + e0_Q_r );
    Y(45) = 0.0 - ( e0_F_j1 * e0_z_i1 - e0_L_j1 * e0_x_j1_i1 - e0_V_j1 * e0_y_j1_i1 + e0_V_j2 * e0_y_j2_i1 + e0_L_j0 * e0_x_j0_i1 + e0_greek_delta_j1 * e0_v_i1 *
e0_r_j1 );
    Y(46) = 0.0 - ( e0_F_j1 * e0_z_i2 - e0_L_j1 * e0_x_j1_i2 - e0_V_j1 * e0_y_j1_i2 + e0_V_j2 * e0_y_j2_i2 + e0_L_j0 * e0_x_j0_i2 + e0_greek_delta_j1 * e0_v_i2 *
e0_r_j1 );
    Y(47) = 0.0 - ( e0_F_j1 * e0_z_i3 - e0_L_j1 * e0_x_j1_i3 - e0_V_j1 * e0_y_j1_i3 + e0_V_j2 * e0_y_j2_i3 + e0_L_j0 * e0_x_j0_i3 + e0_greek_delta_j1 * e0_v_i3 *
e0_r_j1 );
    Y(48) = 0.0 - ( e0_F_j1 * e0_z_i4 - e0_L_j1 * e0_x_j1_i4 - e0_V_j1 * e0_y_j1_i4 + e0_V_j2 * e0_y_j2_i4 + e0_L_j0 * e0_x_j0_i4 + e0_greek_delta_j1 * e0_v_i4 *
e0_r_j1 );
    Y(49) = 0.0 - ( e0_F_j2 * e0_z_i1 - e0_L_j2 * e0_x_j2_i1 - e0_V_j2 * e0_y_j2_i1 + e0_V_j3 * e0_y_j3_i1 + e0_L_j1 * e0_x_j1_i1 + e0_greek_delta_j2 * e0_v_i1 *
e0_r_j2 );
    Y(50) = 0.0 - ( e0_F_j2 * e0_z_i2 - e0_L_j2 * e0_x_j2_i2 - e0_V_j2 * e0_y_j2_i2 + e0_V_j3 * e0_y_j3_i2 + e0_L_j1 * e0_x_j1_i2 + e0_greek_delta_j2 * e0_v_i2 *
e0_r_j2 );
    Y(51) = 0.0 - ( e0_F_j2 * e0_z_i3 - e0_L_j2 * e0_x_j2_i3 - e0_V_j2 * e0_y_j2_i3 + e0_V_j3 * e0_y_j3_i3 + e0_L_j1 * e0_x_j1_i3 + e0_greek_delta_j2 * e0_v_i3 *
e0_r_j2 );
    Y(52) = 0.0 - ( e0_F_j2 * e0_z_i4 - e0_L_j2 * e0_x_j2_i4 - e0_V_j2 * e0_y_j2_i4 + e0_V_j3 * e0_y_j3_i4 + e0_L_j1 * e0_x_j1_i4 + e0_greek_delta_j2 * e0_v_i4 *
e0_r_j2 );
    Y(53) = 0.0 - ( e0_F_j3 * e0_z_i1 - e0_L_j3 * e0_x_j3_i1 - e0_V_j3 * e0_y_j3_i1 + e0_V_j4 * e0_y_j4_i1 + e0_L_j2 * e0_x_j2_i1 + e0_greek_delta_j3 * e0_v_i1 *
e0_r_j3 );
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Y(54) = 0.0 - ( e0_F_j3 * e0_z_i2 - e0_L_j3 * e0_x_j3_i2 - e0_V_j3 * e0_y_j3_i2 + e0_V_j4 * e0_y_j4_i2 + e0_L_j2 * e0_x_j2_i2 + e0_greek_delta_j3 * e0_v_i2 * e0_r_j3 );
Y(55) = 0.0 - ( e0_F_j3 * e0_z_i3 - e0_L_j3 * e0_x_j3_i3 - e0_V_j3 * e0_y_j3_i3 + e0_V_j4 * e0_y_j4_i3 + e0_L_j2 * e0_x_j2_i3 + e0_greek_delta_j3 * e0_v_i3 * e0_r_j3 );
Y(56) = 0.0 - ( e0_F_j3 * e0_z_i4 - e0_L_j3 * e0_x_j3_i4 - e0_V_j3 * e0_y_j3_i4 + e0_V_j4 * e0_y_j4_i4 + e0_L_j2 * e0_x_j2_i4 + e0_greek_delta_j3 * e0_v_i4 * e0_r_j3 );
Y(57) = 0.0 - ( e0_F_j4 * e0_z_i1 - e0_L_j4 * e0_x_j4_i1 - e0_V_j4 * e0_y_j4_i1 + e0_V_j5 * e0_y_j5_i1 + e0_L_j3 * e0_x_j3_i1 + e0_greek_delta_j4 * e0_v_i1 * e0_r_j4 );
Y(58) = 0.0 - ( e0_F_j4 * e0_z_i2 - e0_L_j4 * e0_x_j4_i2 - e0_V_j4 * e0_y_j4_i2 + e0_V_j5 * e0_y_j5_i2 + e0_L_j3 * e0_x_j3_i2 + e0_greek_delta_j4 * e0_v_i2 * e0_r_j4 );
Y(59) = 0.0 - ( e0_F_j4 * e0_z_i3 - e0_L_j4 * e0_x_j4_i3 - e0_V_j4 * e0_y_j4_i3 + e0_V_j5 * e0_y_j5_i3 + e0_L_j3 * e0_x_j3_i3 + e0_greek_delta_j4 * e0_v_i3 * e0_r_j4 );
Y(60) = 0.0 - ( e0_F_j4 * e0_z_i4 - e0_L_j4 * e0_x_j4_i4 - e0_V_j4 * e0_y_j4_i4 + e0_V_j5 * e0_y_j5_i4 + e0_L_j3 * e0_x_j3_i4 + e0_greek_delta_j4 * e0_v_i4 * e0_r_j4 );
Y(61) = 0.0 - ( e0_F_j5 * e0_z_i1 - e0_L_j5 * e0_x_j5_i1 - e0_V_j5 * e0_y_j5_i1 + e0_V_j6 * e0_y_j6_i1 + e0_L_j4 * e0_x_j4_i1 + e0_greek_delta_j5 * e0_v_i1 * e0_r_j5 );
Y(62) = 0.0 - ( e0_F_j5 * e0_z_i2 - e0_L_j5 * e0_x_j5_i2 - e0_V_j5 * e0_y_j5_i2 + e0_V_j6 * e0_y_j6_i2 + e0_L_j4 * e0_x_j4_i2 + e0_greek_delta_j5 * e0_v_i2 * e0_r_j5 );
Y(63) = 0.0 - ( e0_F_j5 * e0_z_i3 - e0_L_j5 * e0_x_j5_i3 - e0_V_j5 * e0_y_j5_i3 + e0_V_j6 * e0_y_j6_i3 + e0_L_j4 * e0_x_j4_i3 + e0_greek_delta_j5 * e0_v_i3 * e0_r_j5 );
Y(64) = 0.0 - ( e0_F_j5 * e0_z_i4 - e0_L_j5 * e0_x_j5_i4 - e0_V_j5 * e0_y_j5_i4 + e0_V_j6 * e0_y_j6_i4 + e0_L_j4 * e0_x_j4_i4 + e0_greek_delta_j5 * e0_v_i4 * e0_r_j5 );
