

# **SUPPORTING INFORMATION**

## **Comparing Composition Control Structures for Kaibel Distillation Columns**

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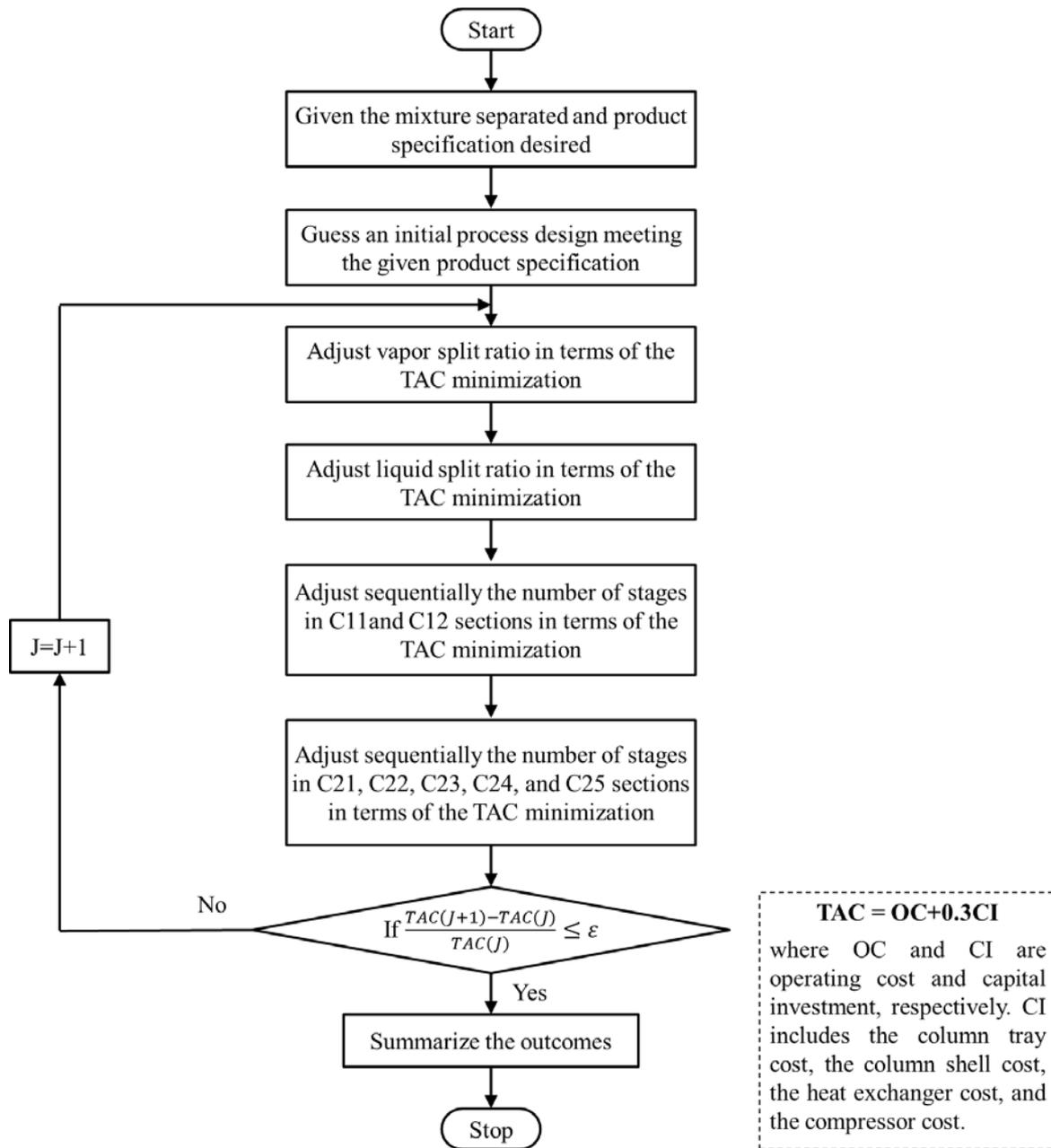
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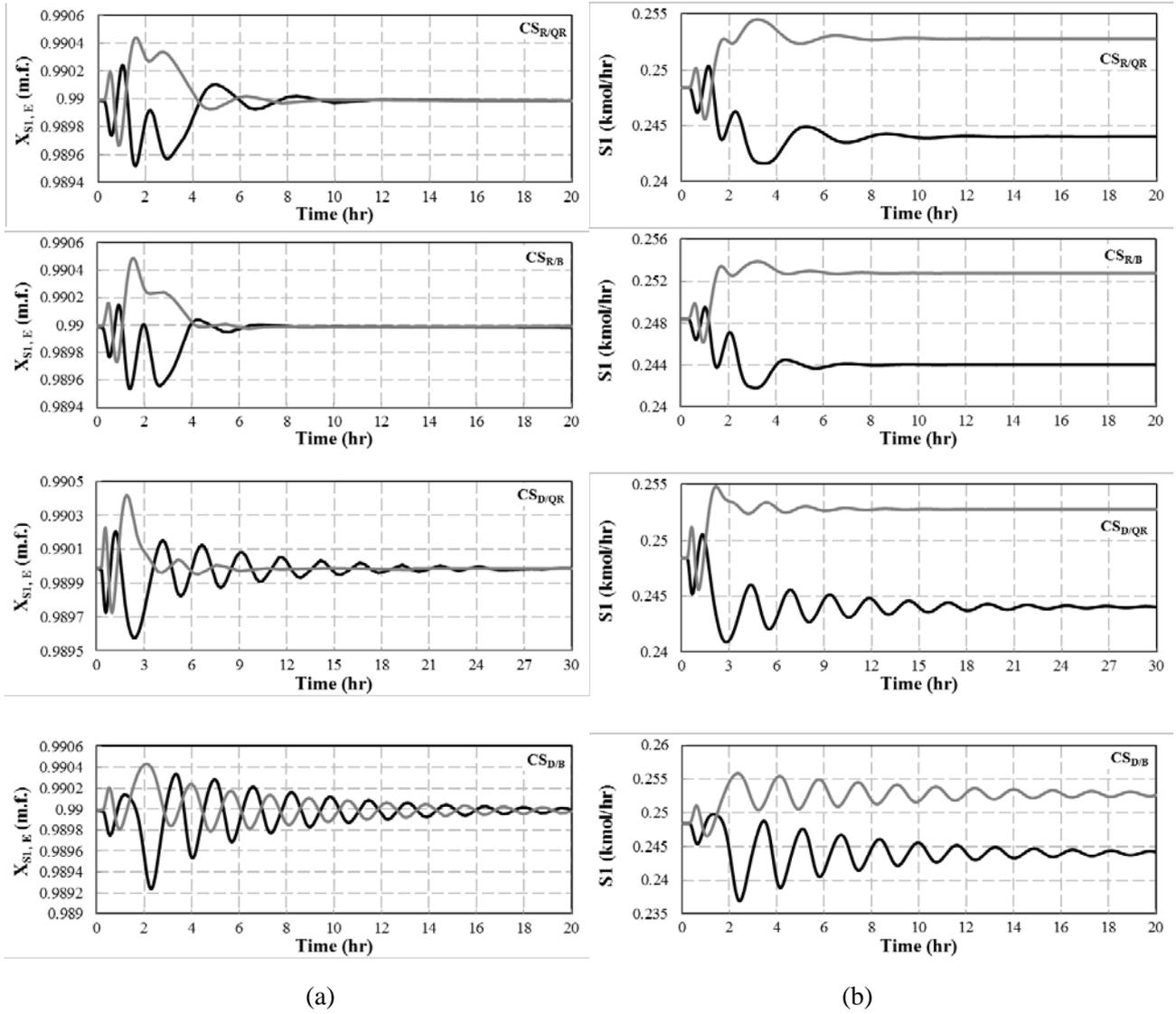


**Figure S1.** A simple sequential search algorithm for the synthesis and design of the Kaibel distillation column

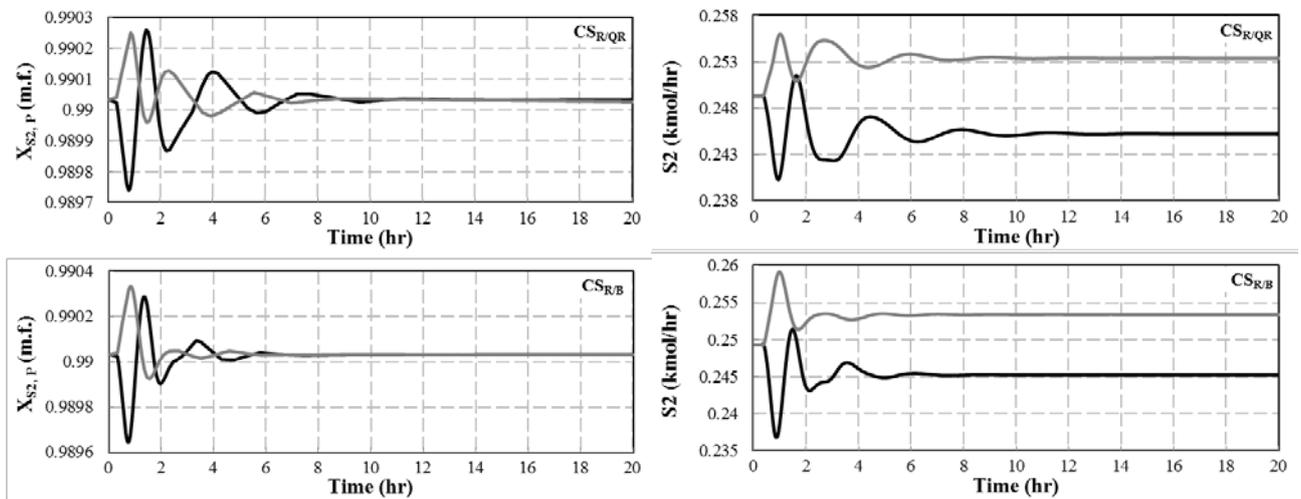
**Table S1.** Column dimensions of the MEPB Kaibel distillation column

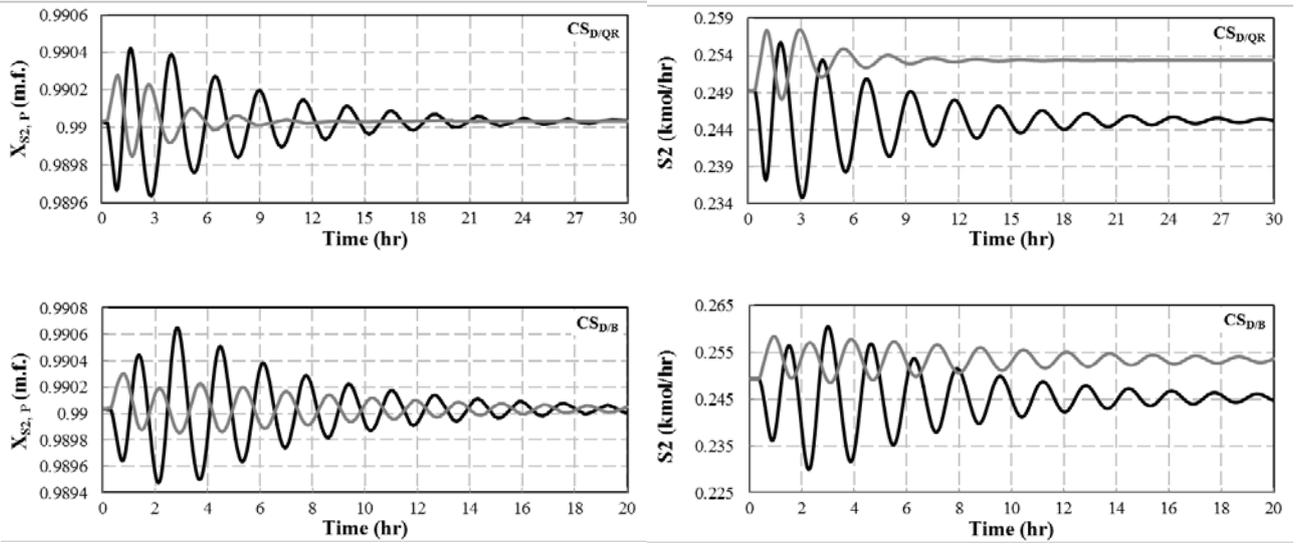
Column	Column shell		Reflux drum (Elliptical)		Column base (Elliptical)	
	Diameter (m)	Spacing (m)	Length (m)	Diameter (m)	Length (m)	Diameter (m)
C1 Column	0.11	0.6096	0.455	0.227	0.478	0.239
C2 Column	0.076	0.6096	-	-	0.375	0.188
C3 Column	0.11	0.6096	-	-	0.578	0.289
P Column	0.083	0.6096	-	-	0.486	0.243

