Separation Technologies for Advanced Biofuels

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Topics

1. Bioethanol Distillation and Purification in Industrial Practice.
2. Some Research Results and Research Groups on the Subject.
3. Questions to be Investigated

Alcoholic products	Specifications	Standards fixed by
Fuel (Hydrous/ Anhydrous)	alcoholic content, pH, acidity, conductivity, density, chloride, sulfate, iron, hydrocarbons	ANP
Special/ Neutral	alcoholic content, pH, acidity, conductivity, density, chloride, sulfate, iron, hydrocarbons, sulfur, copper, sodium, nitrogen, phosphorus, acetaldehyde, ethyl acetate, methanol, propanol, isopropanol, butanol, isobutanol, isoamilic alcohol, higher alcohols, crotonaldehyde, dioxane, ciclohexane, benzene, ethylene glycol, diethjylene glycol, acetal	Market

Hydrous Bioethanol Distillation

AA1DBB1

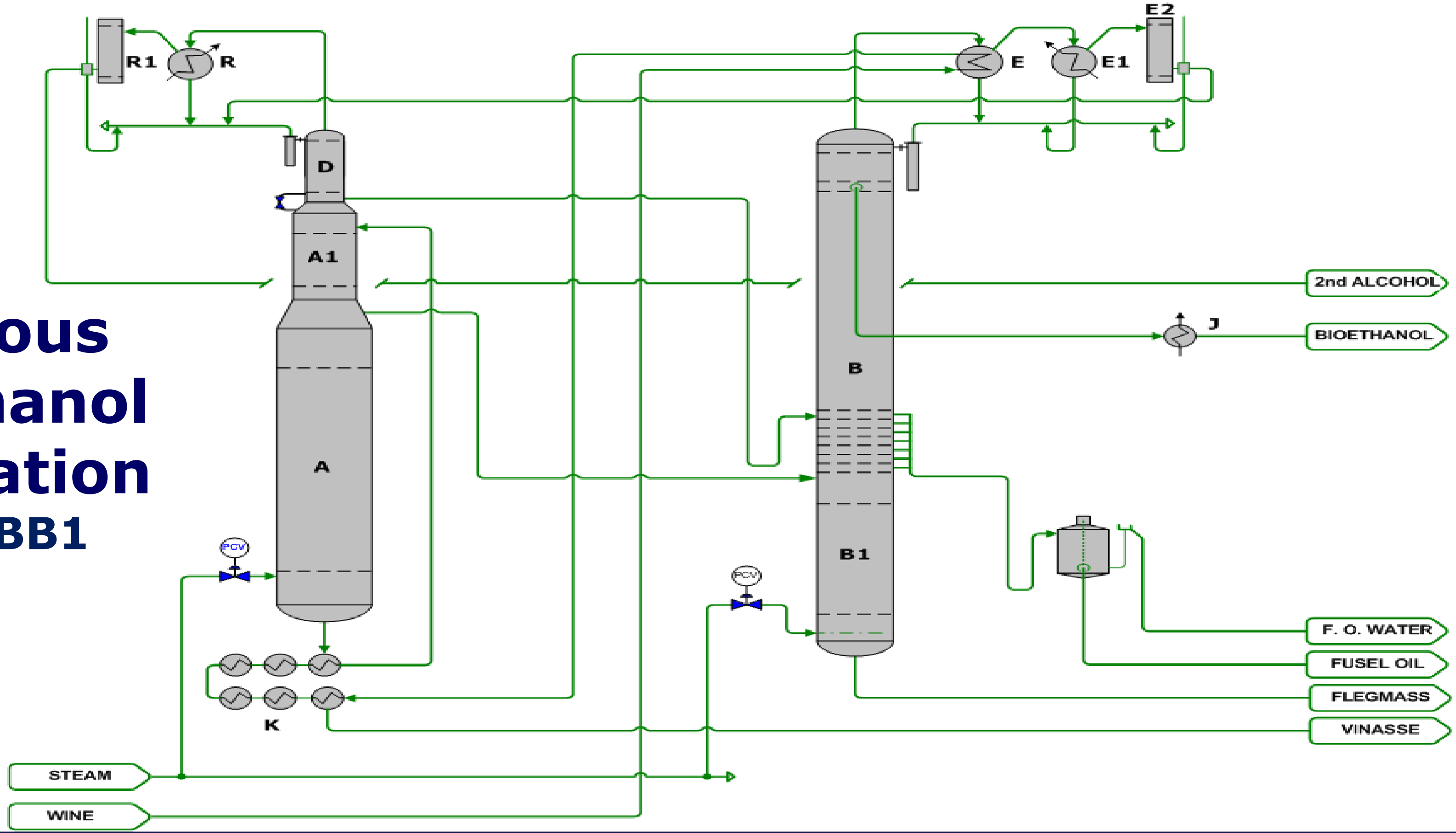
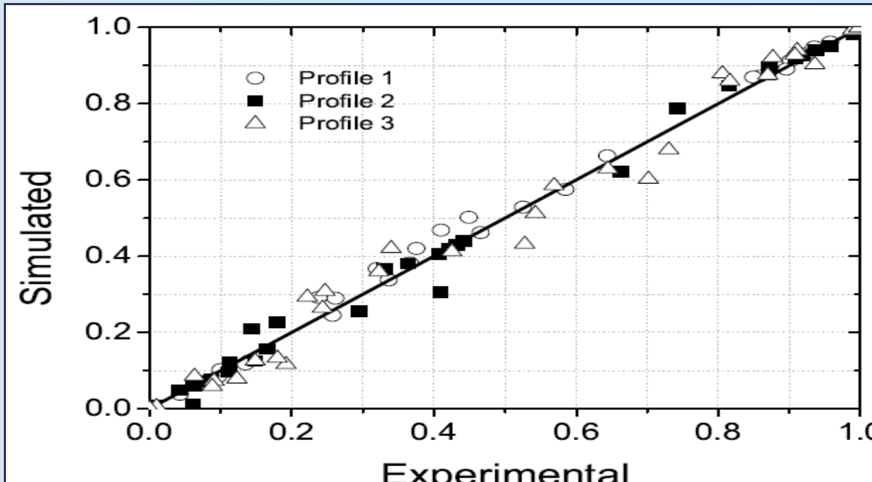


