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Interconnection of Thermal Plant Steam Circuits: Case of the Three Thermal Plants of the Burkina Faso Northern Ouaga Production Service (Sptn)

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Abstract: In this work, we are interested in the overheating of the Heavy Fuel Oil (HFO), for its permutation with the DDO. The practical aspect of this study is the design of an automated collector to make steam available at full load by exploiting steam potential. In the rest of our work, we have studied the influence of certain parameters on heat transfer. We concluded that temperature and pressure remain the most important parameters in the production of steam and the overheating of Heavy Fuel Oil. The choice of devices is made according to these two parameters. In the light of our analysis, this study shows that interconnection is an ideal solution for reducing the cost of production by using steam at full load.

Keywords: Steam Circuits, Interconnection, Overheating, Automated Collector, Heavy Fuel Oil, Thermal Transfer

1. Introduction

Boilers producing steam are of different powers and steam at different pressures. This steam is used to overheat HFO for the operation of the generators. The water used by boilers for the production of steam comes from the National Office of Water and Sanitation (ONEA). The quality of this water is insufficient to allow its use without treatment. To do this, this water is treated to offer the necessary properties for use by boilers [15].

Heating improves the quality of the HFO, making it lighter before switching with DDO. The mode of overheating used here is that of natural convection, it allows a simultaneous transfer of heat and mass (Steam from the product).

2. Materials and Methods

The approach consists in identifying the equipment that can be used as a framework for carrying out the technical and financial feasibility study, and sizing the steam production units. According to the results of this study, which remain specific to the plant [15], an analysis of the generalization of the results to other plants will be made.

2.1. Water Requirements of Different Steam Balloons

Boiler feed tanks called steam tanks should not be full. They are filled at a given percentage of the total balloon volume [15].

We have basically three steam balloons for three classes of generators (DEUTZ, WARTSILA and BWSC & MAN) [15]. The different values are shown in the table below:

Table 1. *Water requirement.*

Steam flask	% in water	Volume of the steam flask in dm^3
DEUTZ	75	574
WARTSILA	78	4000
BWSC&MAN	75	1000

2.2. The Heat/Steam Transfer Mode

Heat transfer is the transmission of energy from one temperature region T to another lower temperature region. This passage of energy can be done in several ways namely conduction, convection, radiation and mixed transfers. In our context, the mode of transfer refers to conduction.

i. Conduction

Conduction is a mode of energy transfer made by interaction between atoms or molecules in matter. This mode of transfer tends to a homogeneous distribution within the medium of the average kinetic energy. Various particles by diffusion of the zones where the average value of this energy, that is to say that the temperature, is raised towards the zones where it is weaker.

ii. The thermal field

Par By reference to our situation, the thermal field is defined by the knowledge at each point M of a gaseous body of the temperature, as a function of the coordinates of the point and of the time T (M, t).

To do this, we will identify five distinct points where we will find in each point the pressure and the temperature. The points P1 to P5, at each generator, are selected respectively at the entrance of the generator and the coils of the boiler.

Then we will average the temperatures and pressures according to the different generating sets in order to establish the summary table of the heat transfer [15].

Table 2. *Pressure and temperature readings.*

G.S.	DEUTZ					WARTSILA					BWSC&MAN				
Points	P_1	P_2	P_3	P_4	P_5	P_1	P_2	P_3	P_4	P_5	P_1	P_2	P_3	P_4	P_5
P (bar)	5	5.40	5.91	6.44	8	5 5	5.39 5.39	5.85 5.85	7.01 7.01	8 8	5	5.35	5.71	6.69	8
T (°C)	160	163	166	171	200	117 117	130 130	145.5 145.5	161 161	184 184	126	146	206	296	331

G.S.:Generating Set.

To average pressure and temperature for each type of group, we sum the pressures and temperatures of the five points and divide by five. For the case of WARTSILA, we divide by ten because we have at each point two values (we have two functional boilers). These are the G6 and G7 generators.

$$P\text{ (bar)} = \frac{p1+p2+p3+p4+p5}{5} \quad T\text{ (°C)} = \frac{t1+t2+t3+t4+t5}{5}$$

$p1,\ldots, p5$ et $t1, \ldots, t5$ are respectively the pressures and the temperatures at the points P_1, P_2, P_3, P_4, P_5.