Y(65) = 0.0 - ( e0_F_j6 * e0_z_i1 - e0_L_j6 * e0_x_j6_i1 - e0_V_j6 * e0_y_j6_i1 + e0_V_j7 * e0_y_j7_i1 + e0_L_j5 * e0_x_j5_i1 + e0_greek_delta_j6 * e0_v_i1 * e0_r_j6 );
Y(66) = 0.0 - ( e0_F_j6 * e0_z_i2 - e0_L_j6 * e0_x_j6_i2 - e0_V_j6 * e0_y_j6_i2 + e0_V_j7 * e0_y_j7_i2 + e0_L_j5 * e0_x_j5_i2 + e0_greek_delta_j6 * e0_v_i2 * e0_r_j6 );
Y(67) = 0.0 - ( e0_F_j6 * e0_z_i3 - e0_L_j6 * e0_x_j6_i3 - e0_V_j6 * e0_y_j6_i3 + e0_V_j7 * e0_y_j7_i3 + e0_L_j5 * e0_x_j5_i3 + e0_greek_delta_j6 * e0_v_i3 * e0_r_j6 );
Y(68) = 0.0 - ( e0_F_j6 * e0_z_i4 - e0_L_j6 * e0_x_j6_i4 - e0_V_j6 * e0_y_j6_i4 + e0_V_j7 * e0_y_j7_i4 + e0_L_j5 * e0_x_j5_i4 + e0_greek_delta_j6 * e0_v_i4 * e0_r_j6 );
Y(69) = 0.0 - ( e0_F_j7 * e0_z_i1 - e0_L_j7 * e0_x_j7_i1 - e0_V_j7 * e0_y_j7_i1 + e0_V_j8 * e0_y_j8_i1 + e0_L_j6 * e0_x_j6_i1 + e0_greek_delta_j7 * e0_v_i1 * e0_r_j7 );
Y(70) = 0.0 - ( e0_F_j7 * e0_z_i2 - e0_L_j7 * e0_x_j7_i2 - e0_V_j7 * e0_y_j7_i2 + e0_V_j8 * e0_y_j8_i2 + e0_L_j6 * e0_x_j6_i2 + e0_greek_delta_j7 * e0_v_i2 * e0_r_j7 );
Y(71) = 0.0 - ( e0_F_j7 * e0_z_i3 - e0_L_j7 * e0_x_j7_i3 - e0_V_j7 * e0_y_j7_i3 + e0_V_j8 * e0_y_j8_i3 + e0_L_j6 * e0_x_j6_i3 + e0_greek_delta_j7 * e0_v_i3 * e0_r_j7 );
Y(72) = 0.0 - ( e0_F_j7 * e0_z_i4 - e0_L_j7 * e0_x_j7_i4 - e0_V_j7 * e0_y_j7_i4 + e0_V_j8 * e0_y_j8_i4 + e0_L_j6 * e0_x_j6_i4 + e0_greek_delta_j7 * e0_v_i4 * e0_r_j7 );
Y(73) = 0.0 - ( e0_F_j8 * e0_z_i1 - e0_L_j8 * e0_x_j8_i1 - e0_V_j8 * e0_y_j8_i1 + e0_V_j9 * e0_y_j9_i1 + e0_L_j7 * e0_x_j7_i1 + e0_greek_delta_j8 * e0_v_i1 * e0_r_j8 );
Y(74) = 0.0 - ( e0_F_j8 * e0_z_i2 - e0_L_j8 * e0_x_j8_i2 - e0_V_j8 * e0_y_j8_i2 + e0_V_j9 * e0_y_j9_i2 + e0_L_j7 * e0_x_j7_i2 + e0_greek_delta_j8 * e0_v_i2 * e0_r_j8 );
Y(75) = 0.0 - ( e0_F_j8 * e0_z_i3 - e0_L_j8 * e0_x_j8_i3 - e0_V_j8 * e0_y_j8_i3 + e0_V_j9 * e0_y_j9_i3 + e0_L_j7 * e0_x_j7_i3 + e0_greek_delta_j8 * e0_v_i3 * e0_r_j8 );
Y(76) = 0.0 - ( e0_F_j8 * e0_z_i4 - e0_L_j8 * e0_x_j8_i4 - e0_V_j8 * e0_y_j8_i4 + e0_V_j9 * e0_y_j9_i4 + e0_L_j7 * e0_x_j7_i4 + e0_greek_delta_j8 * e0_v_i4 * e0_r_j8 );
Y(77) = 0.0 - ( e0_F_j9 * e0_z_i1 - e0_L_j9 * e0_x_j9_i1 - e0_V_j9 * e0_y_j9_i1 + e0_V_j10 * e0_y_j10_i1 + e0_L_j8 * e0_x_j8_i1 + e0_greek_delta_j9 * e0_v_i1 * e0_r_j9 );
Y(78) = 0.0 - ( e0_F_j9 * e0_z_i2 - e0_L_j9 * e0_x_j9_i2 - e0_V_j9 * e0_y_j9_i2 + e0_V_j10 * e0_y_j10_i2 + e0_L_j8 * e0_x_j8_i2 + e0_greek_delta_j9 * e0_v_i2 * e0_r_j9 );
Y(79) = 0.0 - ( e0_F_j9 * e0_z_i3 - e0_L_j9 * e0_x_j9_i3 - e0_V_j9 * e0_y_j9_i3 + e0_V_j10 * e0_y_j10_i3 + e0_L_j8 * e0_x_j8_i3 + e0_greek_delta_j9 * e0_v_i3 * e0_r_j9 );
Y(80) = 0.0 - ( e0_F_j9 * e0_z_i4 - e0_L_j9 * e0_x_j9_i4 - e0_V_j9 * e0_y_j9_i4 + e0_V_j10 * e0_y_j10_i4 + e0_L_j8 * e0_x_j8_i4 + e0_greek_delta_j9 * e0_v_i4 * e0_r_j9 );
Y(81) = 0.0 - ( e0_F_j10 * e0_z_i1 - e0_L_j10 * e0_x_j10_i1 - e0_V_j10 * e0_y_j10_i1 + e0_V_j11 * e0_y_j11_i1 + e0_L_j9 * e0_x_j9_i1 + e0_greek_delta_j10 * e0_v_i1 * e0_r_j10 );
Y(82) = 0.0 - ( e0_F_j10 * e0_z_i2 - e0_L_j10 * e0_x_j10_i2 - e0_V_j10 * e0_y_j10_i2 + e0_V_j11 * e0_y_j11_i2 + e0_L_j9 * e0_x_j9_i2 + e0_greek_delta_j10 * e0_v_i2 * e0_r_j10 );
Y(83) = 0.0 - ( e0_F_j10 * e0_z_i3 - e0_L_j10 * e0_x_j10_i3 - e0_V_j10 * e0_y_j10_i3 + e0_V_j11 * e0_y_j11_i3 + e0_L_j9 * e0_x_j9_i3 + e0_greek_delta_j10 * e0_v_i3 * e0_r_j10 );
Y(84) = 0.0 - ( e0_F_j10 * e0_z_i4 - e0_L_j10 * e0_x_j10_i4 - e0_V_j10 * e0_y_j10_i4 + e0_V_j11 * e0_y_j11_i4 + e0_L_j9 * e0_x_j9_i4 + e0_greek_delta_j10 * e0_v_i4 * e0_r_j10 );