Table 1
Wine composition.

Component	Mass fraction	Component	Mass fraction
Ethanol	0.081	1-Pentanol	1.00×10^{-6}
Water	0.91712934	Methanol	3.20×10^{-7}
Isoamyl alcohol	0.0001425	Acetaldehyde	1.58×10^{-5}
Propanol	3.00×10^{-5}	Acetone	1.50×10^{-5}
Isopropanol	1.02×10^{-6}	Ethyl acetate	7.69×10^{-6}
Isobutanol	2.78×10^{-5}	Methyl acetate	1.00×10^{-6}
Butanol	1.43×10^{-6}	Acetic acid	0.0004351
2-Butanol	1.00×10^{-6}	Propionic acid	1.00×10^{-6}
Active amyl alcohol	1.00×10^{-6}	Sulfur dioxide	1.90×10^{-5}
1-Hexanol	1.00×10^{-6}	Carbon dioxide	0.001169



$$F = \frac{\left(\dfrac{w_{ethanol}}{\sum w_{congeners}}\right)_{product}}{\left(\dfrac{w_{ethanol}}{\sum w_{congeners}}\right)_{wine}}$$

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Computational simulation applied to the investigation of industrial plants for bioethanol distillation

Fabio R.M. Batista, Luis A. Follegatti-Romero, L.C.B.A. Bessa, Antonio J.A. Meirelles

Table 8
Purification factor and steam consumption for the three configurations studied.

Configurations	$F_{volatile}$	$F_{Intermediate}$	F_{heavy}	F_{Total}	Steam consumption (kg steam/l of bioethanol)
AB	1.85	294.87	$>10^{30}$	25.01	1.78
ABB1	2.10	307.83	$>10^{30}$	28.31	1.80
AA1DBB1	2.53	309.83	$>10^{30}$	33.85	2.17

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Energy
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Double-effect integration of multicomponent alcoholic distillation columns

Larissa C.B.A. Bessa, Fabio R.M. Batista, Antonio J.A. Meirelles

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Performance and cost evaluation of a new double-effect integration of multicomponent bioethanol distillation