\*The C1, C2, C3 and P columns are labeled in Figure 4 of the main manuscript



**Figure S2.** Dynamic responses of the upper sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in  $M$  feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

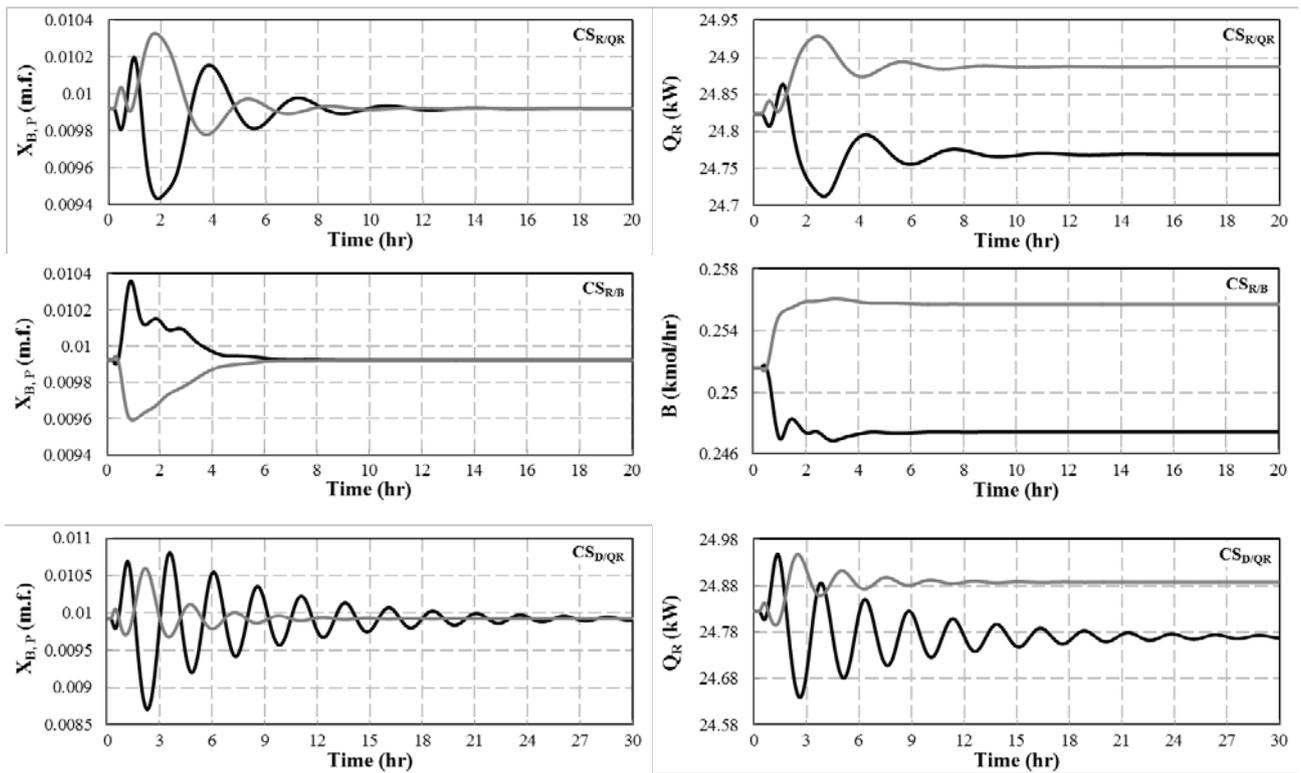


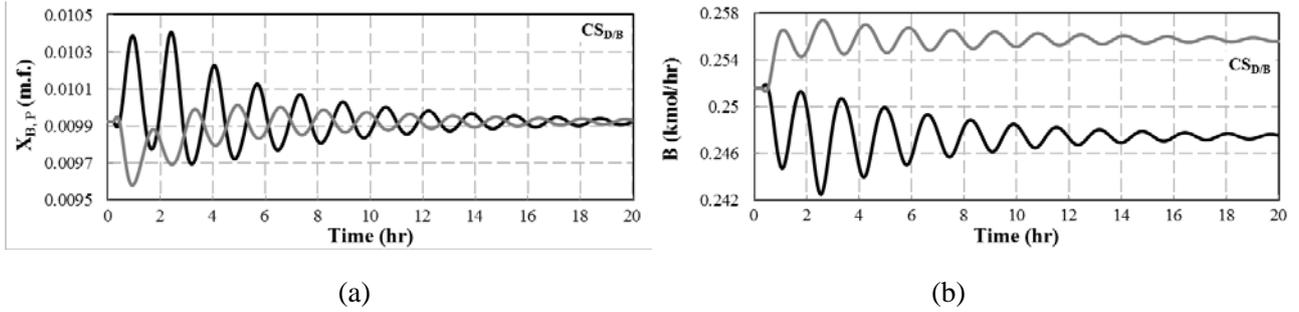


(a)

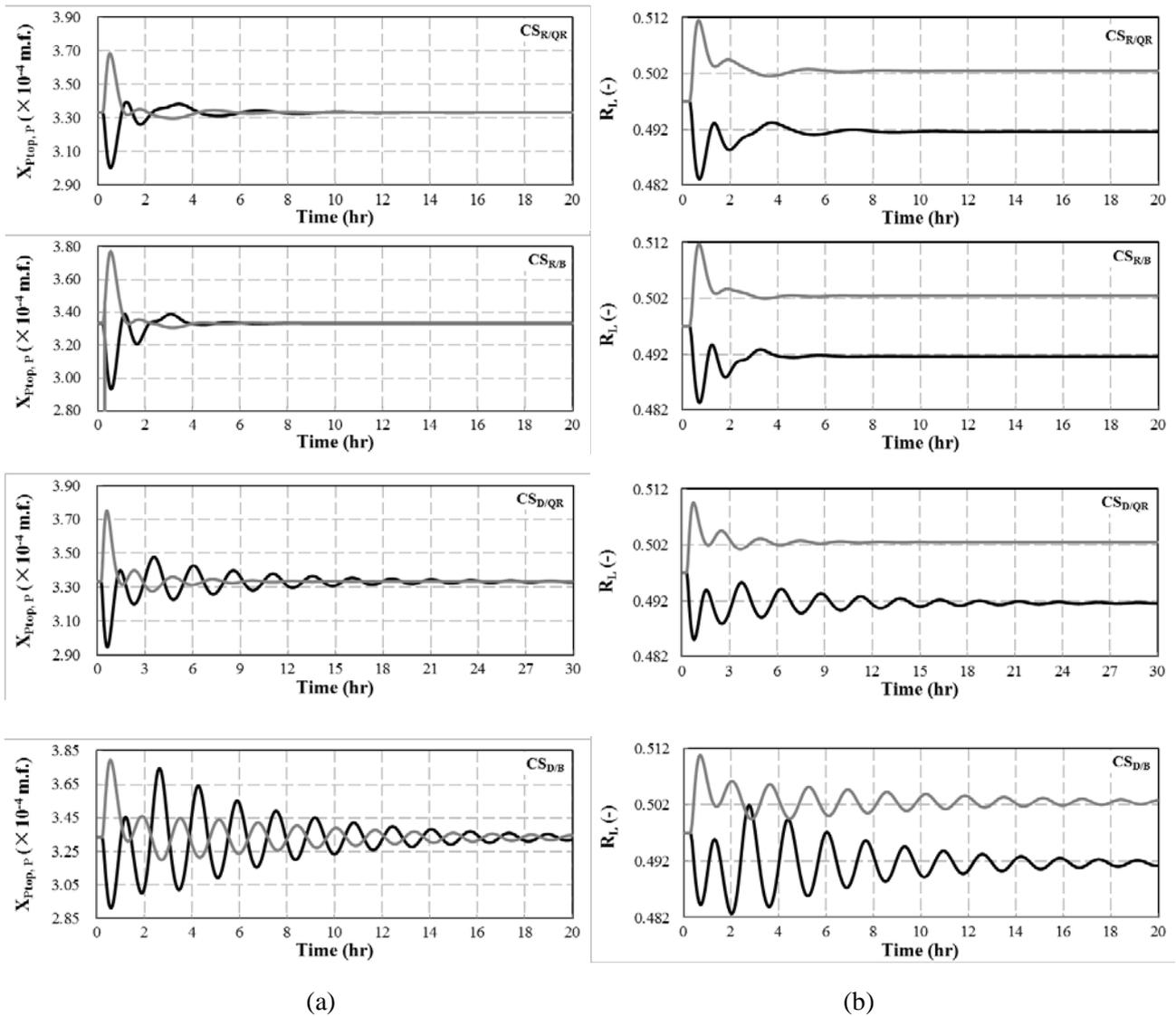
(b)

**Figure S3.** Dynamic responses of the lower sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in M feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