P: Pressure of steam in bar

T: Steam temperature in °C

D: Outer diameter of steam piping in mm [13]

d: Inner diameter of steam piping in mm [13]

Table 3. *Summary of heat transfer.*

Steam circuits		P (bar)	T (°C)	d (mm)	D (mm)
DEUTZ	G1	-	-	15	20
	G2	6,15	172	15	20
	G3	-	-	15	20
	G4	-	-	15	20
	G5	-	-	15	20
WARTSILA	G6	6,25	147,5	15	20
	G7	6,25	147,5	15	20
BWSC & MAN	G8	6,4	221	15	20

iii. Energypotential/steam available

Table 4. *Energypotential.*

Boilers		P (bar)	T (°C)	Pce (KJ/h)
DEUTZ	G1	-	-	-
	G2	8	200	490
	G3	-	-	-
	G4	-	-	-
	G5	-	-	-
WARTSILA	G6	8	184	1642
	G7	8	184	1642
BWSC & MAN	G8	8	331	1000

1) Groups G1 to G5 come from the manufacturer DEUTZ;
2) Groups G6 and G7 are from the manufacturer WARTSILA;
3) And the G8 group comes from the manufacturer BWSC & MAN.

It should be noted that the boilers from these three classes of generators do not have the same architectures and therefore they do not have the same operation [15].

The operation of the boilers differs according to the class of generators as well as the pressures, the temperatures and the powers.

iv. Evaluationof the steam demand of generators

The parameters used in the context of the use of steam by generators are pressure and temperature. The other parameters are not taken into account in the overheating of the HFO.

Table 5. *Steam Generator Requirements.*

Overheating of HFO (Generator)		Pressure (bar)	Temperature (°C)	Viscosity (cst)
DEUTZ	G1	-	-	12
	G2	5	160	12
	G3	-	-	12
	G4	-	-	12
	G5	-	-	12
WARTSILA	G6	5	117	16
	G7	5	117	16
BWSC & MAN	G8	5	126	12

2.3. Energybalance

Decreases in temperature and steam pressure are observed during the transfer. These variations are due to several factors which are among others:

1) The purge systems installed on the boilers in the event of a very large rise in the pressure of the steam [4, 10, 11, 13];
2) Leaks at the pipe level. The flow of the fluid (steam) causes piping phenomena, especially in the case of a bent flow [8];
3) The distance between each boiler and the generator;
4) And the thermal conductivity of the materials used.

The following histograms illustrate these declines.

Histograms of pressures (ordinate: pressure (bar); abscissa: equipment).