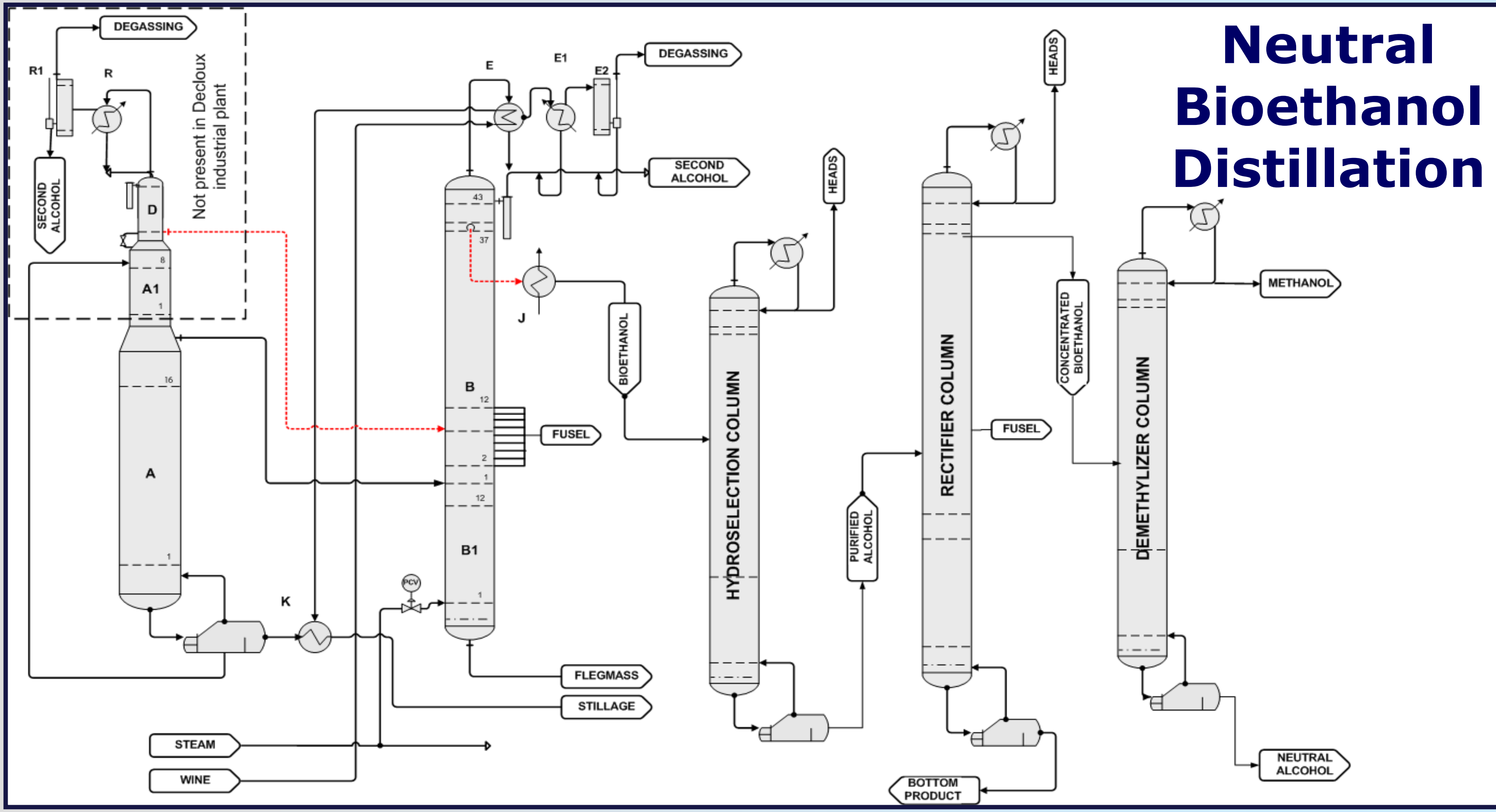
Larissa C.B.A. Bessa, M.C. Ferreira, Eduardo A.C. Batista, Antonio J.A. Meirelles

Table 6
Results for the conventional and integrated processes.