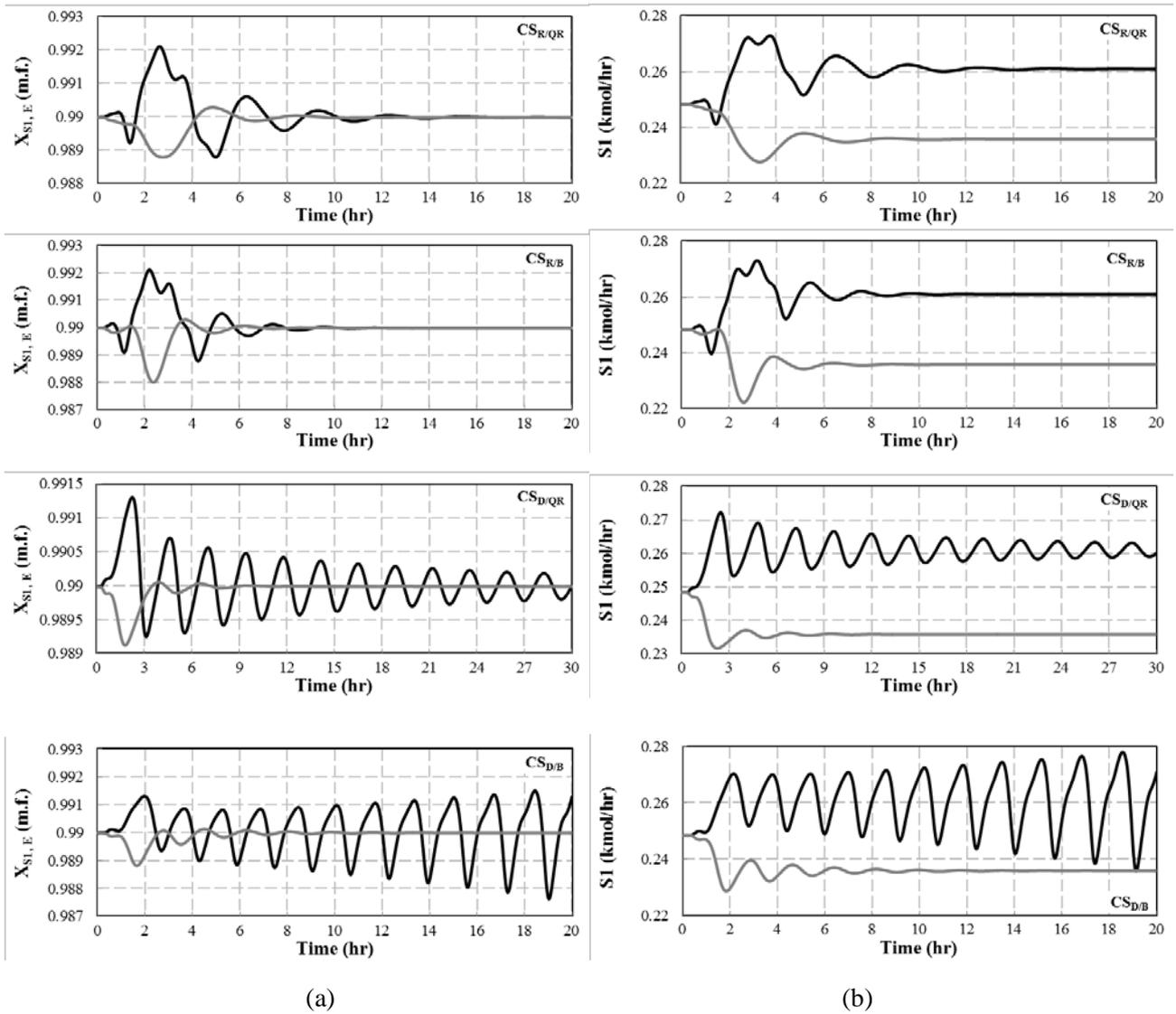




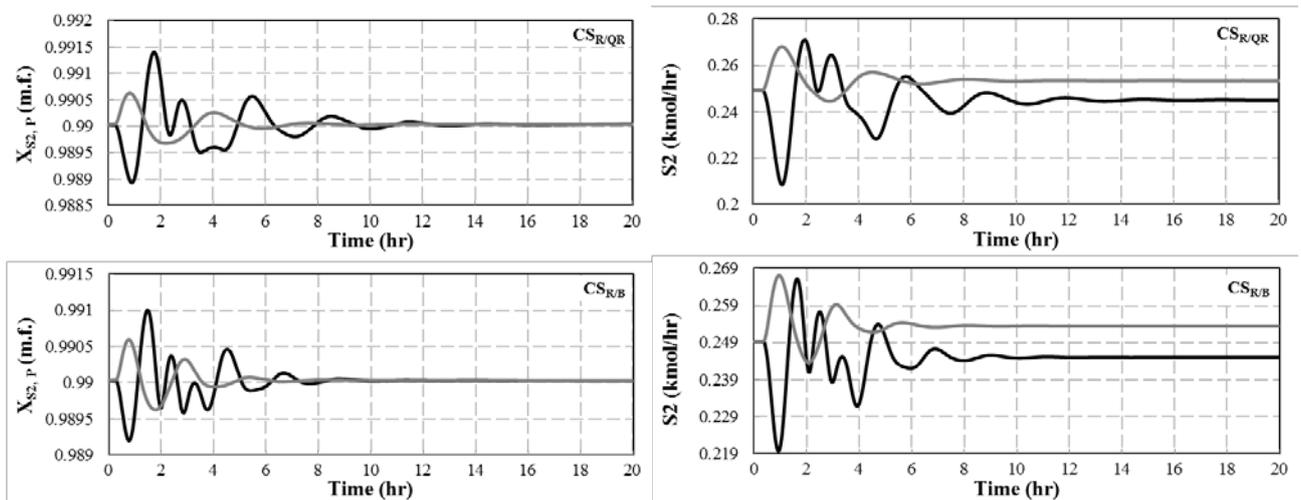
**Figure S4.** Dynamic responses of the bottom control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in M feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

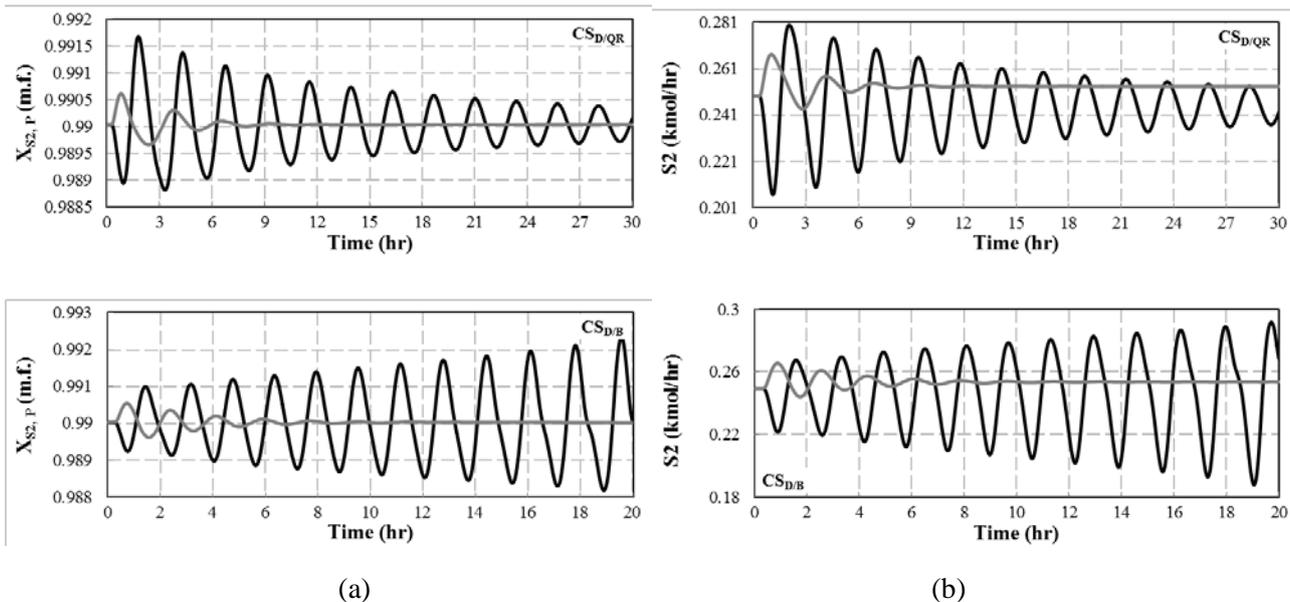


**Figure S5.** Dynamic responses of the prefractionator control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in M feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

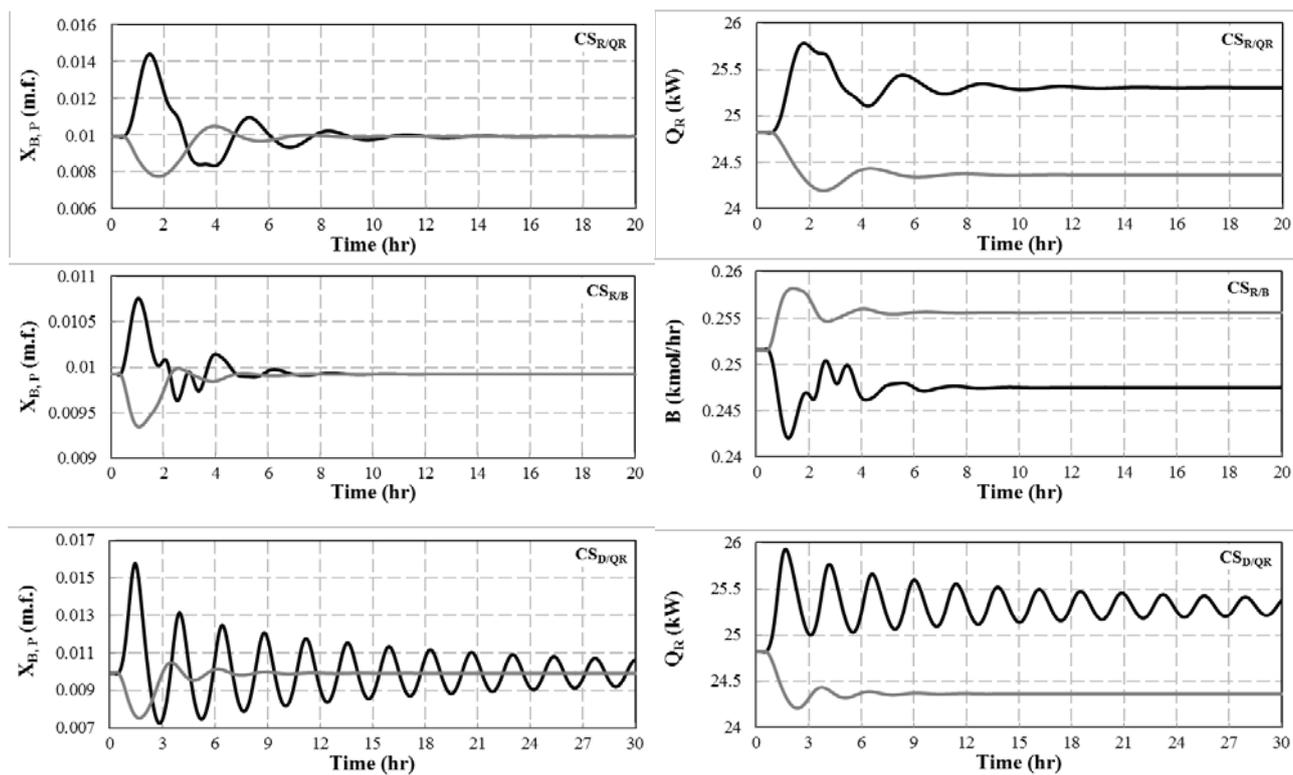


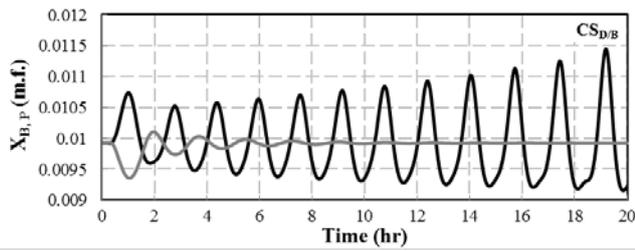
**Figure S6.** Dynamic responses of the upper sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in E feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.



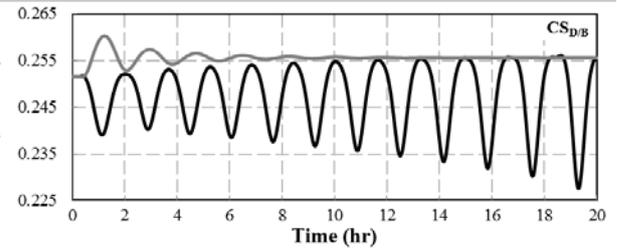


**Figure S7.** Dynamic responses of the lower sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in E feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.