Y(85) = 0.0 - ( e0_F_j11 * e0_z_i1 - e0_L_j11 * e0_x_j11_i1 - e0_V_j11 * e0_y_j11_i1 + e0_V_j12 * e0_y_j12_i1 + e0_L_j10 * e0_x_j10_i1 + e0_greek_delta_j11 * e0_v_i1 * e0_r_j11 );
Y(86) = 0.0 - ( e0_F_j11 * e0_z_i2 - e0_L_j11 * e0_x_j11_i2 - e0_V_j11 * e0_y_j11_i2 + e0_V_j12 * e0_y_j12_i2 + e0_L_j10 * e0_x_j10_i2 + e0_greek_delta_j11 * e0_v_i2 * e0_r_j11 );
Y(87) = 0.0 - ( e0_F_j11 * e0_z_i3 - e0_L_j11 * e0_x_j11_i3 - e0_V_j11 * e0_y_j11_i3 + e0_V_j12 * e0_y_j12_i3 + e0_L_j10 * e0_x_j10_i3 + e0_greek_delta_j11 * e0_v_i3 * e0_r_j11 );
Y(88) = 0.0 - ( e0_F_j11 * e0_z_i4 - e0_L_j11 * e0_x_j11_i4 - e0_V_j11 * e0_y_j11_i4 + e0_V_j12 * e0_y_j12_i4 + e0_L_j10 * e0_x_j10_i4 + e0_greek_delta_j11 * e0_v_i4 * e0_r_j11 );
Y(89) = 0.0 - ( e0_F_j12 * e0_z_i1 - e0_L_j12 * e0_x_j12_i1 - e0_V_j12 * e0_y_j12_i1 + e0_V_j13 * e0_y_j13_i1 + e0_L_j11 * e0_x_j11_i1 + e0_greek_delta_j12 * e0_v_i1 * e0_r_j12 );
Y(90) = 0.0 - ( e0_F_j12 * e0_z_i2 - e0_L_j12 * e0_x_j12_i2 - e0_V_j12 * e0_y_j12_i2 + e0_V_j13 * e0_y_j13_i2 + e0_L_j11 * e0_x_j11_i2 + e0_greek_delta_j12 * e0_v_i2 * e0_r_j12 );
Y(91) = 0.0 - ( e0_F_j12 * e0_z_i3 - e0_L_j12 * e0_x_j12_i3 - e0_V_j12 * e0_y_j12_i3 + e0_V_j13 * e0_y_j13_i3 + e0_L_j11 * e0_x_j11_i3 + e0_greek_delta_j12 * e0_v_i3 * e0_r_j12 );
Y(92) = 0.0 - ( e0_F_j12 * e0_z_i4 - e0_L_j12 * e0_x_j12_i4 - e0_V_j12 * e0_y_j12_i4 + e0_V_j13 * e0_y_j13_i4 + e0_L_j11 * e0_x_j11_i4 + e0_greek_delta_j12 * e0_v_i4 * e0_r_j12 );
Y(93) = 0.0 - ( e0_F_j13 * e0_z_i1 - e0_L_j13 * e0_x_j13_i1 - e0_V_j13 * e0_y_j13_i1 + e0_V_j14 * e0_y_j14_i1 + e0_L_j12 * e0_x_j12_i1 + e0_greek_delta_j13 * e0_v_i1 * e0_r_j13 );
Y(94) = 0.0 - ( e0_F_j13 * e0_z_i2 - e0_L_j13 * e0_x_j13_i2 - e0_V_j13 * e0_y_j13_i2 + e0_V_j14 * e0_y_j14_i2 + e0_L_j12 * e0_x_j12_i2 + e0_greek_delta_j13 * e0_v_i2 * e0_r_j13 );
Y(95) = 0.0 - ( e0_F_j13 * e0_z_i3 - e0_L_j13 * e0_x_j13_i3 - e0_V_j13 * e0_y_j13_i3 + e0_V_j14 * e0_y_j14_i3 + e0_L_j12 * e0_x_j12_i3 + e0_greek_delta_j13 * e0_v_i3 * e0_r_j13 );
Y(96) = 0.0 - ( e0_F_j13 * e0_z_i4 - e0_L_j13 * e0_x_j13_i4 - e0_V_j13 * e0_y_j13_i4 + e0_V_j14 * e0_y_j14_i4 + e0_L_j12 * e0_x_j12_i4 + e0_greek_delta_j13 * e0_v_i4 * e0_r_j13 );
Y(97) = 0.0 - ( e0_F_j14 * e0_z_i1 - e0_L_j14 * e0_x_j14_i1 - e0_V_j14 * e0_y_j14_i1 + e0_V_j15 * e0_y_j15_i1 + e0_L_j13 * e0_x_j13_i1 + e0_greek_delta_j14 * e0_v_i1 * e0_r_j14 );
Y(98) = 0.0 - ( e0_F_j14 * e0_z_i2 - e0_L_j14 * e0_x_j14_i2 - e0_V_j14 * e0_y_j14_i2 + e0_V_j15 * e0_y_j15_i2 + e0_L_j13 * e0_x_j13_i2 + e0_greek_delta_j14 * e0_v_i2 * e0_r_j14 );
Y(99) = 0.0 - ( e0_F_j14 * e0_z_i3 - e0_L_j14 * e0_x_j14_i3 - e0_V_j14 * e0_y_j14_i3 + e0_V_j15 * e0_y_j15_i3 + e0_L_j13 * e0_x_j13_i3 + e0_greek_delta_j14 * e0_v_i3 * e0_r_j14 );
Y(100) = 0.0 - ( e0_F_j14 * e0_z_i4 - e0_L_j14 * e0_x_j14_i4 - e0_V_j14 * e0_y_j14_i4 + e0_V_j15 * e0_y_j15_i4 + e0_L_j13 * e0_x_j13_i4 + e0_greek_delta_j14 * e0_v_i4 * e0_r_j14 );
Y(101) = 0.0 - ( e0_F_j15 * e0_z_i1 - e0_L_j15 * e0_x_j15_i1 - e0_V_j15 * e0_y_j15_i1 + e0_V_j16 * e0_y_j16_i1 + e0_L_j14 * e0_x_j14_i1 + e0_greek_delta_j15 * e0_v_i1 * e0_r_j15 );
Y(102) = 0.0 - ( e0_F_j15 * e0_z_i2 - e0_L_j15 * e0_x_j15_i2 - e0_V_j15 * e0_y_j15_i2 + e0_V_j16 * e0_y_j16_i2 + e0_L_j14 * e0_x_j14_i2 + e0_greek_delta_j15 * e0_v_i2 * e0_r_j15 );
Y(103) = 0.0 - ( e0_F_j15 * e0_z_i3 - e0_L_j15 * e0_x_j15_i3 - e0_V_j15 * e0_y_j15_i3 + e0_V_j16 * e0_y_j16_i3 + e0_L_j14 * e0_x_j14_i3 + e0_greek_delta_j15 * e0_v_i3 * e0_r_j15 );
```

```