Parameter	Conventional	Integrated	
Specific steam consumption (SSC)	2.151	0.995	
Ethanol recovery (ER)	99.21	99.26	
		HP	LP
$(\sum w_m)_P$	1.16×10^{-2}	7.98×10^{-3}	8.28×10^{-3}
Purification factor (PF)	1.844	2.692	2.592
Distillate ethanol content	0.930	0.930	0.930

Heat integration techniques still scarcely used in the industrial practice

Neutral Bioethanol Distillation



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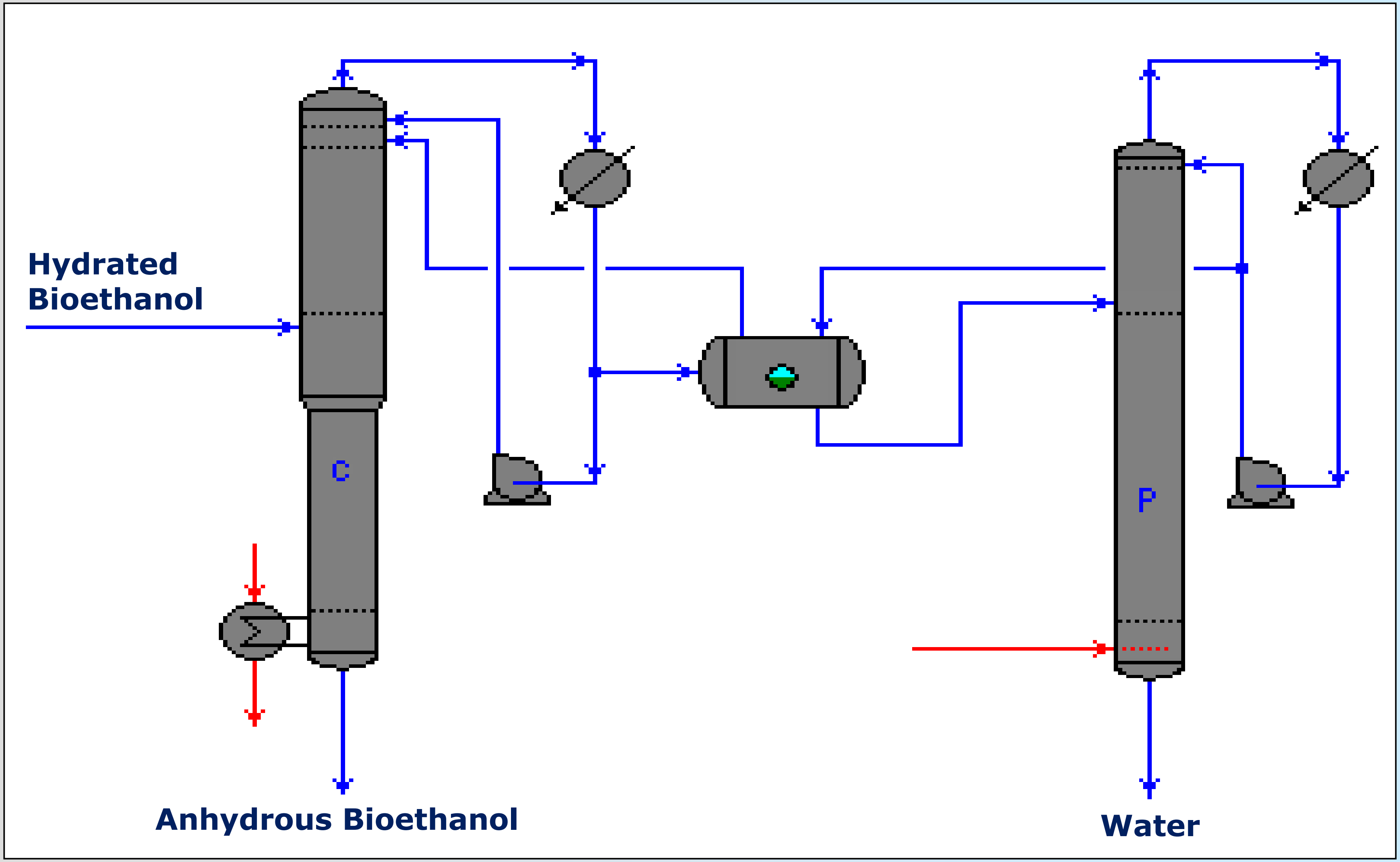
A new distillation plant for neutral alcohol production