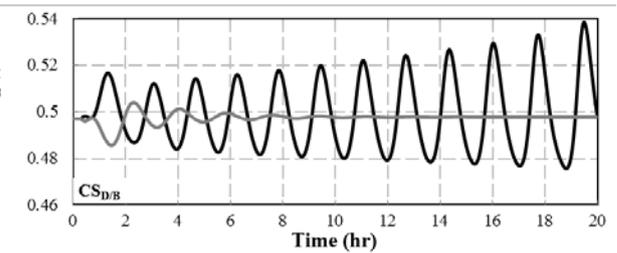
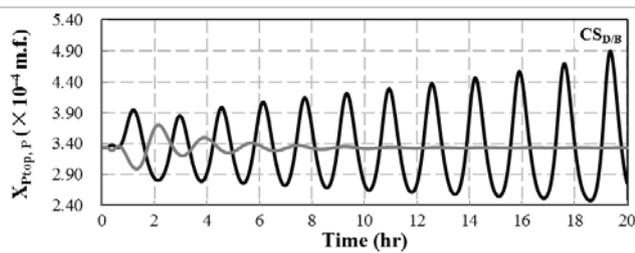
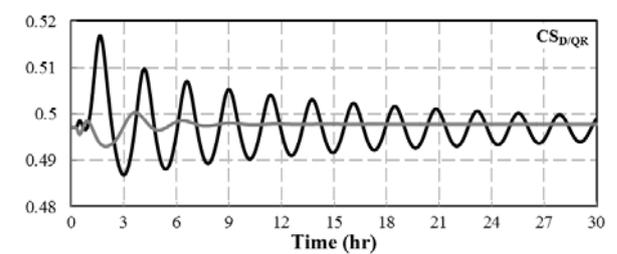
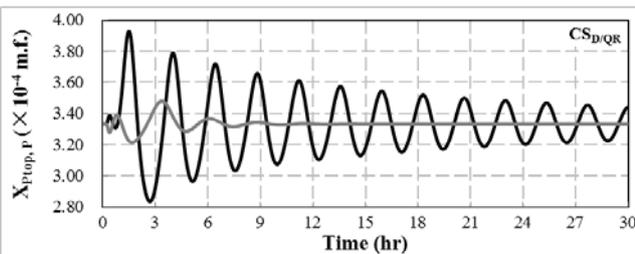
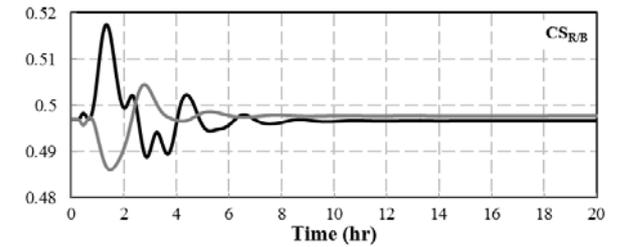
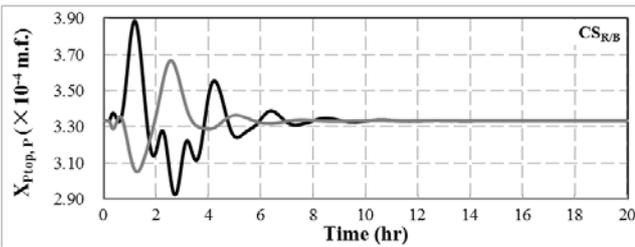
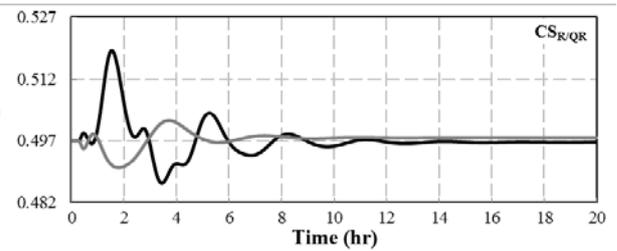
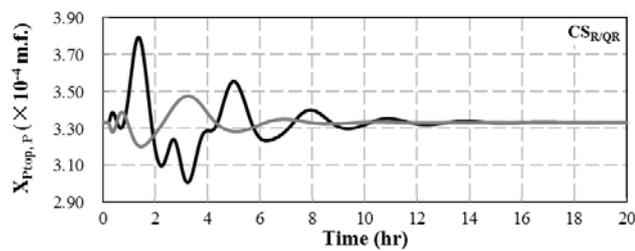


(a)



(b)

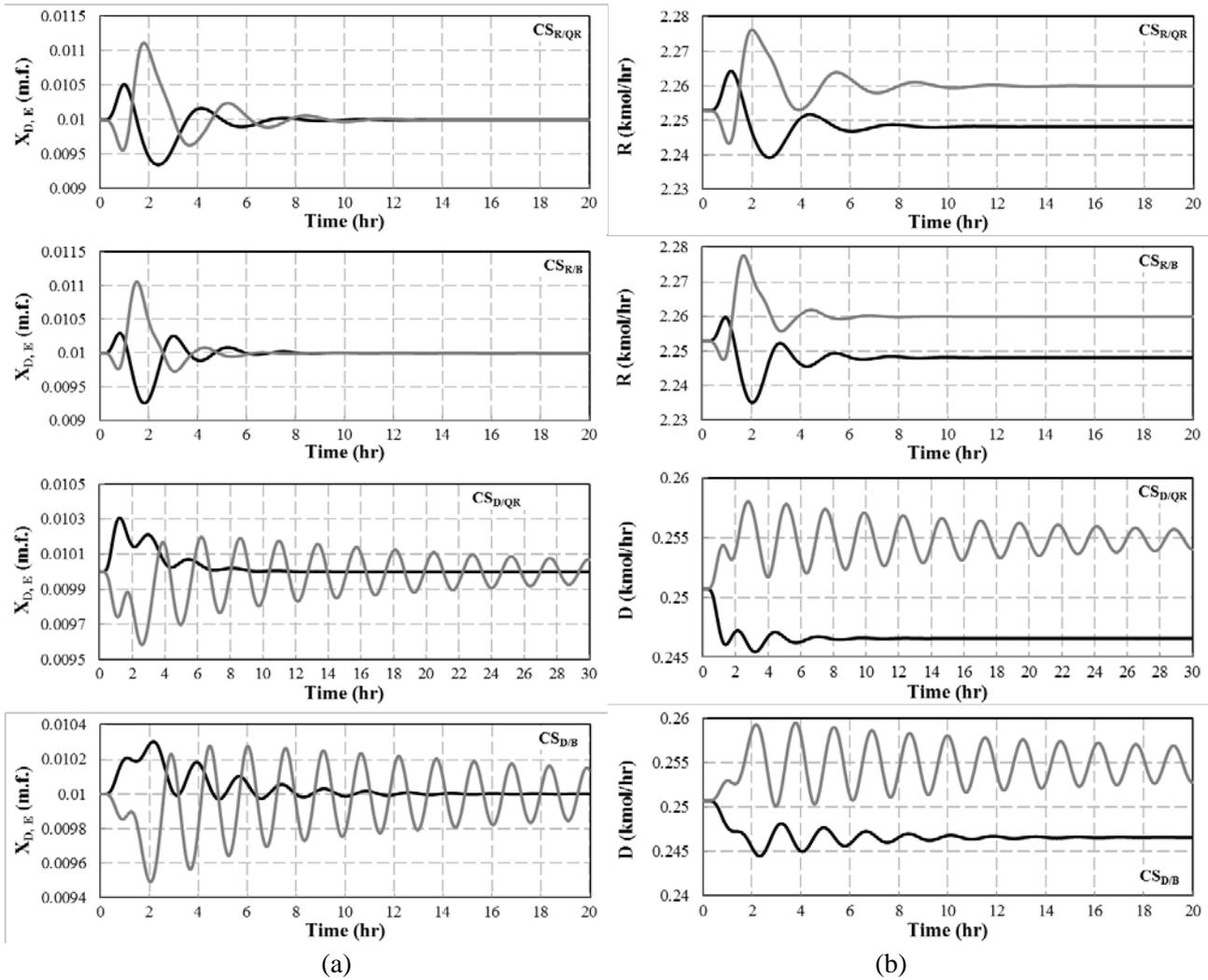
**Figure S8.** Dynamic responses of the bottom control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in E feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.



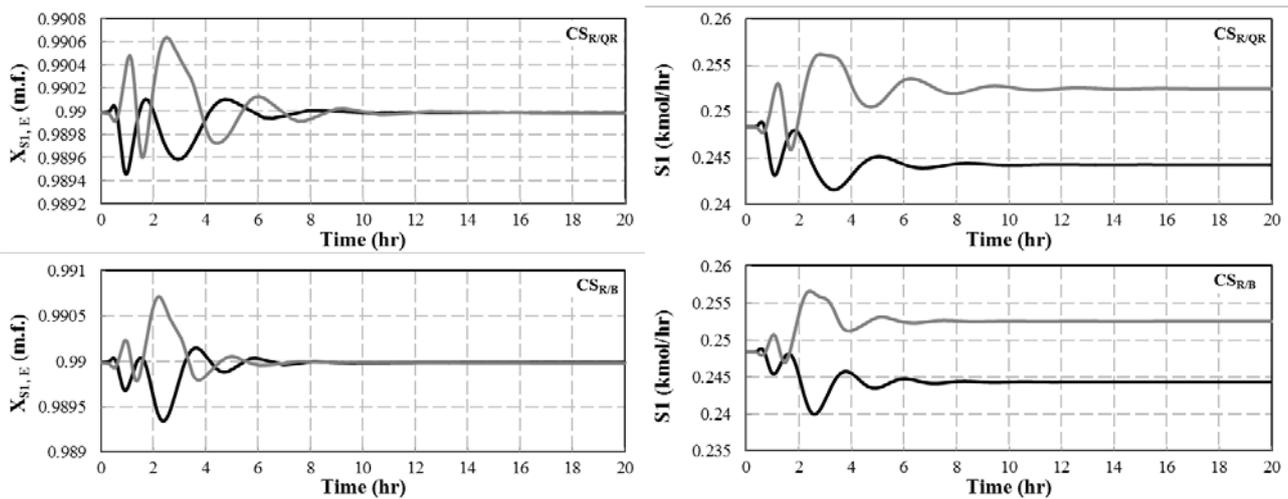
(a)

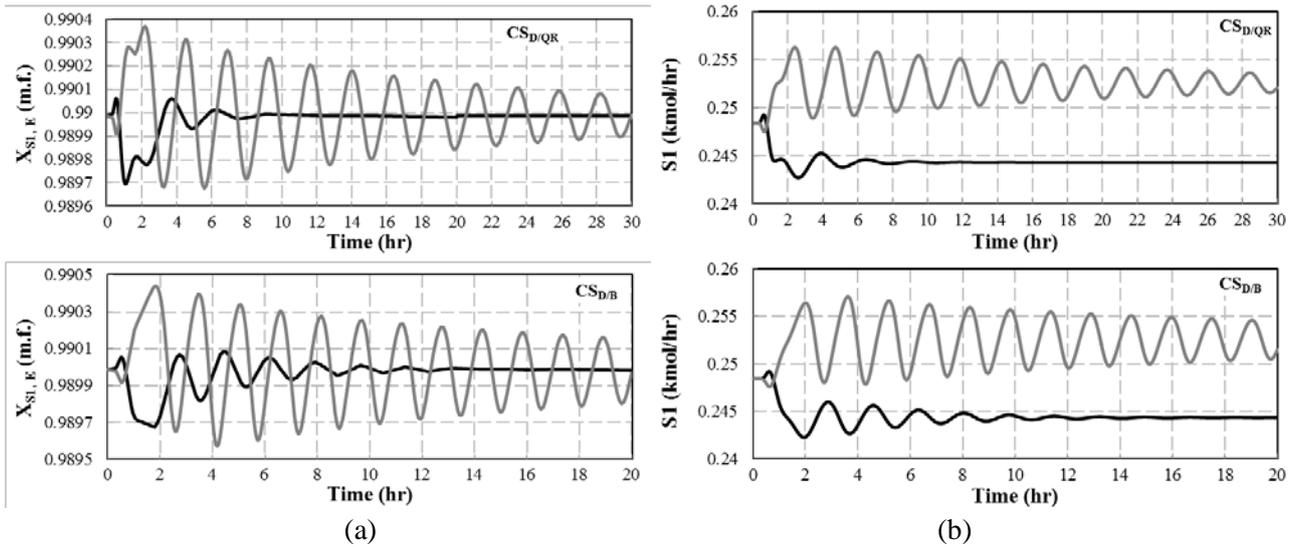
(b)

**Figure S9.** Dynamic responses of the prefractionator control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in E feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