Y(104) = 0.0 - ( e0_F_j15 * e0_z_i4 - e0_L_j15 * e0_x_j15_i4 - e0_V_j15 * e0_y_j15_i4 + e0_V_j16 * e0_y_j16_i4 + e0_L_j14 * e0_x_j14_i4 + e0_greek_delta_j15 * e0_v_i4 * e0_r_j15 );
Y(105) = 0.0 - ( e0_F_j1 * e0_h_F + e0_L_j0 * e0_h_L_j0 + e0_V_j2 * e0_h_V_j2 - e0_greek_delta_j1 * e0_greek_DeltaH * e0_r_j1 - e0_V_j1 * e0_h_V_j1 - e0_L_j1 * e0_h_L_j1 );
Y(106) = 0.0 - ( e0_F_j2 * e0_h_F + e0_L_j1 * e0_h_L_j1 + e0_V_j3 * e0_h_V_j3 - e0_greek_delta_j2 * e0_greek_DeltaH * e0_r_j2 - e0_V_j2 * e0_h_V_j2 - e0_L_j2 * e0_h_L_j2 );
Y(107) = 0.0 - ( e0_F_j3 * e0_h_F + e0_L_j2 * e0_h_L_j2 + e0_V_j4 * e0_h_V_j4 - e0_greek_delta_j3 * e0_greek_DeltaH * e0_r_j3 - e0_V_j3 * e0_h_V_j3 - e0_L_j3 * e0_h_L_j3 );
Y(108) = 0.0 - ( e0_F_j4 * e0_h_F + e0_L_j3 * e0_h_L_j3 + e0_V_j5 * e0_h_V_j5 - e0_greek_delta_j4 * e0_greek_DeltaH * e0_r_j4 - e0_V_j4 * e0_h_V_j4 - e0_L_j4 * e0_h_L_j4 );
Y(109) = 0.0 - ( e0_F_j5 * e0_h_F + e0_L_j4 * e0_h_L_j4 + e0_V_j6 * e0_h_V_j6 - e0_greek_delta_j5 * e0_greek_DeltaH * e0_r_j5 - e0_V_j5 * e0_h_V_j5 - e0_L_j5 * e0_h_L_j5 );
Y(110) = 0.0 - ( e0_F_j6 * e0_h_F + e0_L_j5 * e0_h_L_j5 + e0_V_j7 * e0_h_V_j7 - e0_greek_delta_j6 * e0_greek_DeltaH * e0_r_j6 - e0_V_j6 * e0_h_V_j6 - e0_L_j6 * e0_h_L_j6 );
Y(111) = 0.0 - ( e0_F_j7 * e0_h_F + e0_L_j6 * e0_h_L_j6 + e0_V_j8 * e0_h_V_j8 - e0_greek_delta_j7 * e0_greek_DeltaH * e0_r_j7 - e0_V_j7 * e0_h_V_j7 - e0_L_j7 * e0_h_L_j7 );
Y(112) = 0.0 - ( e0_F_j8 * e0_h_F + e0_L_j7 * e0_h_L_j7 + e0_V_j9 * e0_h_V_j9 - e0_greek_delta_j8 * e0_greek_DeltaH * e0_r_j8 - e0_V_j8 * e0_h_V_j8 - e0_L_j8 * e0_h_L_j8 );
Y(113) = 0.0 - ( e0_F_j9 * e0_h_F + e0_L_j8 * e0_h_L_j8 + e0_V_j10 * e0_h_V_j10 - e0_greek_delta_j9 * e0_greek_DeltaH * e0_r_j9 - e0_V_j9 * e0_h_V_j9 - e0_L_j9 * e0_h_L_j9 );
Y(114) = 0.0 - ( e0_F_j10 * e0_h_F + e0_L_j9 * e0_h_L_j9 + e0_V_j11 * e0_h_V_j11 - e0_greek_delta_j10 * e0_greek_DeltaH * e0_r_j10 - e0_V_j10 * e0_h_V_j10 - e0_L_j10 * e0_h_L_j10 );
Y(115) = 0.0 - ( e0_F_j11 * e0_h_F + e0_L_j10 * e0_h_L_j10 + e0_V_j12 * e0_h_V_j12 - e0_greek_delta_j11 * e0_greek_DeltaH * e0_r_j11 - e0_V_j11 * e0_h_V_j11 - e0_L_j11 * e0_h_L_j11 );
Y(116) = 0.0 - ( e0_F_j12 * e0_h_F + e0_L_j11 * e0_h_L_j11 + e0_V_j13 * e0_h_V_j13 - e0_greek_delta_j12 * e0_greek_DeltaH * e0_r_j12 - e0_V_j12 * e0_h_V_j12 - e0_L_j12 * e0_h_L_j12 );
Y(117) = 0.0 - ( e0_F_j13 * e0_h_F + e0_L_j12 * e0_h_L_j12 + e0_V_j14 * e0_h_V_j14 - e0_greek_delta_j13 * e0_greek_DeltaH * e0_r_j13 - e0_V_j13 * e0_h_V_j13 - e0_L_j13 * e0_h_L_j13 );
Y(118) = 0.0 - ( e0_F_j14 * e0_h_F + e0_L_j13 * e0_h_L_j13 + e0_V_j15 * e0_h_V_j15 - e0_greek_delta_j14 * e0_greek_DeltaH * e0_r_j14 - e0_V_j14 * e0_h_V_j14 - e0_L_j14 * e0_h_L_j14 );
Y(119) = 0.0 - ( e0_F_j15 * e0_h_F + e0_L_j14 * e0_h_L_j14 + e0_V_j16 * e0_h_V_j16 - e0_greek_delta_j15 * e0_greek_DeltaH * e0_r_j15 - e0_V_j15 * e0_h_V_j15 - e0_L_j15 * e0_h_L_j15 );
Y(120) = e0_y_j1_i1 - ( e0_K_j1_i1 * e0_x_j1_i1 );
Y(121) = e0_y_j1_i2 - ( e0_K_j1_i2 * e0_x_j1_i2 );
Y(122) = e0_y_j1_i3 - ( e0_K_j1_i3 * e0_x_j1_i3 );
Y(123) = e0_y_j1_i4 - ( e0_K_j1_i4 * e0_x_j1_i4 );
Y(124) = e0_y_j2_i1 - ( e0_K_j2_i1 * e0_x_j2_i1 );
Y(125) = e0_y_j2_i2 - ( e0_K_j2_i2 * e0_x_j2_i2 );
Y(126) = e0_y_j2_i3 - ( e0_K_j2_i3 * e0_x_j2_i3 );
Y(127) = e0_y_j2_i4 - ( e0_K_j2_i4 * e0_x_j2_i4 );
Y(128) = e0_y_j3_i1 - ( e0_K_j3_i1 * e0_x_j3_i1 );
Y(129) = e0_y_j3_i2 - ( e0_K_j3_i2 * e0_x_j3_i2 );
Y(130) = e0_y_j3_i3 - ( e0_K_j3_i3 * e0_x_j3_i3 );
Y(131) = e0_y_j3_i4 - ( e0_K_j3_i4 * e0_x_j3_i4 );
Y(132) = e0_y_j4_i1 - ( e0_K_j4_i1 * e0_x_j4_i1 );
Y(133) = e0_y_j4_i2 - ( e0_K_j4_i2 * e0_x_j4_i2 );