Fabio R.M. Batista, Luis A. Follegatti-Romero, Antonio J.A. Meirelles

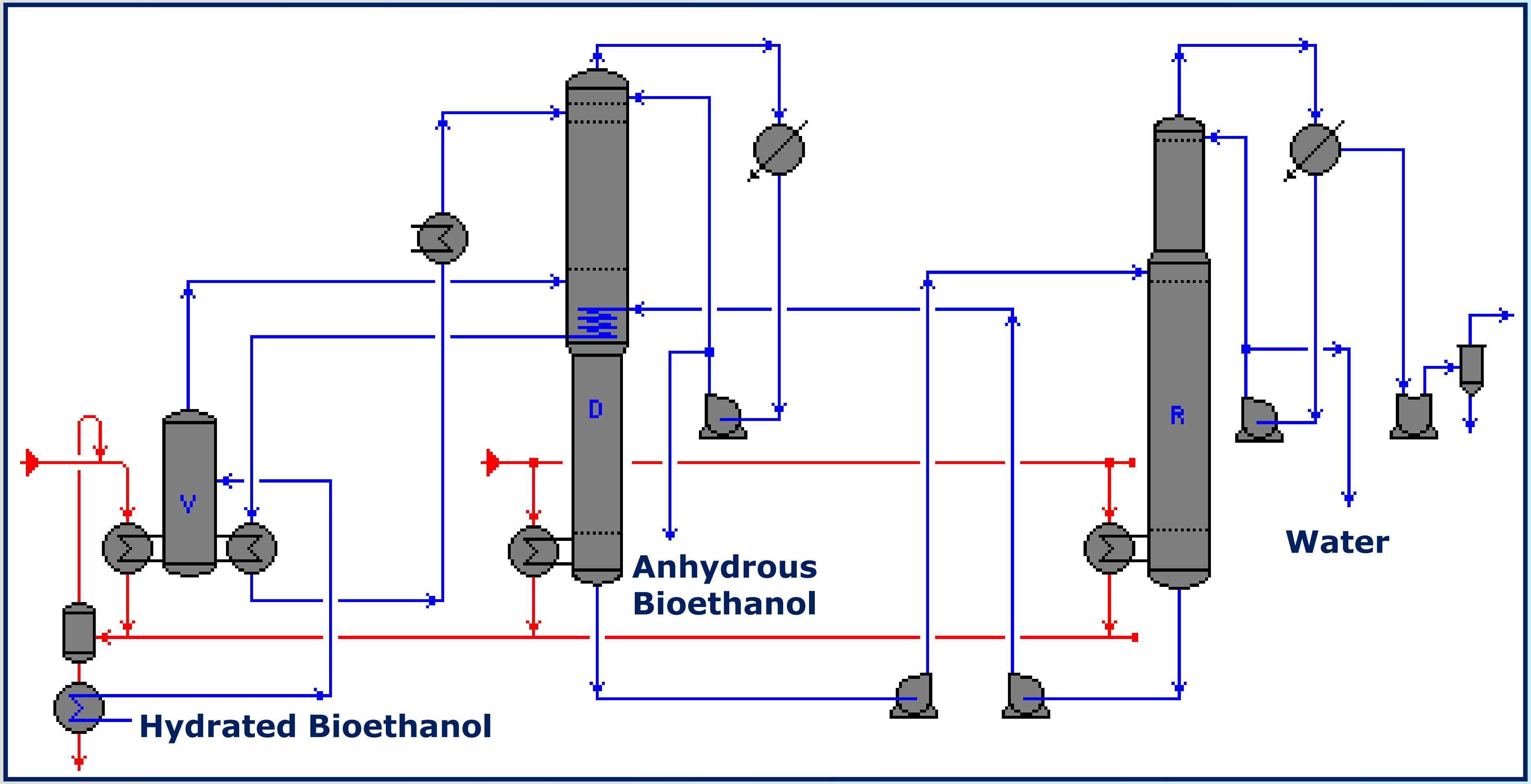
	Plant	New Plant
Steam (Kg/L)	5.22	5.22
N_{Trays}	279	144
F	8250	8804