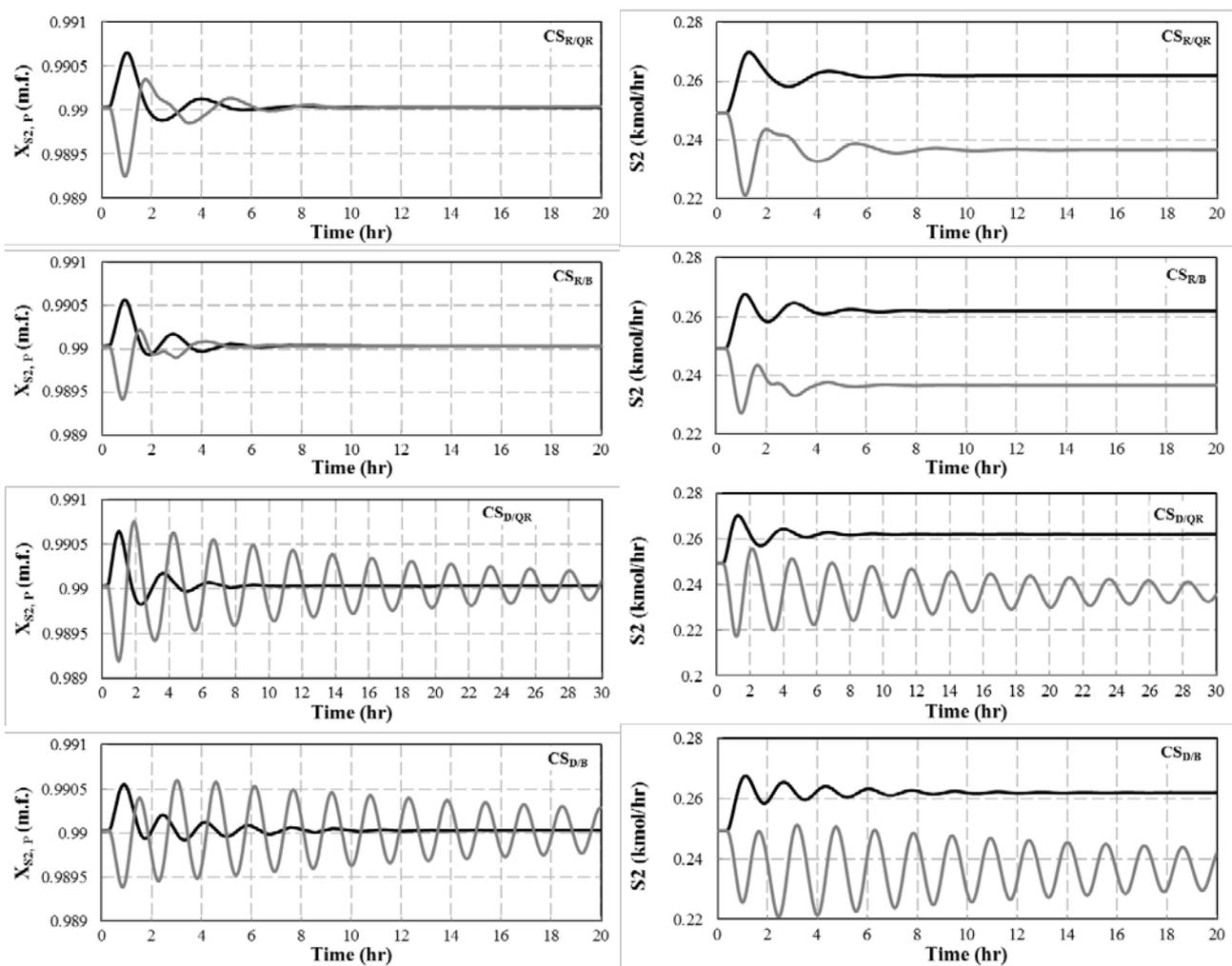


**Figure S10.** Dynamic responses of the top control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in P feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

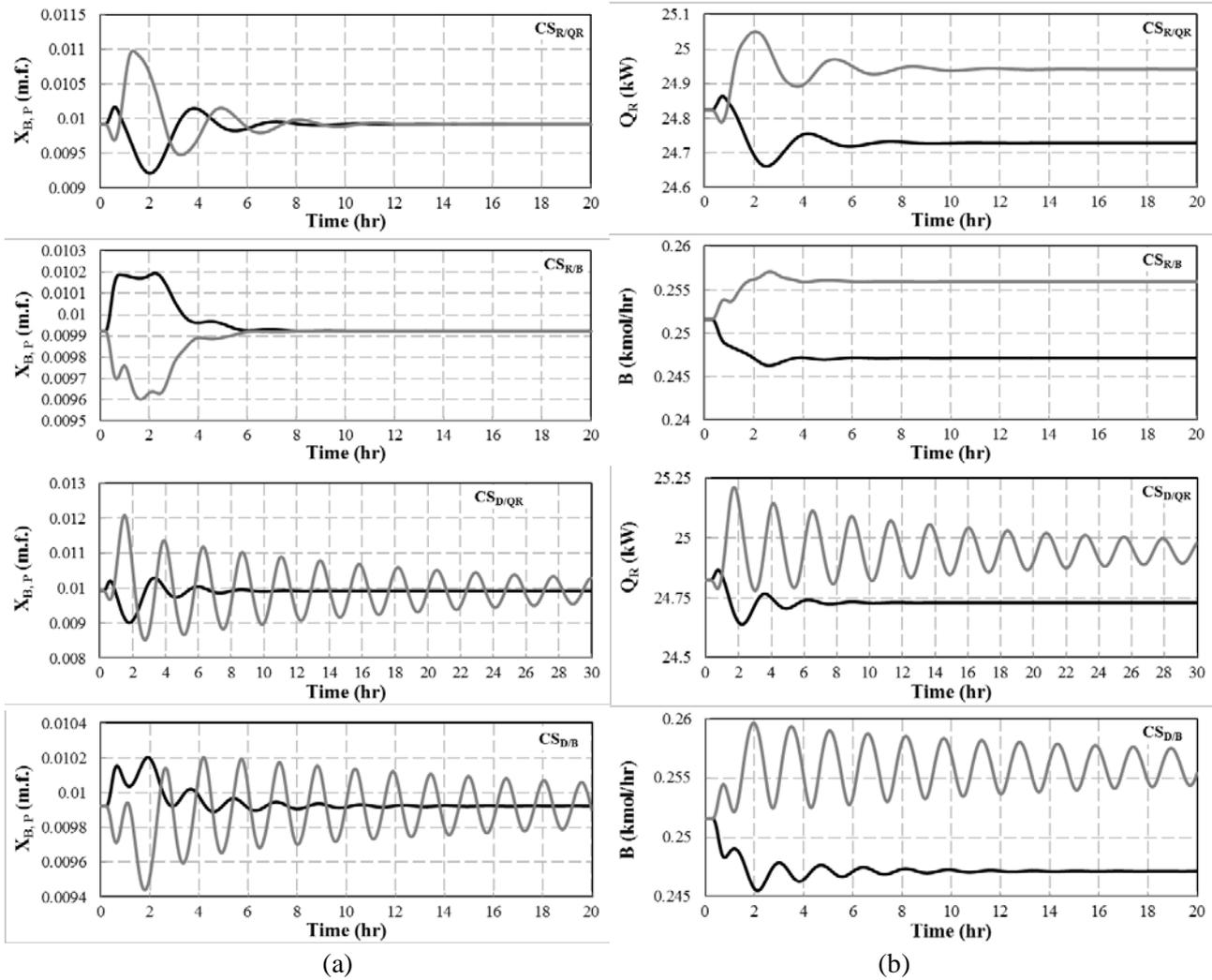




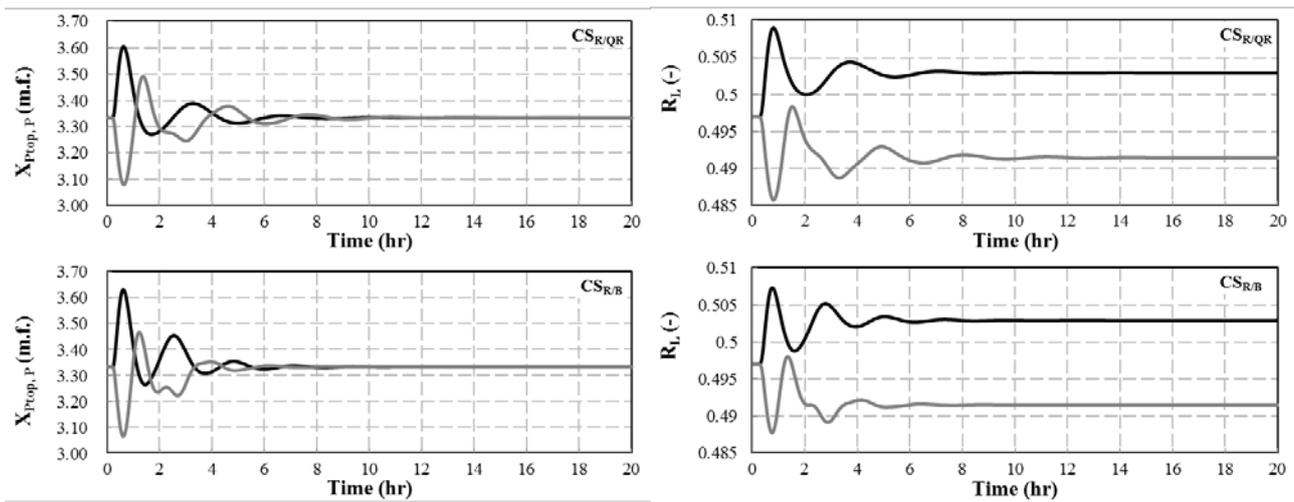
**Figure S11.** Dynamic responses of the upper sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in P feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

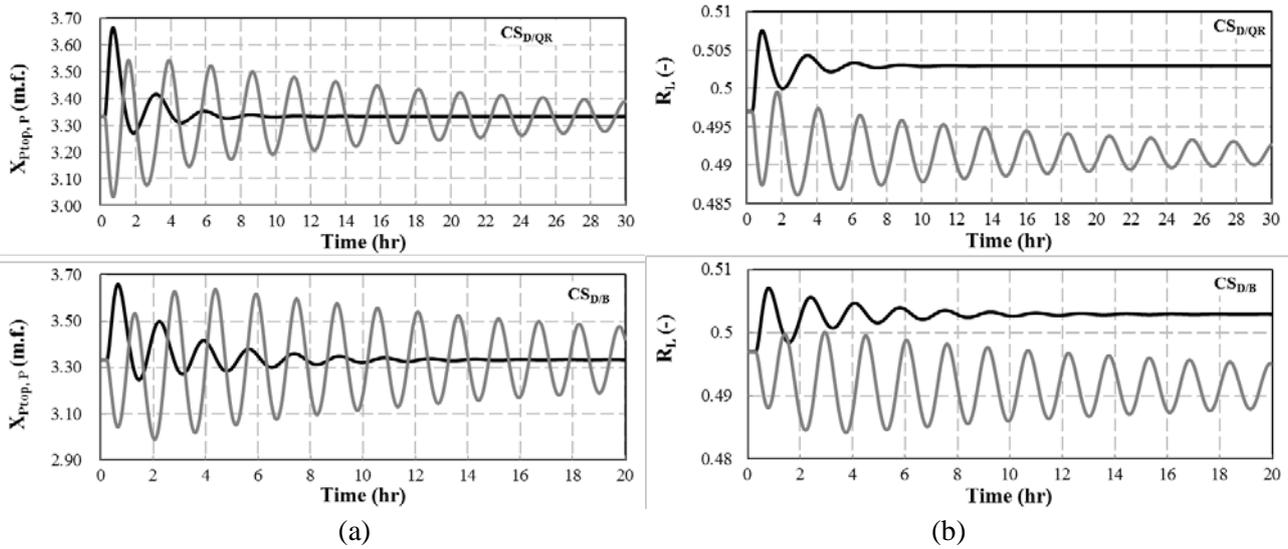


**Figure S12.** Dynamic responses of the lower sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in P feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