Y(134) = e0_y_j4_i3 - ( e0_K_j4_i3 * e0_x_j4_i3 );
Y(135) = e0_y_j4_i4 - ( e0_K_j4_i4 * e0_x_j4_i4 );
Y(136) = e0_y_j5_i1 - ( e0_K_j5_i1 * e0_x_j5_i1 );
Y(137) = e0_y_j5_i2 - ( e0_K_j5_i2 * e0_x_j5_i2 );
Y(138) = e0_y_j5_i3 - ( e0_K_j5_i3 * e0_x_j5_i3 );
Y(139) = e0_y_j5_i4 - ( e0_K_j5_i4 * e0_x_j5_i4 );
Y(140) = e0_y_j6_i1 - ( e0_K_j6_i1 * e0_x_j6_i1 );
Y(141) = e0_y_j6_i2 - ( e0_K_j6_i2 * e0_x_j6_i2 );
Y(142) = e0_y_j6_i3 - ( e0_K_j6_i3 * e0_x_j6_i3 );
Y(143) = e0_y_j6_i4 - ( e0_K_j6_i4 * e0_x_j6_i4 );
Y(144) = e0_y_j7_i1 - ( e0_K_j7_i1 * e0_x_j7_i1 );
Y(145) = e0_y_j7_i2 - ( e0_K_j7_i2 * e0_x_j7_i2 );
Y(146) = e0_y_j7_i3 - ( e0_K_j7_i3 * e0_x_j7_i3 );
Y(147) = e0_y_j7_i4 - ( e0_K_j7_i4 * e0_x_j7_i4 );
Y(148) = e0_y_j8_i1 - ( e0_K_j8_i1 * e0_x_j8_i1 );
Y(149) = e0_y_j8_i2 - ( e0_K_j8_i2 * e0_x_j8_i2 );
Y(150) = e0_y_j8_i3 - ( e0_K_j8_i3 * e0_x_j8_i3 );
Y(151) = e0_y_j8_i4 - ( e0_K_j8_i4 * e0_x_j8_i4 );
Y(152) = e0_y_j9_i1 - ( e0_K_j9_i1 * e0_x_j9_i1 );
Y(153) = e0_y_j9_i2 - ( e0_K_j9_i2 * e0_x_j9_i2 );
Y(154) = e0_y_j9_i3 - ( e0_K_j9_i3 * e0_x_j9_i3 );
Y(155) = e0_y_j9_i4 - ( e0_K_j9_i4 * e0_x_j9_i4 );
Y(156) = e0_y_j10_i1 - ( e0_K_j10_i1 * e0_x_j10_i1 );
Y(157) = e0_y_j10_i2 - ( e0_K_j10_i2 * e0_x_j10_i2 );
Y(158) = e0_y_j10_i3 - ( e0_K_j10_i3 * e0_x_j10_i3 );
Y(159) = e0_y_j10_i4 - ( e0_K_j10_i4 * e0_x_j10_i4 );
Y(160) = e0_y_j11_i1 - ( e0_K_j11_i1 * e0_x_j11_i1 );
Y(161) = e0_y_j11_i2 - ( e0_K_j11_i2 * e0_x_j11_i2 );
Y(162) = e0_y_j11_i3 - ( e0_K_j11_i3 * e0_x_j11_i3 );
Y(163) = e0_y_j11_i4 - ( e0_K_j11_i4 * e0_x_j11_i4 );
Y(164) = e0_y_j12_i1 - ( e0_K_j12_i1 * e0_x_j12_i1 );
Y(165) = e0_y_j12_i2 - ( e0_K_j12_i2 * e0_x_j12_i2 );
Y(166) = e0_y_j12_i3 - ( e0_K_j12_i3 * e0_x_j12_i3 );
Y(167) = e0_y_j12_i4 - ( e0_K_j12_i4 * e0_x_j12_i4 );
Y(168) = e0_y_j13_i1 - ( e0_K_j13_i1 * e0_x_j13_i1 );
Y(169) = e0_y_j13_i2 - ( e0_K_j13_i2 * e0_x_j13_i2 );
Y(170) = e0_y_j13_i3 - ( e0_K_j13_i3 * e0_x_j13_i3 );
Y(171) = e0_y_j13_i4 - ( e0_K_j13_i4 * e0_x_j13_i4 );
Y(172) = e0_y_j14_i1 - ( e0_K_j14_i1 * e0_x_j14_i1 );
Y(173) = e0_y_j14_i2 - ( e0_K_j14_i2 * e0_x_j14_i2 );
Y(174) = e0_y_j14_i3 - ( e0_K_j14_i3 * e0_x_j14_i3 );
Y(175) = e0_y_j14_i4 - ( e0_K_j14_i4 * e0_x_j14_i4 );
Y(176) = e0_y_j15_i1 - ( e0_K_j15_i1 * e0_x_j15_i1 );
Y(177) = e0_y_j15_i2 - ( e0_K_j15_i2 * e0_x_j15_i2 );
Y(178) = e0_y_j15_i3 - ( e0_K_j15_i3 * e0_x_j15_i3 );
Y(179) = e0_y_j15_i4 - ( e0_K_j15_i4 * e0_x_j15_i4 );
Y(180) = e0_y_j16_i1 - ( e0_K_j16_i1 * e0_x_j16_i1 );
Y(181) = e0_y_j16_i2 - ( e0_K_j16_i2 * e0_x_j16_i2 );
Y(182) = e0_y_j16_i3 - ( e0_K_j16_i3 * e0_x_j16_i3 );
Y(183) = e0_y_j16_i4 - ( e0_K_j16_i4 * e0_x_j16_i4 );

end
```

```
function[std_r] =
fun_28540__rate_equation(std_T,std_W,std_q,std_A1,std_A2,std_A3,std_A4,std_A5,std_A6,std_greek_gamma_i1,std_greek_gamma_i2,std_greek_gamma_i3,std_x_i1,std_x_
i2,std_x_i3,std_T_o)
    std_r = ( std_W * std_q * 3.67 * ( ( 10.0 ) )^( 12.0 ) * exp( (  - 11110.0 )/( std_T ) ) * ( ( std_greek_gamma_i1 * std_x_i1 )/( std_greek_gamma_i2 * std_x_i2 ) -
( std_greek_gamma_i3 * std_x_i3 )/( 284.0 * exp( std_A1 * ( ( 1.0 )/( std_T ) - ( 1.0 )/( std_T_o ) ) - std_A2 * log( ( std_T )/( std_T_o ) ) + std_A3 * ( std_T - std_T_o ) +
std_A4 * ( ( ( std_T ) )^( 2.0 ) - ( ( std_T_o ) )^( 2.0 ) ) + std_A5 * ( ( ( std_T ) )^( 3.0 ) - ( ( std_T_o ) )^( 3.0 ) ) + std_A6 * ( ( ( std_T ) )^( 4.0 ) - ( ( std_T_o ) )^( 4.0 ) ) ) *
( ( std_greek_gamma_i2 * std_x_i2 ) )^( 2.0 ) ) ) ) ) ;
end