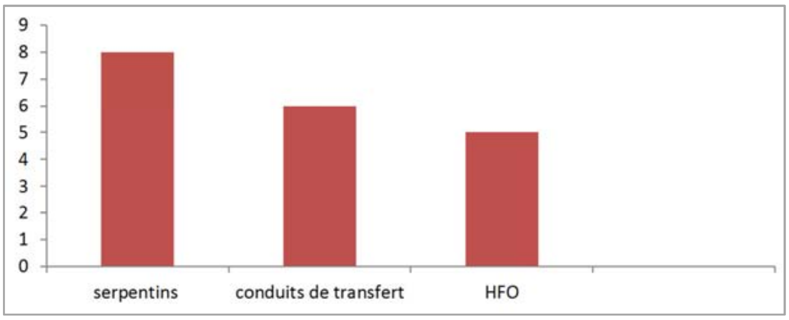

Figure 1. *PressureHistograms DEUTZ.*

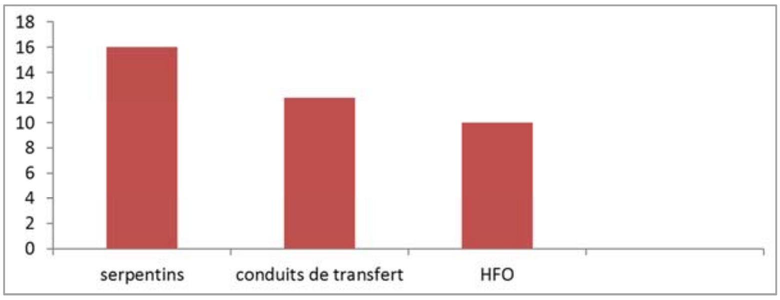

Figure 2. *PressureHistograms WARTSILA.*

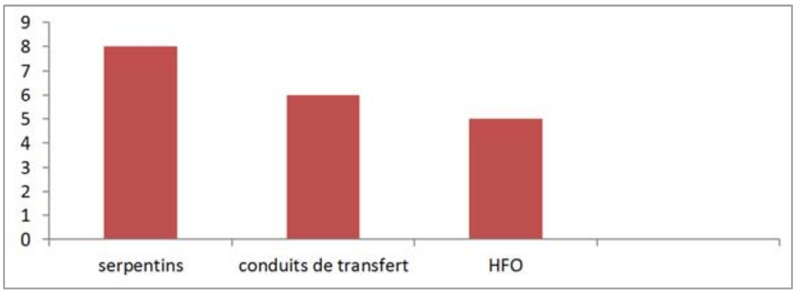

Figure 3. *PressureHistograms BWSC&MAN.*

Histograms of temperatures (ordinate: temperature °C); abscissa: equipments).

It should be noted that the values taken for the construction of histograms (pressures and temperatures) are recorded values for reasons of safety and operating constraints. In addition, the values used are the summations of the pressure and temperature values of the types of generators mentioned above.

3. Results and Discussion

The process of designing or redesigning [1] a product follows a process defined according to the specificity of the product. The main function is the global function that the system must satisfy and this function is determined using the [14]*"Horned Beast" tool.*

The main function of our study interconnection is to *ensure the availability of steam at full load.*

The *Octopus* [14] of our collector line is as follows:

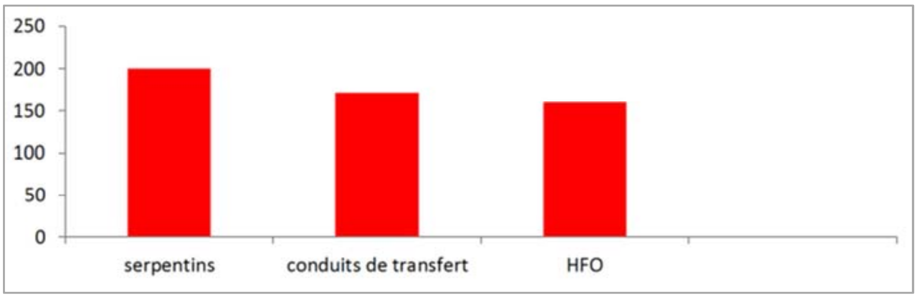

Figure 4. *TemperatureHistogramsDEUTZ.*

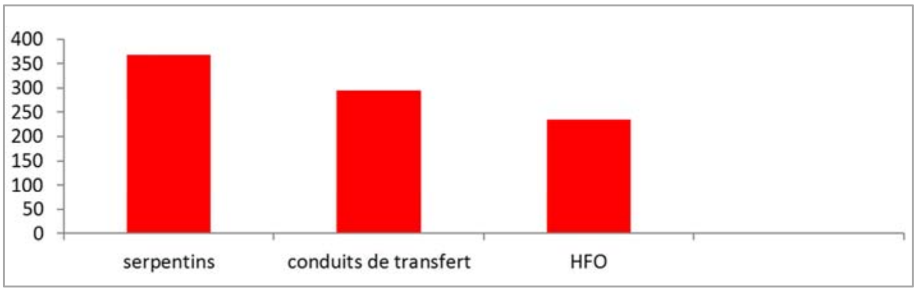

Figure 5. *Temperature HistogramsWARTSILA.*

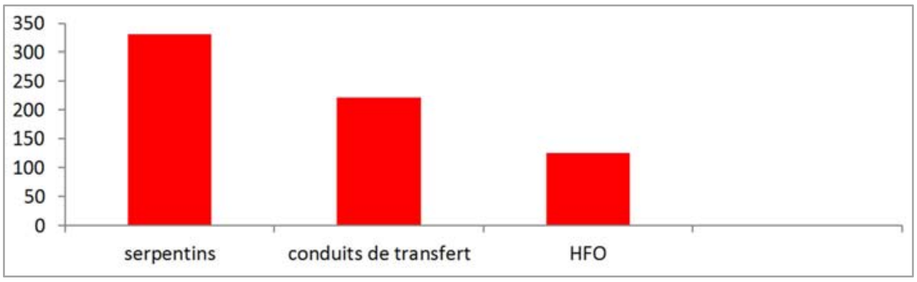

Figure 6. *Temperature Histograms BWSC&MAN.*

Table 6. *Functional specifications [14-15].*

Functions	Criteria		Levels	Limits/flexibility
FP1: Ensuretheavailabilityofsteamatfullload	C1: Cadence		DEUTZ: 1950kJ/h	10kJ/h
			WARTSILA: 3269kJ/h	15kJ/h
			BWSC&MAN: 990kJ/h	10kJ/h
FP2: Remove impurities from the water	C2: Separation		90%pur	5%
FP3: Mix additives with water	C3: Water treatment (Homogeneity)		Total	None
FP4: Generate profits	C4: Cost price			
FC1: Meet environmental standards.	C5: Pollution and degradation		Nopollutionanddegradation	None
FC2: Connect to a power source.	C6: Sector		24h/24	1h
FC3: Be easy to maintain	C7: Standardization of parts		80% of parts	5%
	C8: Demountable	Number of parts	The entire interconnection chain	5%
		Speed	3 at 6 minutes per parts	5%
	C9: Modularity		70% of systems	5%
	C10: Interchangeability		70% of parts	5%
FC4: Implant in a frame	C11: Workspace		2 meters between the installation and the wall	20cm
	C12: Property of the local		Daily cleaning	None
FC5:Enable the operator to easily access	C13: Accessibility		No clutter	None

Functions	Criteria	Levels	Limits/flexibility
all levels of the interconnection chain.			
FC6: Consume less electrical energy	C14: Power of motors	40 kW	5kW
FC7: Bear the vibrations	C15: Solidity of pipes	Ø 15 mm on 1 m in aluminum alloy	None
	C16: Thickness of reinforced concrete	50 centimeters (cm)	5centimeters