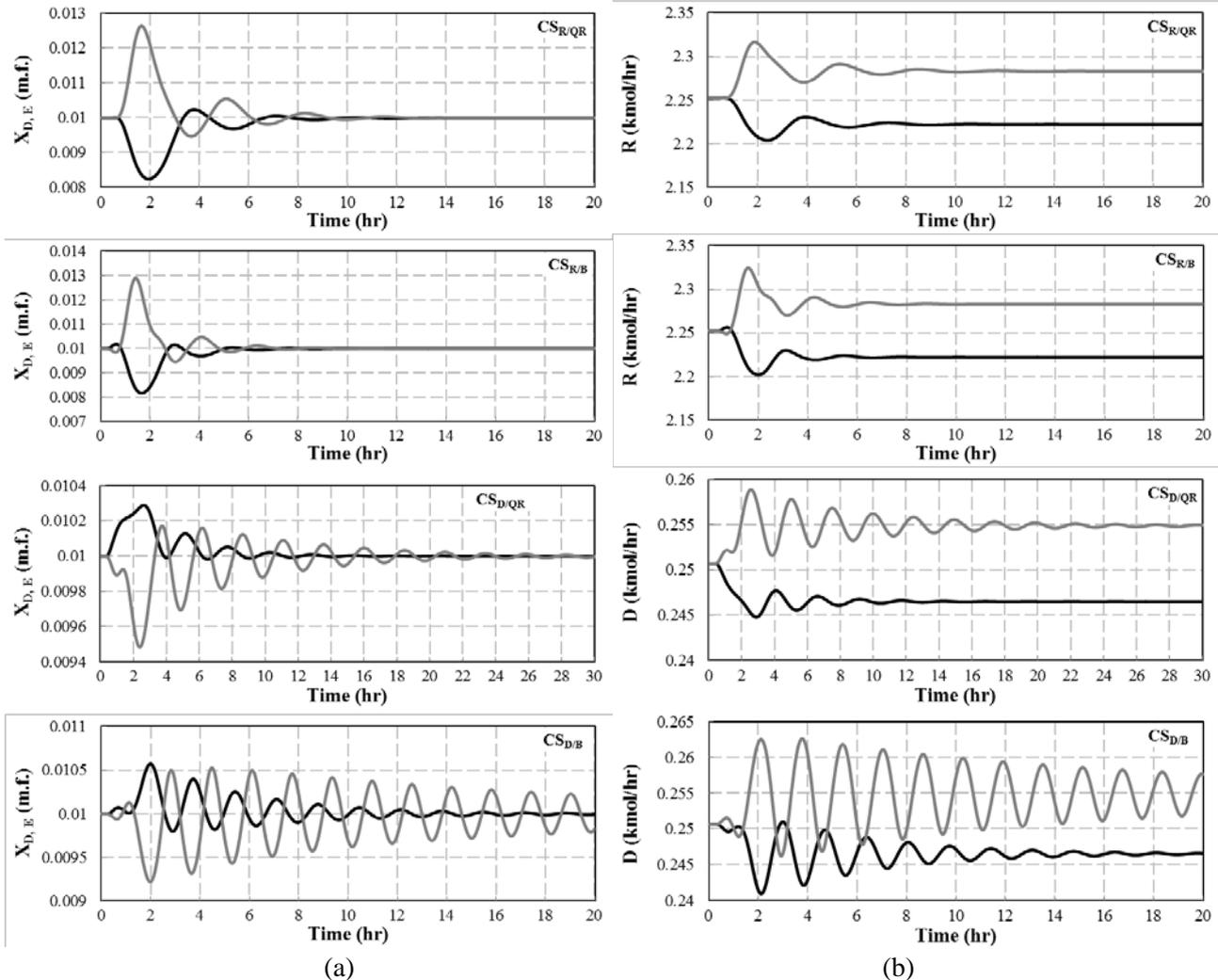


**Figure S13.** Dynamic responses of the bottom control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in P feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

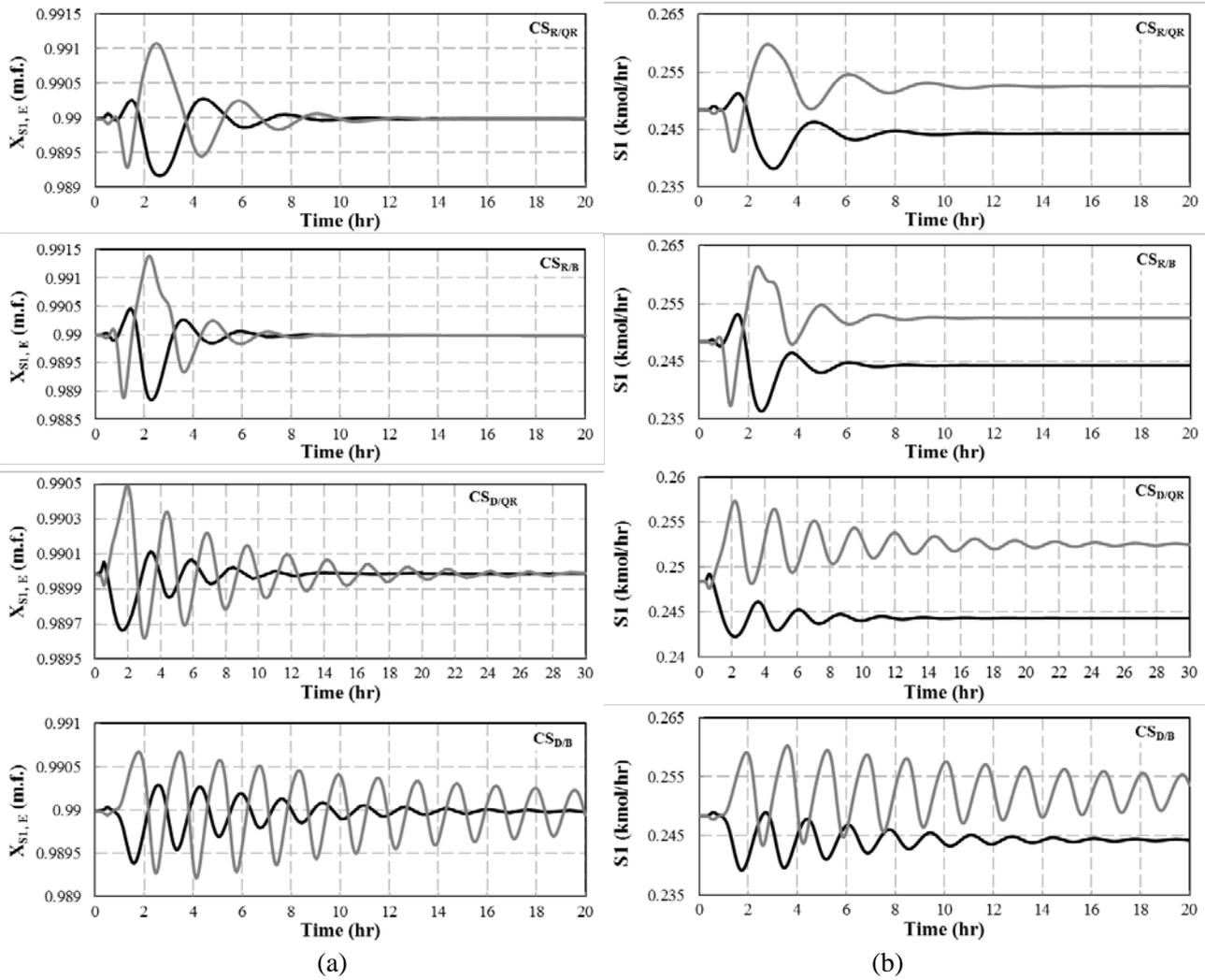




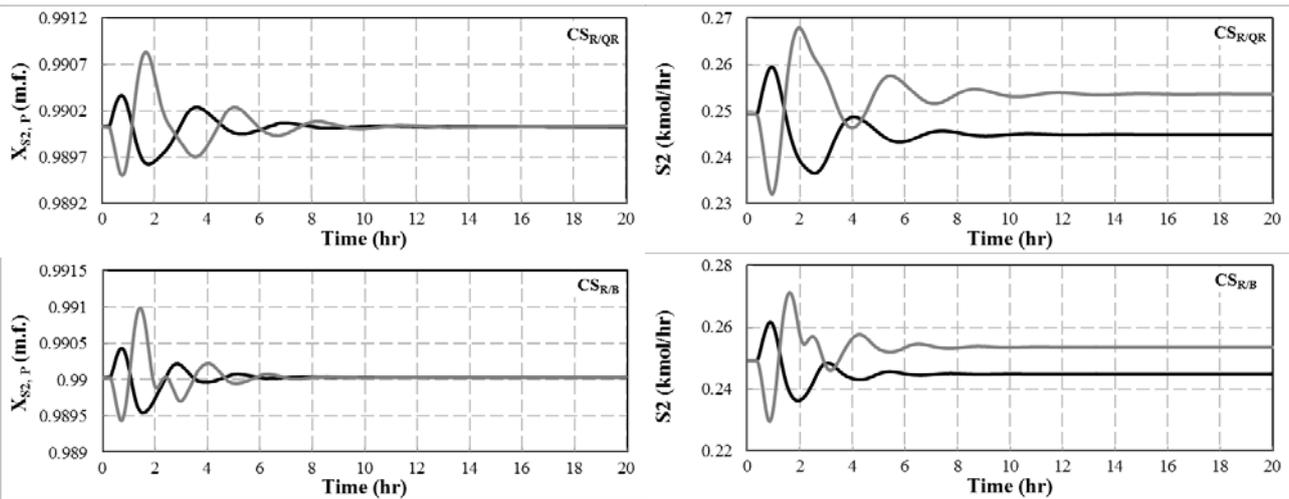
**Figure S14.** Dynamic responses of the prefractionator control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in P feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

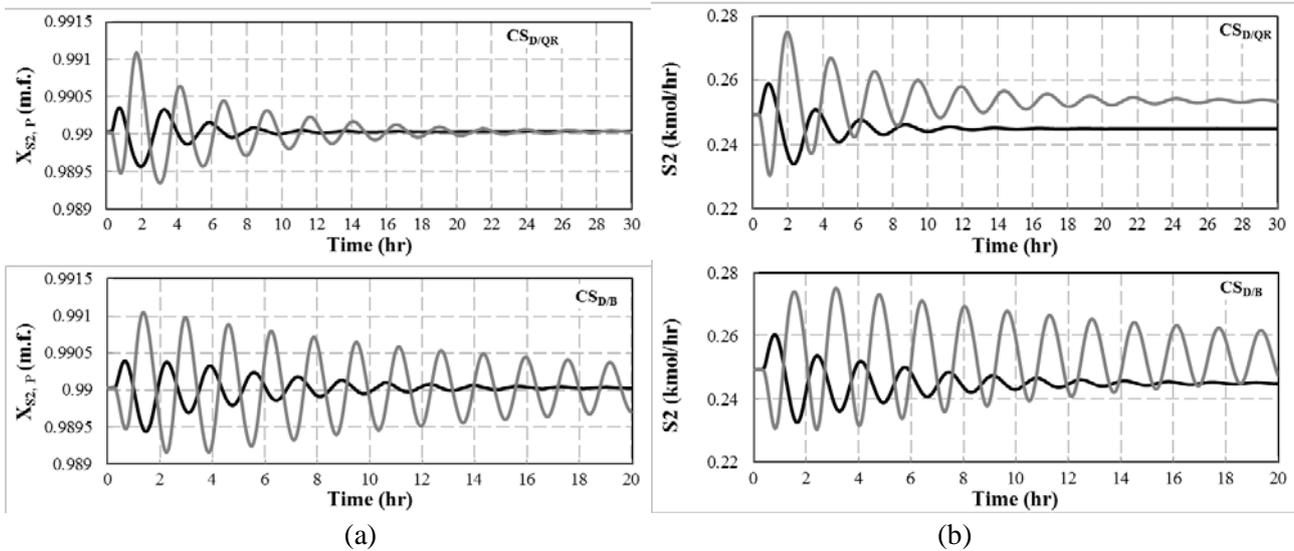


**Figure S15.** Dynamic responses of the top control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in B feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