Dehydration by Azeotropic Distillation with Cycle-Hexane



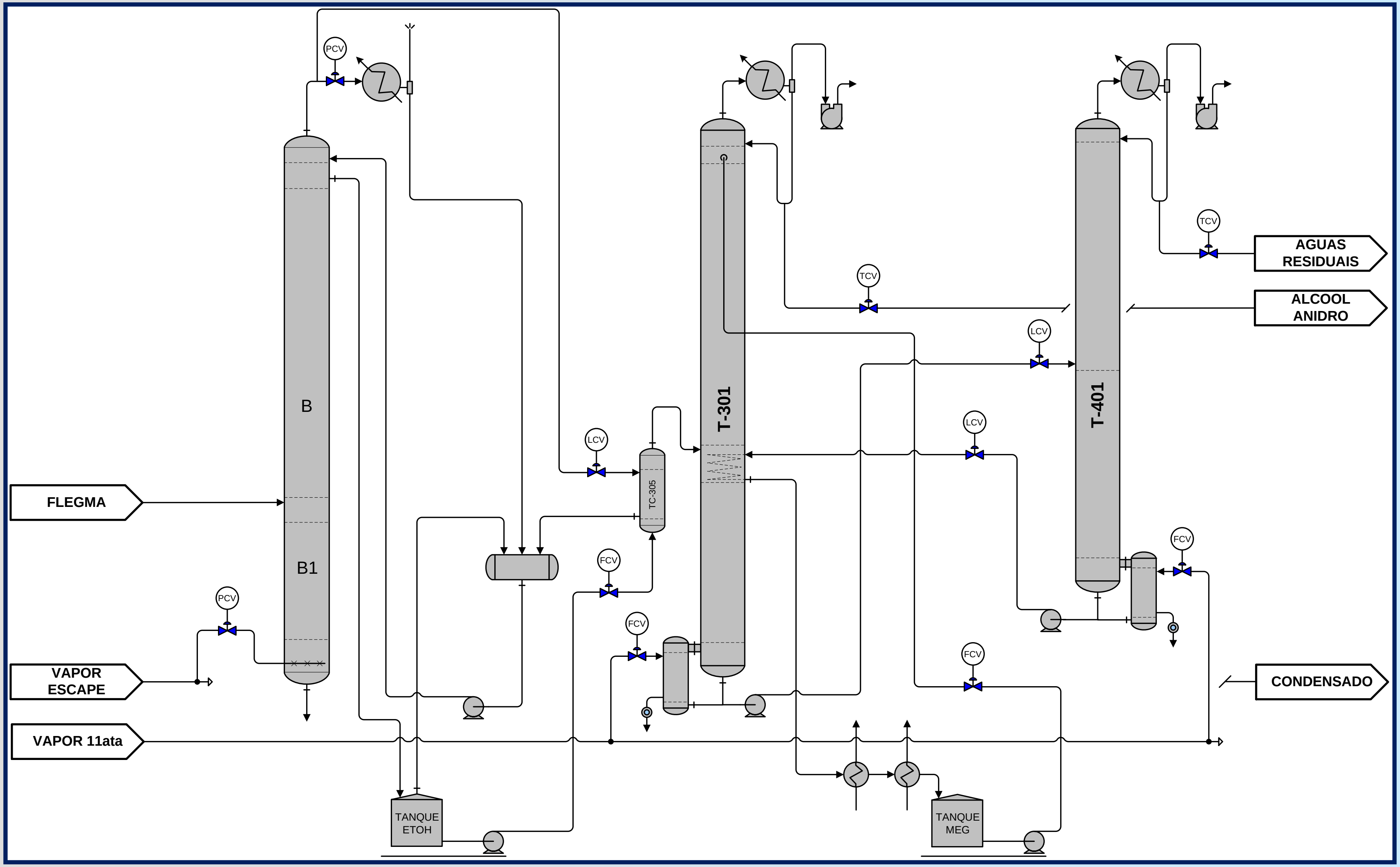
Total Low Pressure Steam
1.50-1.60 Kg/L

Dehydration by Extractive Distillation with MEG



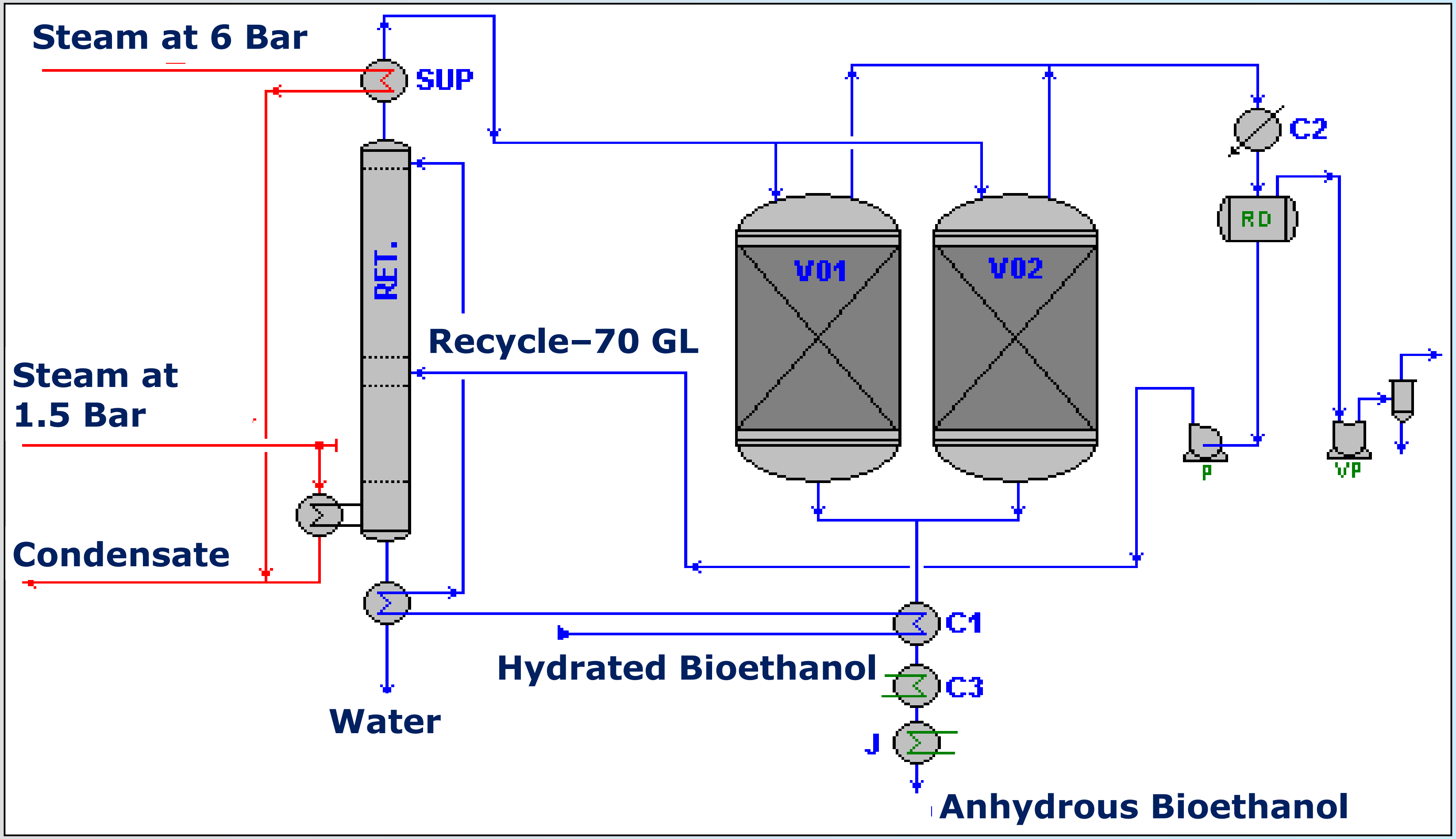
Model	Low Pressure Steam	High Pressure Steam	Total
Liquid Feed	0.30 Kg/L	0.40-0.50 Kg/L	0.70-0.80 Kg/L

Dehydration by Extractive Distillation with MEG



Model	High Pressure Steam	Total
Vapor Feed	0,40-0.50 Kg/L	0,40-0.50 Kg/L

MOLECULAR SIEVE



Low Pressure Steam	High Pressure Steam	Total
0.40-0.50 Kg/L	0.10 Kg/L	0.50-0.60 Kg/L