function[std_K] = fun_36075__phase_equilibrium(std_greek_gamma,std_P_o,std_P,std_greek_phi)
    std_K = ( std_P_o * std_greek_gamma )/( std_P * std_greek_phi ) ;
end

function[std_h_V] = fun_34075__enthapy_of_saturated_vapour(std_h_v_i1,std_h_v_i3,std_h_v_i2,std_h_v_i4,std_y_i1,std_y_i2,std_y_i3,std_y_i4)
    std_h_V = std_h_v_i1 * std_y_i1 + std_h_v_i2 * std_y_i2 + std_h_v_i3 * std_y_i3 + std_h_v_i4 * std_y_i4 ;
end

function[std_h_v] = fun_34070__enthapy_of_saturated_vapour_components(std_T,std_greek_lambda_b,std_A_L,std_B_L,std_C_L,std_T_b,std_T_c)
    std_h_v = ( std_A_L * std_T + ( std_B_L )/( 2.0 ) * ( ( std_T ) )^( 2.0 ) + ( std_C_L )/( 3.0 ) * ( ( std_T ) )^( 3.0 ) ) - ( std_A_L * 298.0 + ( std_B_L )/( 2.0 ) *
( ( 298.0 ) )^( 2.0 ) + ( std_C_L )/( 3.0 ) * ( ( 298.0 ) )^( 3.0 ) ) + std_greek_lambda_b * ( ( ( std_T_c - std_T )/( std_T_c - std_T_b ) ) )^( 0.38 ) ;
end

function[std_h_L] = fun_34073__enthapy_of_saturated_liquid(std_h_l_i1,std_h_l_i2,std_h_l_i3,std_h_l_i4,std_x_i1,std_x_i2,std_x_i3,std_x_i4)
    std_h_L = std_h_l_i1 * std_x_i1 + std_h_l_i2 * std_x_i2 + std_h_l_i3 * std_x_i3 + std_h_l_i4 * std_x_i4 ;
end

function[std_h_l] = fun_34068__enthapy_of_saturated_liquid_components(std_T,std_C_L,std_B_L,std_A_L)
    std_h_l = ( std_A_L * std_T + ( std_B_L )/( 2.0 ) * ( ( std_T ) )^( 2.0 ) + ( std_C_L )/( 3.0 ) * ( ( std_T ) )^( 3.0 ) ) - ( std_A_L * 298.0 + ( std_B_L )/( 2.0 ) *
( ( 298.0 ) )^( 2.0 ) + ( std_C_L )/( 3.0 ) * ( ( 298.0 ) )^( 3.0 ) ) ;
end

function[std_P_o] = fun_34071__saturated_pressure(std_T,std_C,std_B,std_A)
    std_P_o = 100000.0 * exp( std_A + ( std_B )/( std_T + std_C ) ) ;
end

function[] = displayResults(X_ITER)

    % print variable values to display
    disp(['e0_B_r  ', num2str(X_ITER(1))]);
    disp(['e0_D_c  ', num2str(X_ITER(2))]);
    disp(['e0_L_j0  ', num2str(X_ITER(3))]);
    disp(['e0_L_j10  ', num2str(X_ITER(4))]);
    disp(['e0_L_j11  ', num2str(X_ITER(5))]);
    disp(['e0_L_j12  ', num2str(X_ITER(6))]);
    disp(['e0_L_j13  ', num2str(X_ITER(7))]);
    disp(['e0_L_j14  ', num2str(X_ITER(8))]);
    disp(['e0_L_j15  ', num2str(X_ITER(9))]);
    disp(['e0_L_j1  ', num2str(X_ITER(10))]);
    disp(['e0_L_j2  ', num2str(X_ITER(11))]);
    disp(['e0_L_j3  ', num2str(X_ITER(12))]);
    disp(['e0_L_j4  ', num2str(X_ITER(13))]);
    disp(['e0_L_j5  ', num2str(X_ITER(14))]);
    disp(['e0_L_j6  ', num2str(X_ITER(15))]);
    disp(['e0_L_j7  ', num2str(X_ITER(16))]);
    disp(['e0_L_j8  ', num2str(X_ITER(17))]);
    disp(['e0_L_j9  ', num2str(X_ITER(18))]);
    disp(['e0_Q_c  ', num2str(X_ITER(19))]);
    disp(['e0_T_j0  ', num2str(X_ITER(20))]);
    disp(['e0_T_j10  ', num2str(X_ITER(21))]);
    disp(['e0_T_j11  ', num2str(X_ITER(22))]);
    disp(['e0_T_j12  ', num2str(X_ITER(23))]);
    disp(['e0_T_j13  ', num2str(X_ITER(24))]);
    disp(['e0_T_j14  ', num2str(X_ITER(25))]);
    disp(['e0_T_j15  ', num2str(X_ITER(26))]);
    disp(['e0_T_j1  ', num2str(X_ITER(27))]);
    disp(['e0_T_j2  ', num2str(X_ITER(28))]);
    disp(['e0_T_j3  ', num2str(X_ITER(29))]);
    disp(['e0_T_j4  ', num2str(X_ITER(30))]);
    disp(['e0_T_j5  ', num2str(X_ITER(31))]);
    disp(['e0_T_j6  ', num2str(X_ITER(32))]);
    disp(['e0_T_j7  ', num2str(X_ITER(33))]);
    disp(['e0_T_j8  ', num2str(X_ITER(34))]);
    disp(['e0_T_j9  ', num2str(X_ITER(35))]);
    disp(['e0_V_j10  ', num2str(X_ITER(36))]);
    disp(['e0_V_j11  ', num2str(X_ITER(37))]);
    disp(['e0_V_j12  ', num2str(X_ITER(38))]);
    disp(['e0_V_j13  ', num2str(X_ITER(39))]);