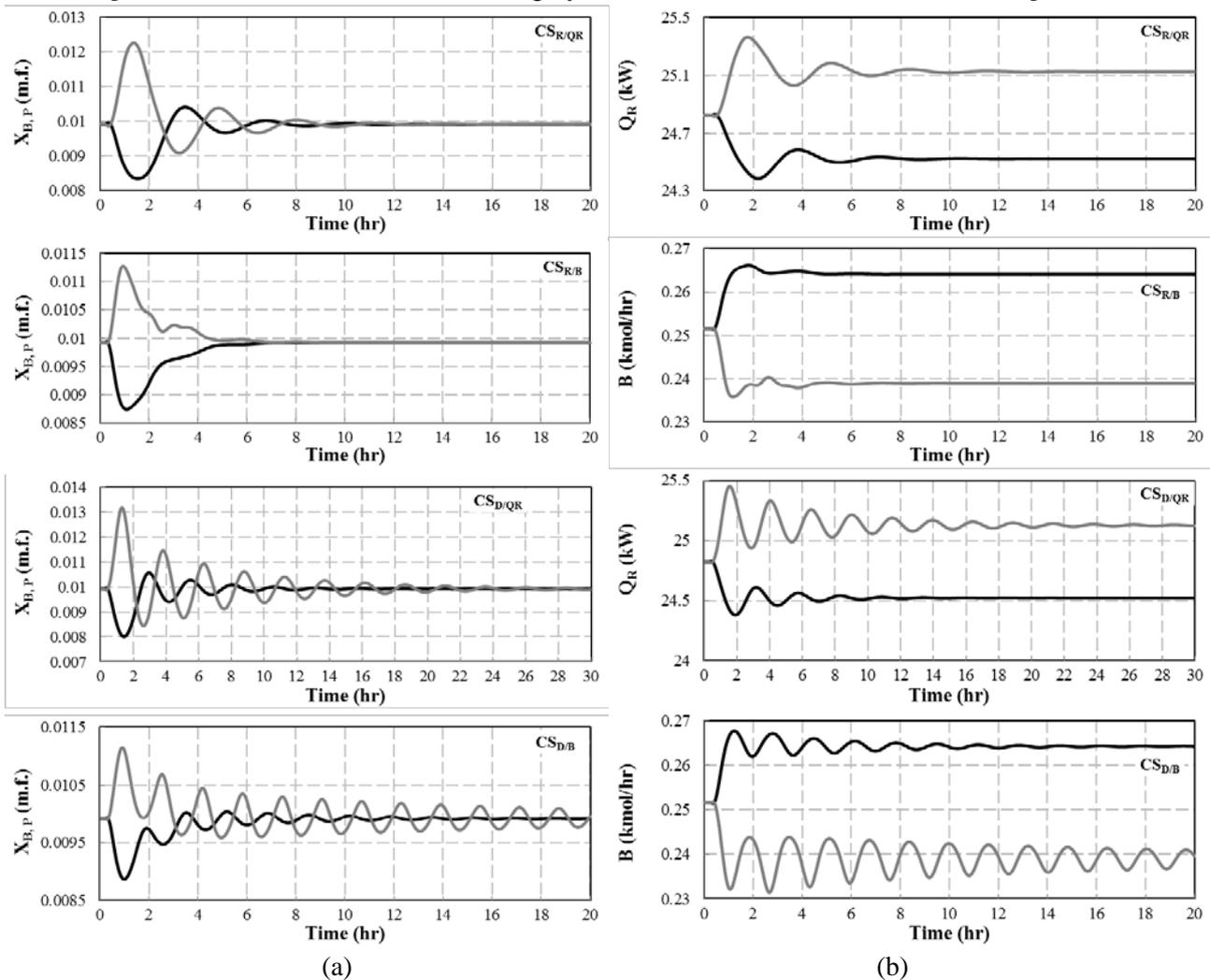


**Figure S16.** Dynamic responses of the upper sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in B feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

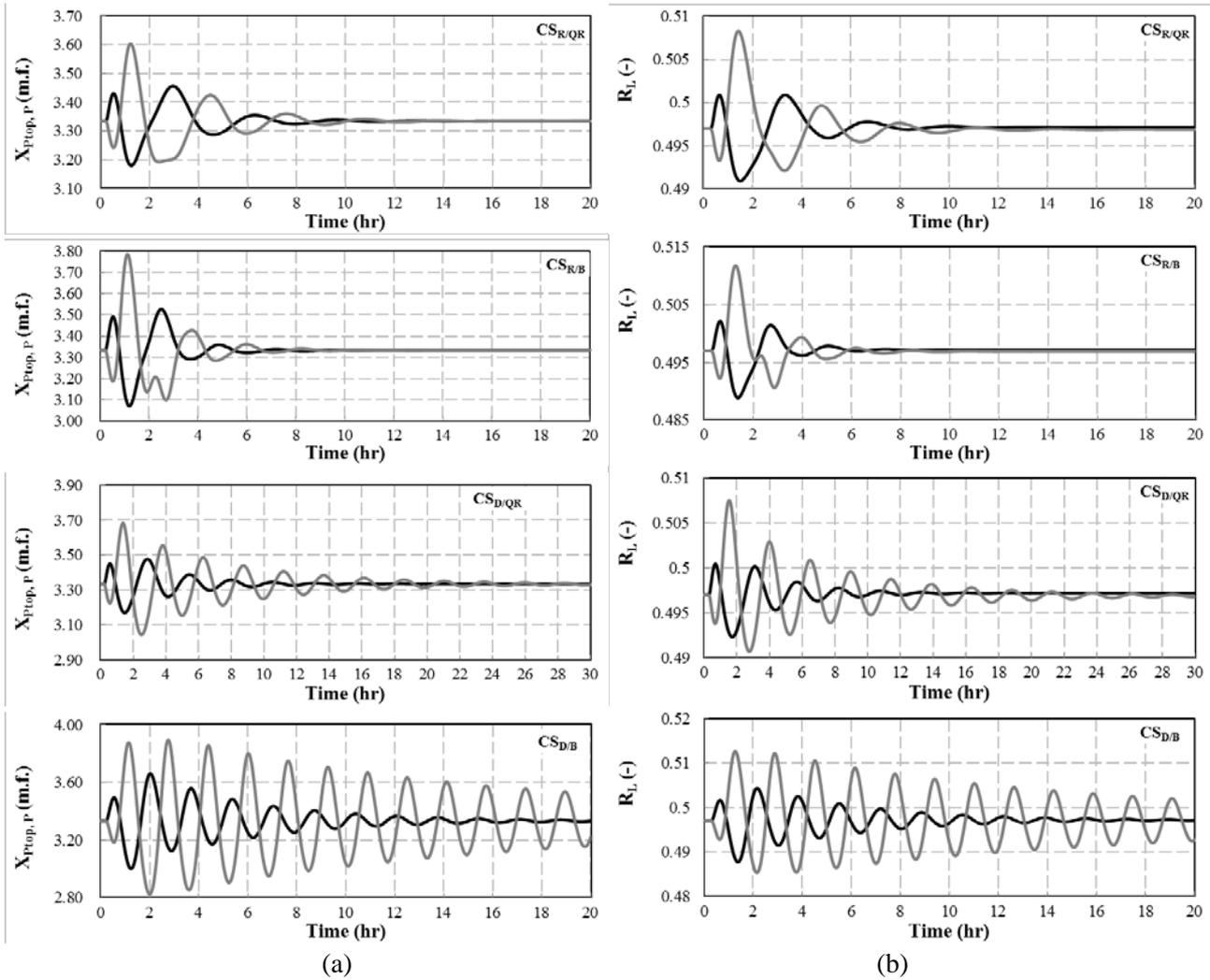




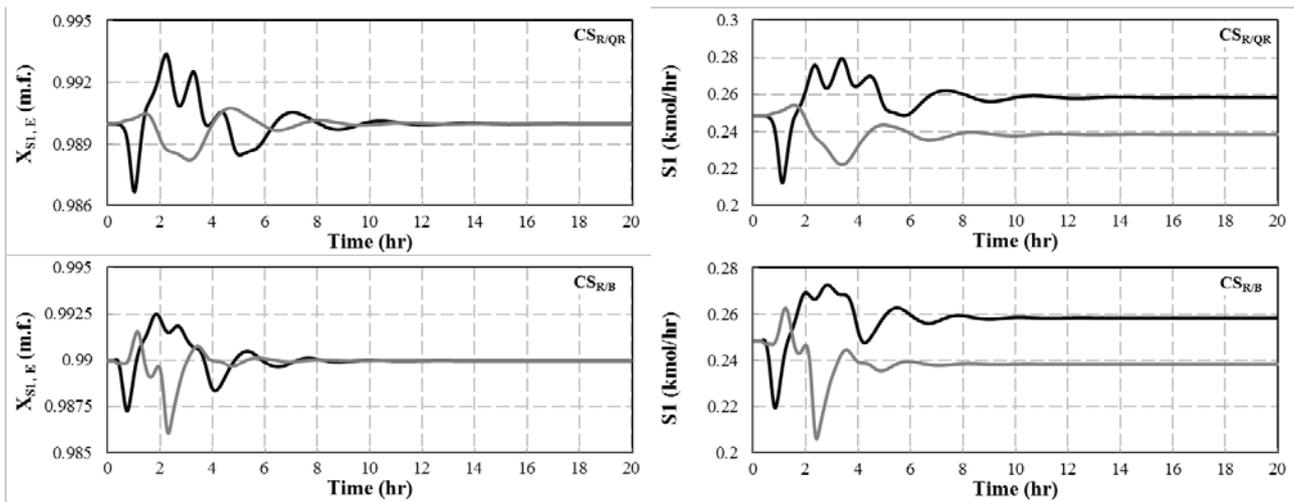
**Figure S17.** Dynamic responses of the lower sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in B feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

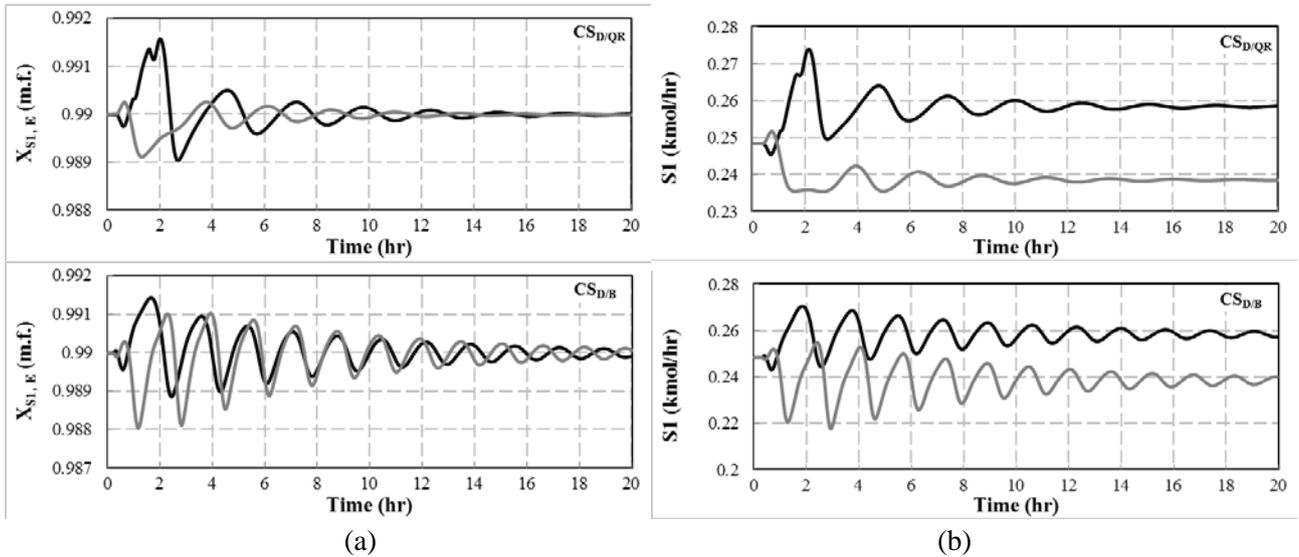


**Figure S18.** Dynamic responses of the bottom control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in B feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

