Cairo University
Faculty of Engineering
Mech. Power Department ------------------------------

ACC **Virtual Labs**
Automatic Control Circuits &Virtual Labs
for Mechanical Power Systems
معمل التحكم الآتوماتيكى و المعامل الإفتراضية لأنظمة القوى الميكانيكية

دبلوم تطبيقات التحكم الأوتوماتيكى فى نظم القوى الميكانيكية

MEP 563 Virtual Labs -   Report # 1a- Virtual Lab Catalog

1-**The next figure is for …   ……   Write correct part # in table below**

#	Part name	#	Part name	#	Part name
	Chimney or Funnel		Re-super heater pipes		Combustion products (fumes)
	Economizer pipes		Superior drum		Steaming tubes up
	Exhaust gases		Main steam outlet pipe		Furnace
	Main super heater pipes		Fuel pipe inlet		Inferior small drum
	Safety valve		Reheat steam inlet		Reheat steam outlet
	Saturated steam from superior drum		Burner		Big diameter falling water tubes from drum
			Air duct inlet		
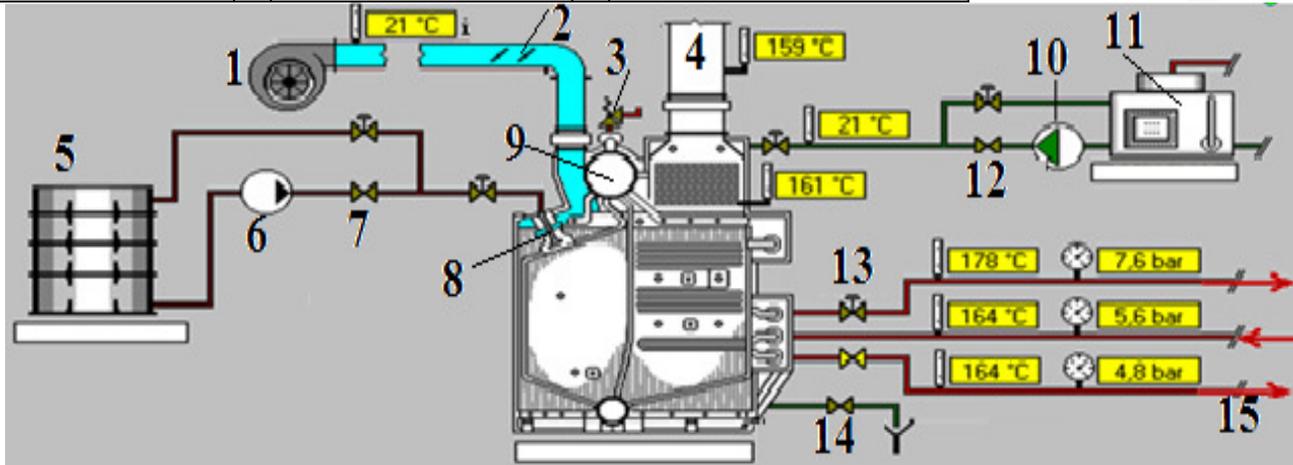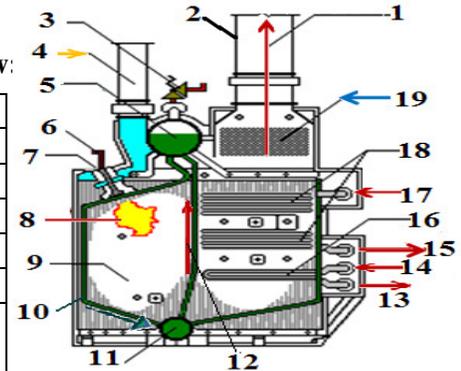
2- **Write the number and the function or job of each part of the above Water Tube Boiler as given in the next table:**

#	Part name	description of part function or job
	Resuperheated steam outlet	
	Inlet air damper	
	Main steam outlet valve	
	Chimney or Funnel	
	De-aerator tank	
	Fuel pump (PDP)	
	Superior drum	
	Burner	
	Fuel flow control valve	
	Water feed pump	
	Fuel tank	
	Feed water control valve	
	Safety valve	
	Blow-down valve	
	Inlet air fan	

Complete the following statements:

3- Steam generators are complex apparatus used to transform..   into..   ..or   …by utilizing.. or..   ..energy stored in.   during the   process. Two main Types of boilers are   &   .

4- In…   , water or   is contained into   in the   section. These   are externally surrounded or lapped by..   products (…   ) which move from the   or…   towards the   ………………(   ).

5- Air inlet..   is used to force   into the   and it is controlled by the A/F ratio and the   control system.

6- Inlet air damper is used to..   the   rate to…   & it must be controlled by   and   control system.

7- Steam..   ..valve is used to   in boiler..   . This valve is a…   ..control type which is normally…..   and it opens when…..   While it returns by a…..   when……..

....

8-In water-tube boilers, the water/steam loop sections includes (in the order from cold to hot):…   , lower…   ,   , superior….   ..,…..   (if needed) and……   …..consequently.