    disp(['e0_V_j14  ', num2str(X_ITER(40))]);
    disp(['e0_V_j15  ', num2str(X_ITER(41))]);
    disp(['e0_V_j16  ', num2str(X_ITER(42))]);
    disp(['e0_V_j1  ', num2str(X_ITER(43))]);
    disp(['e0_V_j2  ', num2str(X_ITER(44))]);
    disp(['e0_V_j3  ', num2str(X_ITER(45))]);
    disp(['e0_V_j4  ', num2str(X_ITER(46))]);
    disp(['e0_V_j5  ', num2str(X_ITER(47))]);
    disp(['e0_V_j6  ', num2str(X_ITER(48))]);
    disp(['e0_V_j7  ', num2str(X_ITER(49))]);
    disp(['e0_V_j8  ', num2str(X_ITER(50))]);
    disp(['e0_V_j9  ', num2str(X_ITER(51))]);
    disp(['e0_x_j0_i1  ', num2str(X_ITER(52))]);
    disp(['e0_x_j0_i2  ', num2str(X_ITER(53))]);
    disp(['e0_x_j0_i3  ', num2str(X_ITER(54))]);
    disp(['e0_x_j0_i4  ', num2str(X_ITER(55))]);
    disp(['e0_x_j1_i1  ', num2str(X_ITER(56))]);
    disp(['e0_x_j1_i2  ', num2str(X_ITER(57))]);
    disp(['e0_x_j1_i3  ', num2str(X_ITER(58))]);
    disp(['e0_x_j1_i4  ', num2str(X_ITER(59))]);
```

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disp(['e0_x_j10_i1  ', num2str(X_ITER(60))]);
disp(['e0_x_j10_i2  ', num2str(X_ITER(61))]);
disp(['e0_x_j10_i3  ', num2str(X_ITER(62))]);
disp(['e0_x_j10_i4  ', num2str(X_ITER(63))]);
disp(['e0_x_j11_i1  ', num2str(X_ITER(64))]);
disp(['e0_x_j11_i2  ', num2str(X_ITER(65))]);
disp(['e0_x_j11_i3  ', num2str(X_ITER(66))]);
disp(['e0_x_j11_i4  ', num2str(X_ITER(67))]);
disp(['e0_x_j12_i1  ', num2str(X_ITER(68))]);
disp(['e0_x_j12_i2  ', num2str(X_ITER(69))]);
disp(['e0_x_j12_i3  ', num2str(X_ITER(70))]);
disp(['e0_x_j12_i4  ', num2str(X_ITER(71))]);
disp(['e0_x_j13_i1  ', num2str(X_ITER(72))]);
disp(['e0_x_j13_i2  ', num2str(X_ITER(73))]);
disp(['e0_x_j13_i3  ', num2str(X_ITER(74))]);
disp(['e0_x_j13_i4  ', num2str(X_ITER(75))]);
disp(['e0_x_j14_i1  ', num2str(X_ITER(76))]);
disp(['e0_x_j14_i2  ', num2str(X_ITER(77))]);
disp(['e0_x_j14_i3  ', num2str(X_ITER(78))]);
disp(['e0_x_j14_i4  ', num2str(X_ITER(79))]);
disp(['e0_x_j15_i1  ', num2str(X_ITER(80))]);
disp(['e0_x_j15_i2  ', num2str(X_ITER(81))]);
disp(['e0_x_j15_i3  ', num2str(X_ITER(82))]);
disp(['e0_x_j15_i4  ', num2str(X_ITER(83))]);
disp(['e0_x_j16_i1  ', num2str(X_ITER(84))]);
disp(['e0_x_j16_i2  ', num2str(X_ITER(85))]);
disp(['e0_x_j16_i3  ', num2str(X_ITER(86))]);
disp(['e0_x_j16_i4  ', num2str(X_ITER(87))]);
disp(['e0_x_j2_i1   ', num2str(X_ITER(88))]);
disp(['e0_x_j2_i2   ', num2str(X_ITER(89))]);
disp(['e0_x_j2_i3   ', num2str(X_ITER(90))]);
disp(['e0_x_j2_i4   ', num2str(X_ITER(91))]);
disp(['e0_x_j3_i1   ', num2str(X_ITER(92))]);
disp(['e0_x_j3_i2   ', num2str(X_ITER(93))]);
disp(['e0_x_j3_i3   ', num2str(X_ITER(94))]);
disp(['e0_x_j3_i4   ', num2str(X_ITER(95))]);
disp(['e0_x_j4_i1   ', num2str(X_ITER(96))]);
disp(['e0_x_j4_i2   ', num2str(X_ITER(97))]);
disp(['e0_x_j4_i3   ', num2str(X_ITER(98))]);
disp(['e0_x_j4_i4   ', num2str(X_ITER(99))]);
disp(['e0_x_j5_i1   ', num2str(X_ITER(100))]);
disp(['e0_x_j5_i2   ', num2str(X_ITER(101))]);
disp(['e0_x_j5_i3   ', num2str(X_ITER(102))]);
disp(['e0_x_j5_i4   ', num2str(X_ITER(103))]);
disp(['e0_x_j6_i1   ', num2str(X_ITER(104))]);
disp(['e0_x_j6_i2   ', num2str(X_ITER(105))]);
disp(['e0_x_j6_i3   ', num2str(X_ITER(106))]);
disp(['e0_x_j6_i4   ', num2str(X_ITER(107))]);
disp(['e0_x_j7_i1   ', num2str(X_ITER(108))]);
disp(['e0_x_j7_i2   ', num2str(X_ITER(109))]);
disp(['e0_x_j7_i3   ', num2str(X_ITER(110))]);
disp(['e0_x_j7_i4   ', num2str(X_ITER(111))]);
disp(['e0_x_j8_i1   ', num2str(X_ITER(112))]);