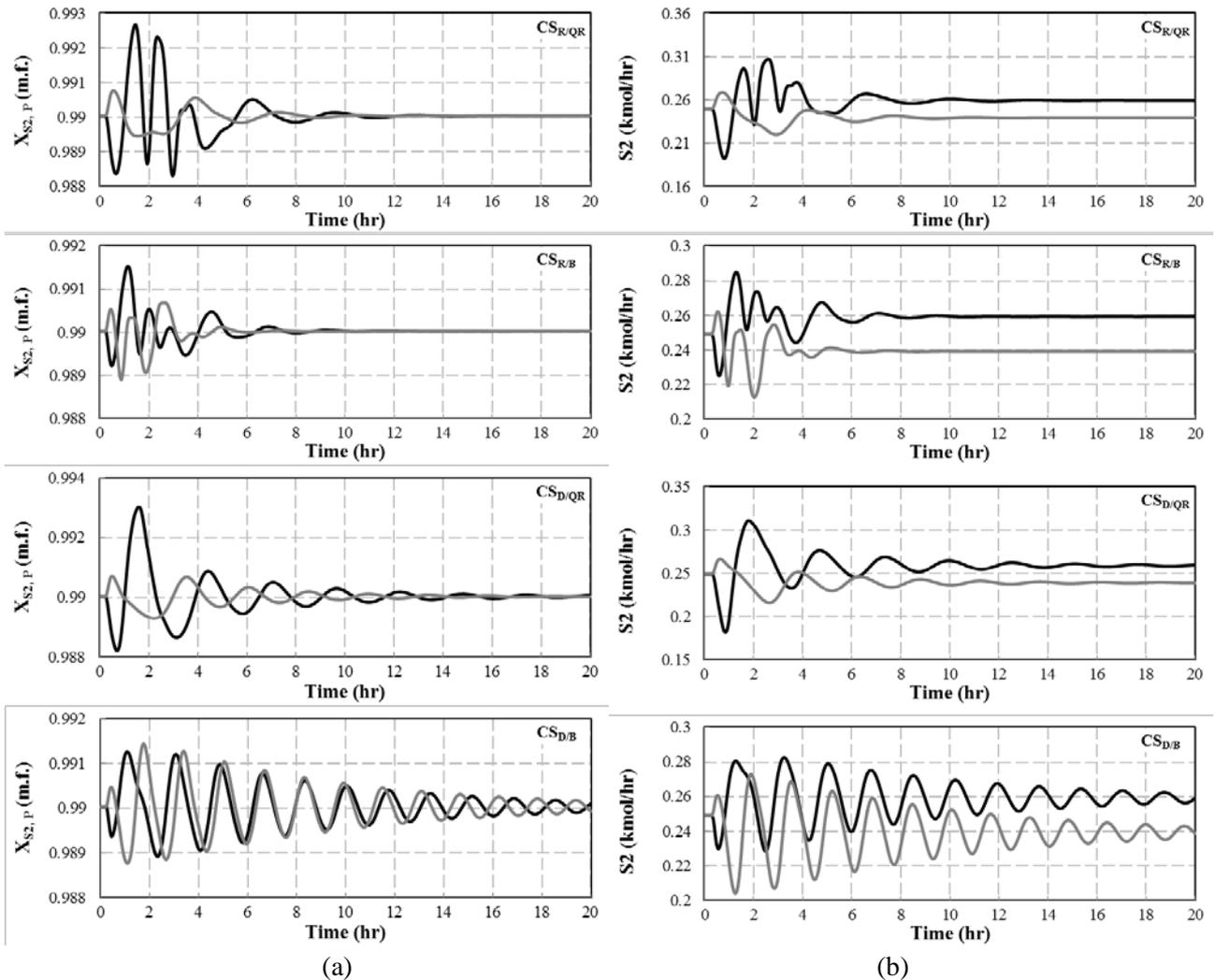


**Figure S19.** Dynamic responses of the prefractional control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in B feed composition (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

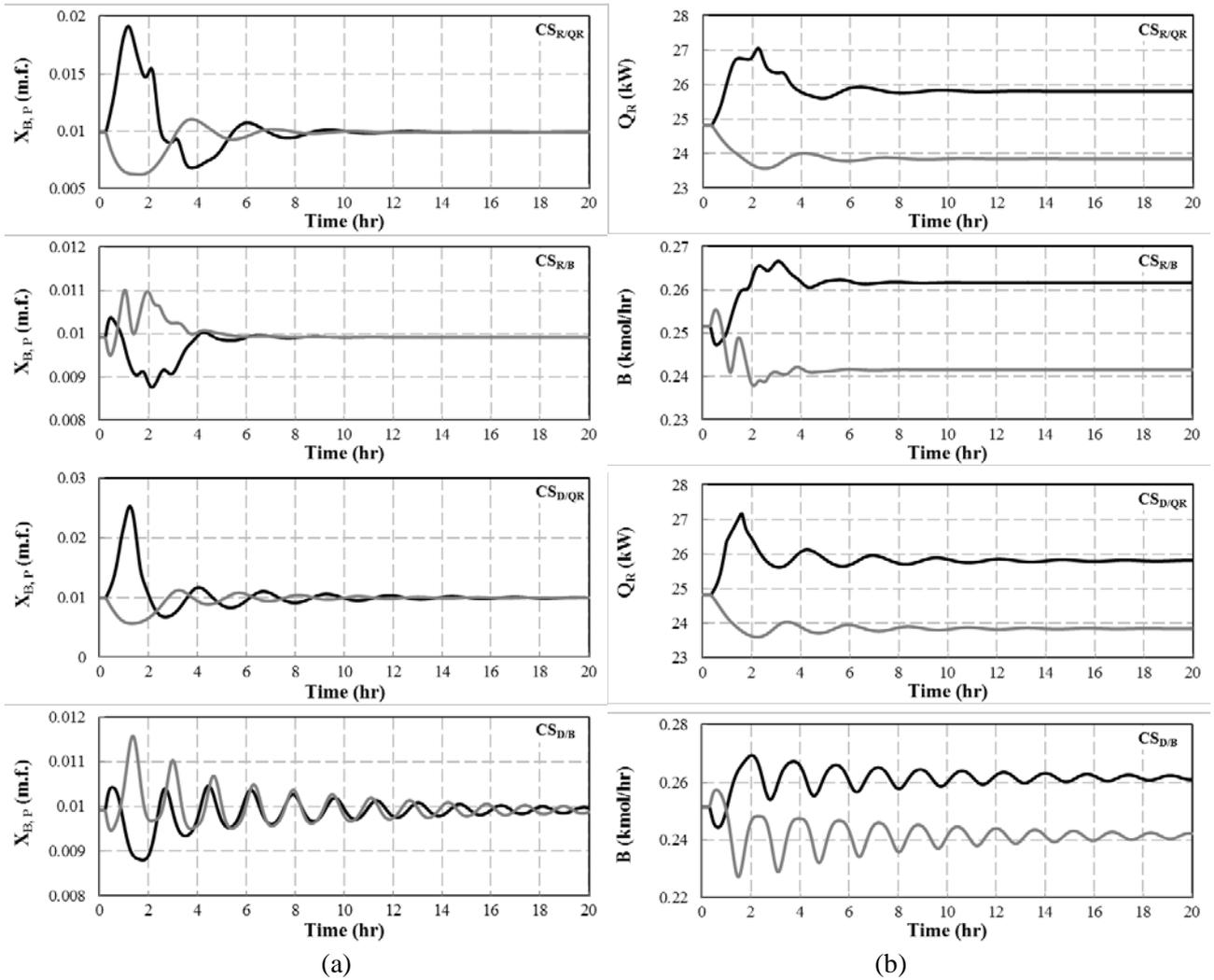




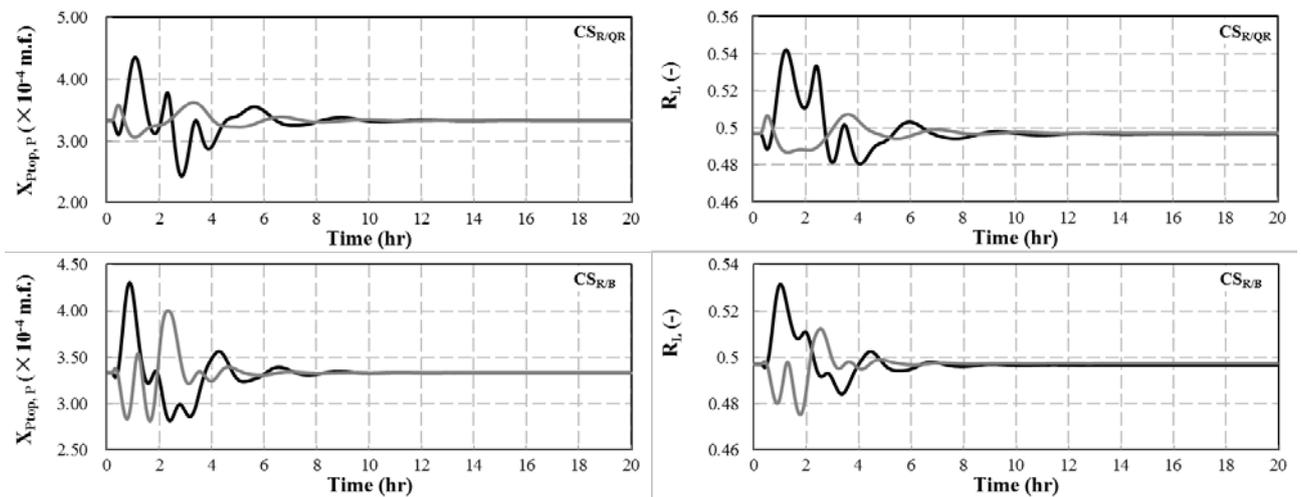
**Figure S20.** Dynamic responses of the upper sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in feed flow rate (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.

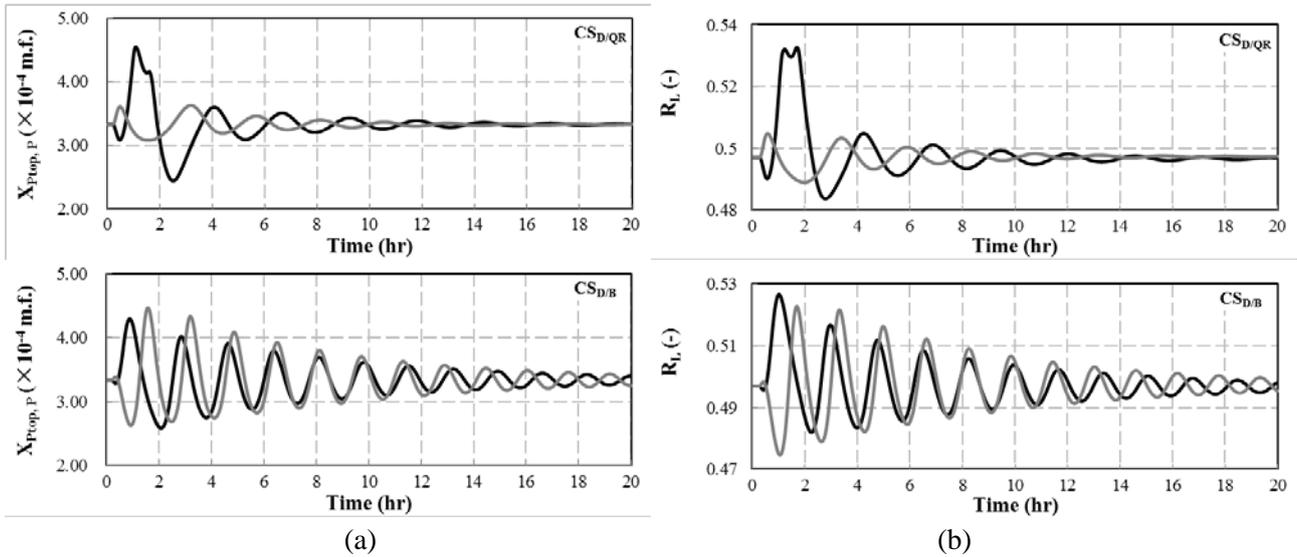


**Figure S21.** Dynamic responses of the lower sidestream control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in feed flow rate (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.



**Figure S22.** Dynamic responses of the bottom control loop of the MEPB Kaibel distillation column controlled, respectively, under the  $CS_{R/QR}$ ,  $CS_{R/B}$ ,  $CS_{D/QR}$ , and  $CS_{D/B}$  structures after facing a  $\pm 5\%$  step change in feed flow rate (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.





**Figure S23.** Dynamic responses of the prefractionator control loop of the MEPB Kaibel distillation column controlled, respectively, under the CS<sub>R/QR</sub>, CS<sub>R/B</sub>, CS<sub>D/QR</sub>, and CS<sub>D/B</sub> structures after facing a  $\pm 5\%$  step change in feed flow rate (+5%: black curves and -5%: grey curves): (a) controlled variables; (b) manipulated variables.