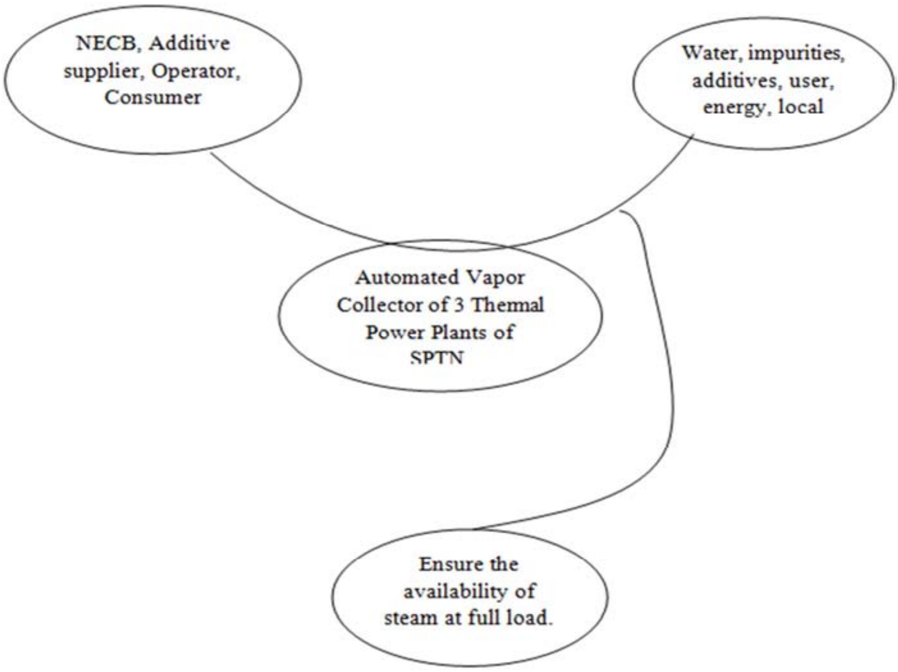

Figure 7. *Horned Beast of our Automated Steam Collector [15].*

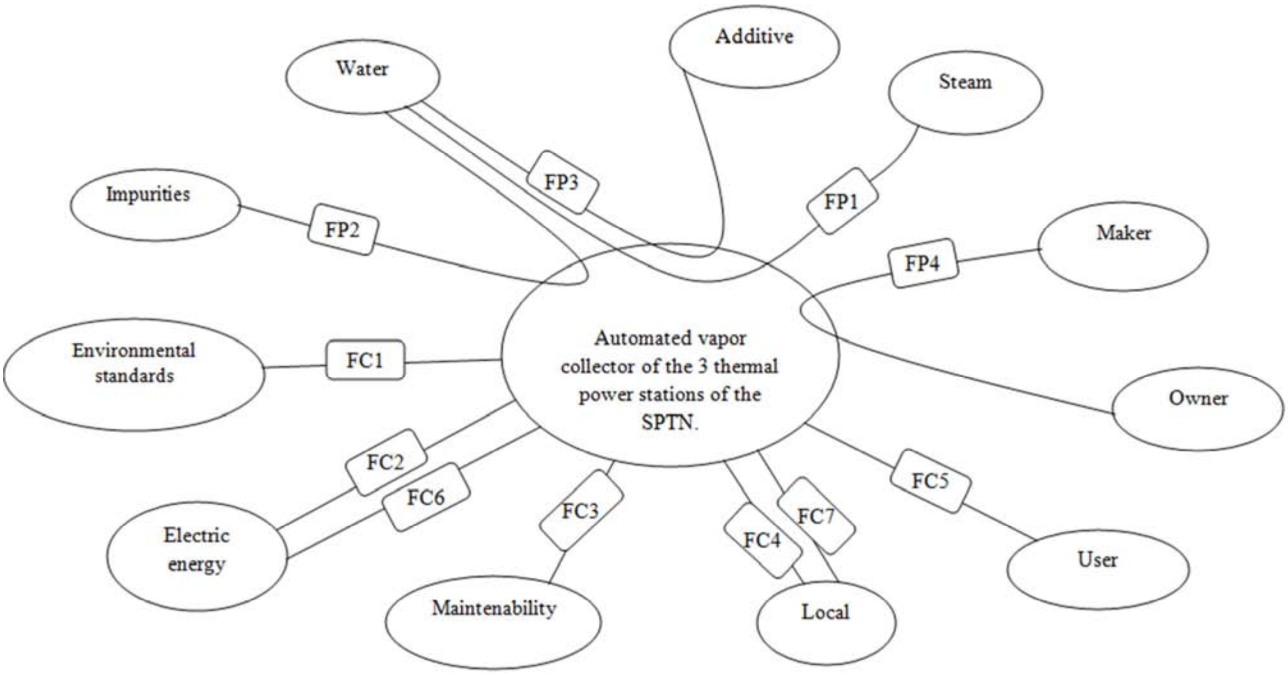

Figure 8. *OCTOPUS of our automated collector [15].*

The technical analysis of our system leads us to use two other steam collectors, one for the DEUTZ groups and one for the BWSC & MAN group. As far as the DEUTZ groups are concerned, the steam will soon have to be passed through steam collectors instead of being transferred to the steam balloon.

In addition, the three collectors will be interconnected according to the "*DEUTZ steam collector - WARTSILA steam collector - BWSC & MAN steam collector - DEUTZ steam collector*" channel diagrammed below [2, 3, 6, 7, 9]:

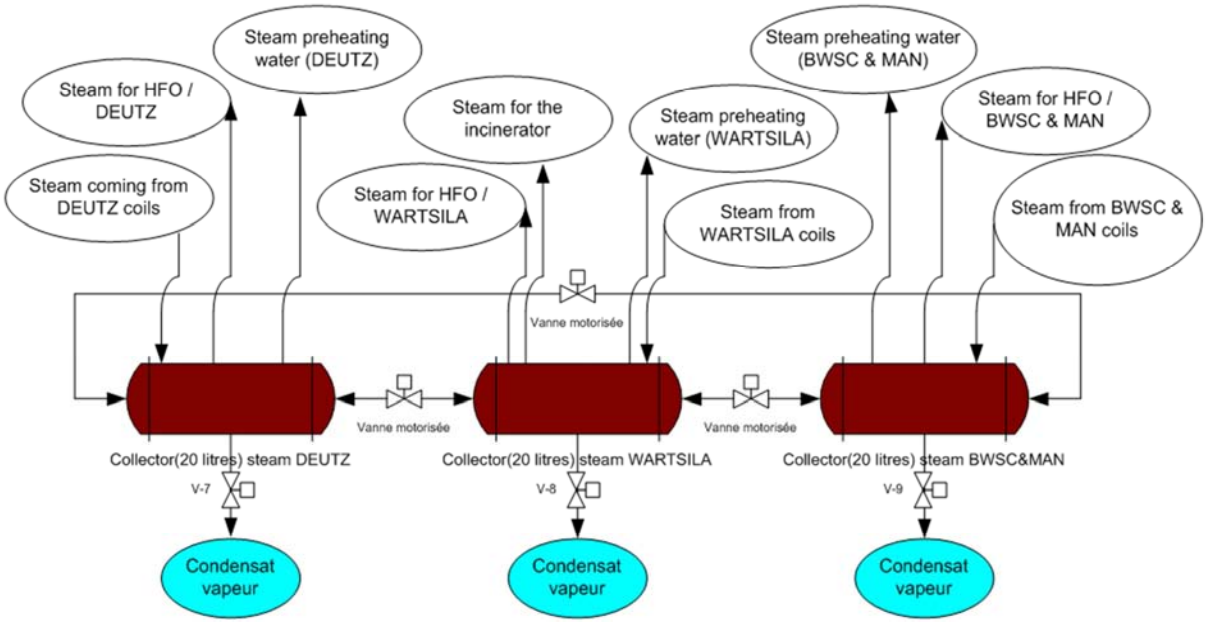

Figure 9. *Synoptic (Simplified) Automated Steam Collector [15].*

It should be noted that at this level we have simplified the diagram by taking only the steam collectors into account because all the steam produced at the boilers of each generator will be passed to the collectors before being sent back for overheating HFO and ancillary circuits of the machine that need it.

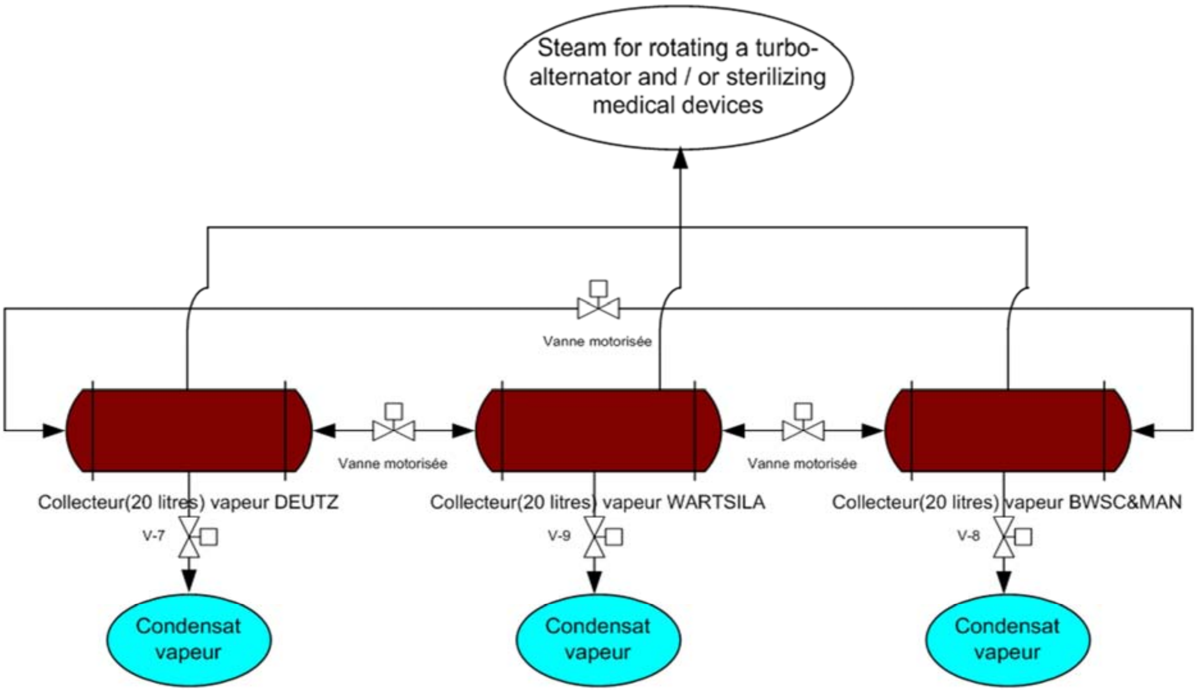

Figure 10. *Recommendation on the new Fromof Energy Production and/or Use of Heat [15].*

4. Conclusion

The experimental study presented in this work is a contribution to improving the availability of full-load steam in order to optimize the overheating of HFO [15]. It saves considerable time on the production time of the steam at full load for overheating and the permutation of DDO to HFO in order to save in terms of fortune.

Our interconnection system allows a considerable economic gain despite some shortcomings that we hope to improve very soon.

In addition, we first of all, in this study, seize the principle of operation of different boilers and steam circuits [15], and then we proposed a new model, of which, we were obliged to study the possibility of Implementation. For example, we modeled the interconnection system and proposed another cogeneration system.

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