disp(['e0_x_j8_i2   ', num2str(X_ITER(113))]);
disp(['e0_x_j8_i3   ', num2str(X_ITER(114))]);
disp(['e0_x_j8_i4   ', num2str(X_ITER(115))]);
disp(['e0_x_j9_i1   ', num2str(X_ITER(116))]);
disp(['e0_x_j9_i2   ', num2str(X_ITER(117))]);
disp(['e0_x_j9_i3   ', num2str(X_ITER(118))]);
disp(['e0_x_j9_i4   ', num2str(X_ITER(119))]);
disp(['e0_y_j1_i1   ', num2str(X_ITER(120))]);
disp(['e0_y_j1_i2   ', num2str(X_ITER(121))]);
disp(['e0_y_j1_i3   ', num2str(X_ITER(122))]);
disp(['e0_y_j1_i4   ', num2str(X_ITER(123))]);
disp(['e0_y_j10_i1  ', num2str(X_ITER(124))]);
disp(['e0_y_j10_i2  ', num2str(X_ITER(125))]);
disp(['e0_y_j10_i3  ', num2str(X_ITER(126))]);
disp(['e0_y_j10_i4  ', num2str(X_ITER(127))]);
disp(['e0_y_j11_i1  ', num2str(X_ITER(128))]);
disp(['e0_y_j11_i2  ', num2str(X_ITER(129))]);
disp(['e0_y_j11_i3  ', num2str(X_ITER(130))]);
disp(['e0_y_j11_i4  ', num2str(X_ITER(131))]);
disp(['e0_y_j12_i1  ', num2str(X_ITER(132))]);
disp(['e0_y_j12_i2  ', num2str(X_ITER(133))]);
disp(['e0_y_j12_i3  ', num2str(X_ITER(134))]);
disp(['e0_y_j12_i4  ', num2str(X_ITER(135))]);
disp(['e0_y_j13_i1  ', num2str(X_ITER(136))]);
disp(['e0_y_j13_i2  ', num2str(X_ITER(137))]);
disp(['e0_y_j13_i3  ', num2str(X_ITER(138))]);
disp(['e0_y_j13_i4  ', num2str(X_ITER(139))]);
disp(['e0_y_j14_i1  ', num2str(X_ITER(140))]);
disp(['e0_y_j14_i2  ', num2str(X_ITER(141))]);
disp(['e0_y_j14_i3  ', num2str(X_ITER(142))]);
disp(['e0_y_j14_i4  ', num2str(X_ITER(143))]);
disp(['e0_y_j15_i1  ', num2str(X_ITER(144))]);
disp(['e0_y_j15_i2  ', num2str(X_ITER(145))]);
disp(['e0_y_j15_i3  ', num2str(X_ITER(146))]);
disp(['e0_y_j15_i4  ', num2str(X_ITER(147))]);
disp(['e0_y_j16_i1  ', num2str(X_ITER(148))]);
disp(['e0_y_j16_i2  ', num2str(X_ITER(149))]);
disp(['e0_y_j16_i3  ', num2str(X_ITER(150))]);
disp(['e0_y_j16_i4  ', num2str(X_ITER(151))]);
disp(['e0_y_j2_i1   ', num2str(X_ITER(152))]);
disp(['e0_y_j2_i2   ', num2str(X_ITER(153))]);
disp(['e0_y_j2_i3   ', num2str(X_ITER(154))]);
disp(['e0_y_j2_i4   ', num2str(X_ITER(155))]);
disp(['e0_y_j3_i1   ', num2str(X_ITER(156))]);
disp(['e0_y_j3_i2   ', num2str(X_ITER(157))]);
disp(['e0_y_j3_i3   ', num2str(X_ITER(158))]);
disp(['e0_y_j3_i4   ', num2str(X_ITER(159))]);
disp(['e0_y_j4_i1   ', num2str(X_ITER(160))]);
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```
    disp(['e0_y_j4_i2  ', num2str(X_ITER(161))]);
    disp(['e0_y_j4_i3  ', num2str(X_ITER(162))]);
    disp(['e0_y_j4_i4  ', num2str(X_ITER(163))]);
    disp(['e0_y_j5_i1  ', num2str(X_ITER(164))]);
    disp(['e0_y_j5_i2  ', num2str(X_ITER(165))]);
    disp(['e0_y_j5_i3  ', num2str(X_ITER(166))]);
    disp(['e0_y_j5_i4  ', num2str(X_ITER(167))]);
    disp(['e0_y_j6_i1  ', num2str(X_ITER(168))]);
    disp(['e0_y_j6_i2  ', num2str(X_ITER(169))]);
    disp(['e0_y_j6_i3  ', num2str(X_ITER(170))]);
    disp(['e0_y_j6_i4  ', num2str(X_ITER(171))]);
    disp(['e0_y_j7_i1  ', num2str(X_ITER(172))]);
    disp(['e0_y_j7_i2  ', num2str(X_ITER(173))]);
    disp(['e0_y_j7_i3  ', num2str(X_ITER(174))]);
    disp(['e0_y_j7_i4  ', num2str(X_ITER(175))]);
    disp(['e0_y_j8_i1  ', num2str(X_ITER(176))]);
    disp(['e0_y_j8_i2  ', num2str(X_ITER(177))]);
    disp(['e0_y_j8_i3  ', num2str(X_ITER(178))]);
    disp(['e0_y_j8_i4  ', num2str(X_ITER(179))]);
    disp(['e0_y_j9_i1  ', num2str(X_ITER(180))]);
    disp(['e0_y_j9_i2  ', num2str(X_ITER(181))]);
    disp(['e0_y_j9_i3  ', num2str(X_ITER(182))]);
    disp(['e0_y_j9_i4  ', num2str(X_ITER(183))]);


end
```