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ABSTRACT

In this work we present a mathematical model for demonstrating how an existing combined heat and power (CHP) plants based on different pressure levels of steam demands, which also integrates the heat derived from processes, can be retrofitted, when extant equipment cannot satisfy current multi-period steam and power loads. To maintain operational stability and flexibility, chemical processes can input steam and electricity as required through a combined heat and power system (CHP) as shown in Fig. 1. With increased steam and power loads, the retrofit optimization problem considers the multi-period operation strategy of the CHP systems, including the decisions on the acquisition of new equipment units. Feasible CHP retrofitting superstructures are constructed, based on which the CHP retrofit tasks can be transformed into mixed-integer nonlinear programming (MINLP) optimization problems. The retrofit target of the two cases is aimed at minimizing total annual cost.

The developed MINLP model was tested with four periods in one year and three pressure levels of steam demands, where two boilers and four turbines are considered, in case 1. In case 2, four pressure levels of steam demands with two boilers and six turbines are taken into account. The MINLP optimization problems were solved using GAMS softwere with DICOPT Solver. Here, the binary integer variables represent the existence of the units of specific boiler and turbine, which suggests the needs of new equipment and/or shut-down of extant equipment. The optimal results in Table1 show that one new boiler and one new turbine need to be purchased in case 1, while in case 2 one new boiler and three new turbines need to be acquired. To sum up, this study provides optimal design and operation solutions for the four periods with the changes of steam and power loads to the existing CHP systems.

Keywords: Multi-period optimization; MINLP; CHP

Table1：The optimal binary integer variables (Case1)

	Boiler1	Boiler2	Turbine1	Turbine2	Turbine4
Period 1,2 and 4	$B_1=1$	$B_2=1$	$T_1=1$	$T_2=1$	$T_4=1$
Period 3	$B_1=0$	$B_2=1$	$T_1=1$	$T_2=0$	$T_4=1$

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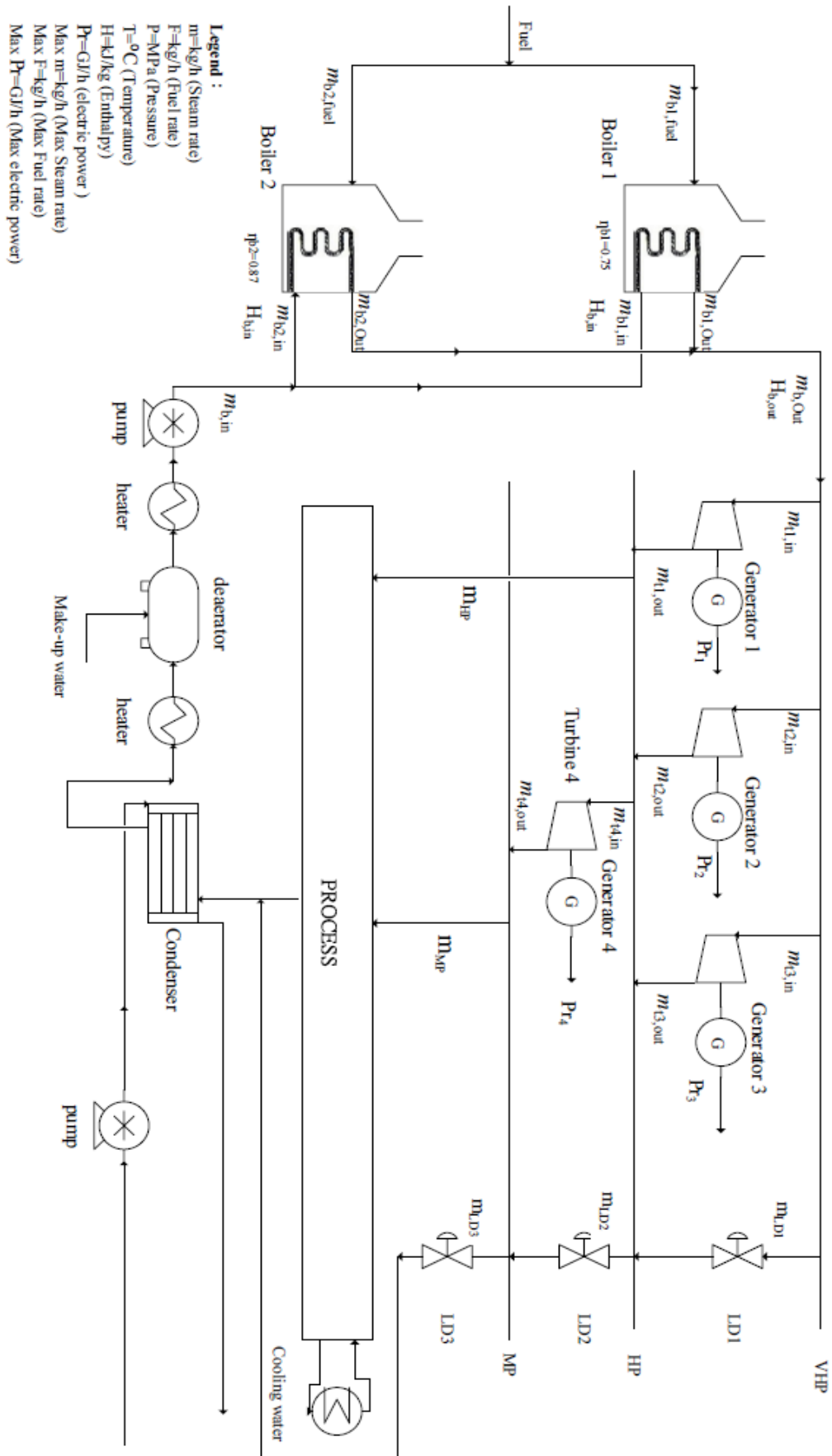
Fig. 1. : The superstructure of the CHP plants aimed at the design of integrated processes (Case1).

Legend :
m=kg/h (Steam rate)
F=kg/h (Fuel rate)
P=MPa (Pressure)
T=°C (Temperature)
H=kJ/kg (Enthalpy)
Pr=GJ/h (electric power)
Max m=kg/h (Max Steam rate)
Max F=kg/h (Max Fuel rate)
Max Pr=GJ/h (Max electric power)