Approximate Market Share		
AD with Cycle-Hexane	ED with MEG	Mol. Sieve
55 %	30 %	15 %

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Evaluation of process configurations for second generation integrated with first generation bioethanol production from sugarcane

Marina O.S. Dias[a, b], Tassia L. Junqueira[a, c], Carlos Eduardo V. Rossell[a, b], Rubens Maciel Filho[a, b], Antonio Bonomi[a]

Chemical Engineering Research and Design
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Special Issue: Computer Aided Process Engineering (CAPE) Tools for a Sustainable World

Cogeneration in integrated first and second generation ethanol from sugarcane

Marina O.S. Dias[a], Tassia L. Junqueira[a, b], Otavio Cavalett[a], Marcelo P. Cunha[a], Charles D.F. Jesus[a], Paulo E. Mantelatto[a], Carlos E.V. Rossell[a], Rubens Maciel Filho[a, b], Antonio Bonomi[a, b]

I&EC research
Industrial & Engineering Chemistry Research

Study of the Fusel Oil Distillation Process

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Biotechnology for Biofuels

RESEARCH Open Access

Bioelectricity versus bioethanol from sugarcane bagasse: is it worth being flexible?

Felipe F Furlan[1], Renato Tonon Filho[1], Fabio HPB Pinto[1], Caliane BB Costa[1,2], Antonio JG Cruz[1,2], Raquel LC Giordano[1,2] and Roberto C Giordano[1,2*]

Some Industrial Constraints nowadays and in the future	
Wine alcoholic content	**≥ 8-11 ºGL (HAC → 16 ºGL)**
Distillation Yield	**≥ 99%**
Ethanol loss in stillage	**≤ 200 Mg/Kg**
Steam (hydrated)	**≤ 1.8-2.2 kg/L**
Steam (anhydrous)	**≤ 0.4-1.6 kg/L**
Plant Scale and Economies of Scale	**300-1.200 m^3/day**
Wine with molasses	**Incrustation in Column A**

Questions to be investigated

1st and 2nd Generation

1. **Are new configurations for distilling bioethanol possible, for instance, flexible configurations for producing bioethanol of different standards in the same plant?**
2. **Control loops in distillation unities are optimal or should be optimized?**
3. **Are other combinations of adsorption and distillation possible, than the alternatives used in the industrial practice.**

4. New configurations, new control loops, new combinations of adsorption and distillation affect or not the suggested heat integration procedures?
5. Are new heat integration techniques possible?
6. Are new distillation techniques (parastillation, divided wall column distilling - DWC, secondary reflux and vaporization – SRV, etc.) cost competitive and viable in bioethanol distillation?

2nd Generation and Modern Purification Techniques

1. How will the Contaminants added/produced during Pre-Treatment and Hydrolysis of lignocellulosic residues affect distillation, adsorption and/or membrane separation?
2. Can membrane technology/pervaporation replace distillation and/or adsorption technologies and compete with them in cost?
3. In the long run can membranes resist, without loss in efficiency, to the contact with the alcoholic wine and its contaminants?
4. Can membrane technology/pervaporation be combined with distillation and/or adsorption technologies in a optimized way?

Bioethanol, Heat Integration, Bioproducts and Other Biofuels

1. Are there new possibilities of heat integration involving bioethanol purification steps and other unit operations related with sugar and bioethanol production?
2. What are the heat integration possibilities in the production of other possible biofuels derived from sugarcane, such as biobutanol and 2,5-Dimethylfuran (DMF)?
3. What are the possibilities of integration in the simultaneous production of bioethanol, biobutanol and/or 2,5-Dimethylfuran (DMF)?
4. What are the possibilities of integration in the purification steps related to the simultaneous production of bioethanol and ethyl biodiesel, considering lignocellulosic residues of oil plants (oil palm trees, for instance), the oils seeds used as crops in the recovery of sugarcane land, and the relatively high sugar content of some oil plants?
5. Are there other possibilities of adding value to byproducts of bioethanol and other sugar-derived biofuels, such as fusel oil?

Thank you for your attention

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FAPESP

BIOEN FAPESP

CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico 60 ANOS

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