9- Select True (v) or False (x) for each statement:

#	True	False	statement
1			Air inlet fan is used to force combustion air into the burner and it is controlled by the feed water control valve
2			Inlet air dumper is used to control air flow to the burner and it must be controlled by combustion control system
3			Steam safety valve is used to limit maximum pressure in boiler drum & it is normally closed directional control valve
4			Boiler chimney is used to create forced draft or suction to move products of combustion outside the boiler house
5			Fuel tank is used to store liquid fuel needed for combustion & it is where we control fuel pressure into the burner
6			Steam generators are complex apparatus used to transform fuel into saturated steam or/and super heated steam.
7			Steam generators utilize chemical or thermal energy stored in fuel during evaporation or superheating processes.
8			Two main types of steam boilers are fire-tube boilers and water-tube boilers.
9			In water-tube boilers, water or dry saturated steam is contained into steel tubes in evaporator or furnace section.
10			Evaporator tubes in the economizer are externally surrounded or lapped by combustion products (fumes).
11			In all steam generators, products of combustion move from evaporator/furnace part towards the chimney(funnel).
12			Air inlet damper forces combustion air into burner and it is controlled by A/F ratio and combustion control system.
13			Steam safety valve is used to limit maximum pressure & steam output flow in boiler superior drum
14			Steam safety valve is normally closed, pressure control type. It opens if pressure exceeds maximum allowable value while it returns closed by a spring when the burner is shut-off.
15			Inlet air damper is used to control air pressure to burner& it must be controlled by A/F ratio & fuel control system.

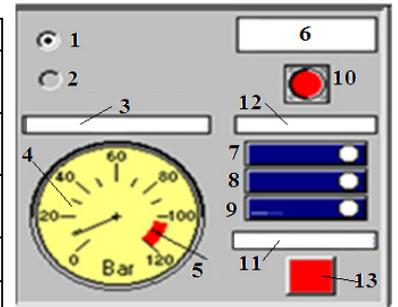**10**-Next figure is for..   . Write correct part# in table below:

#	Part name	#	Part name	#	Part name
	Air inlet fan section		Burner ON button		Inlet air flow meter
	Air inlet fan Off button		Exhaust gases section		Burner Off button
	Fuel feed pump section		Best A/F indicator bar		Inlet fuel flow meter
	Air inlet fan ON button		Fuel pump ON button		Air delivery control bar
	fuel delivery control bar		Fuel pump Off button		Fuel burner section
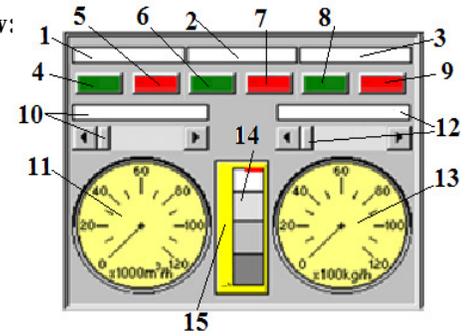
**11**-Next figure is for   . Write correct part# in table below:

#	Part name	#	Part name	#	Part name
	Manual operation mode indicator		Stamp of maximum allowable pressure range		Maximum High pressure alarm
	Muting sound alarms button		Burner shutdowns indicator alarm		Boiler working pressure gauge
	Burner shutdowns section		Level & pressure Alarms section		Boiler working pressure section
	High water level alarm		Low water level alarm		Muting alarms section
	Automatic operation mode indicator				

12-The next figure is for   . Write correct part # in table below:

#	Part name	#	Part name	#	Part name
	Feed water pump section		Feed water delivery control bar		Output steam users On button
	Feed water pump Off button		Drum Water level indicator		Steam delivery flow meter
	Feed water pump On button		Drum Water level section		Steam delivery control bar
	Output steam users section		Feed water flow meter		Output steam users Off button
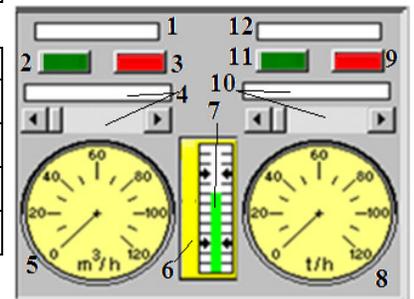
Complete the following statements:

13- **Evaporator complex includes four different sections**:

 a)   or steaming up tubes that are   diameter tubes connect between lower inferior-drum and   superior   .

b) Lower   (also called lower main   or inferior-drum) is used also for extracting   out from the boiler.

c)   tubes are…   diameter tubes used to bring…   ..water down to the..   ..drum or main lower…   .

d)   …-drum (called collector of..   …and..   ). The..   ….steam mixture is collected at the…   of…..
superior-…..   while….   ……steam is extracted out at the drum…..   ….section.

14- The….   or….   …tubes are heated mainly by…..   from the burner……   …...and are heated partially by…….   ………convection from………..   …………………………

15-The Natural…. …in evaporator section is due to…… ….. and it means that…. …goes down in the…… ….tubes while….. …..steam goes…. ….in the… ……tubes.

16-The…. ….steam drawn from the… ……-drum is sent to the *main….* ….and the *re-super-heater sections* and is subsequently sent to the…………. .

17- Select True (√) or False (x) for each statement:

#	True	False	statement
1			Warm water is forced into economizer tubes by feed water pump nearly above required boiler operating pressure.
2			Evaporator Natural circulation is due to pressure temperature differences between superior-drum & inferior-drum
3			Evaporator includes 4 sections: down-comers from superior-drum, lower mud-drum, risers tubes & superior-drum
4			Risers or steaming up tubes are small diameter tubes coming from superior-drum or superior manifold (also called collector of water & steam). The evaporation process takes place mostly inside the Risers tubes.
5			Down-comers are big diameter tubes used to bring warm water down to the inferior drum or water manifold/header.
6			Lower mud-drum(called lower water manifold/header or inferior-drum)is used to connect down-comers&risers tubes
7			Boiler blow-down is extracted out from both the inferior-drum and the superior-drum
8			Wet steam mixture is collected at bottom of superior-drum while saturated steam is extracted out at the drum top.
9			Water/steam loop includes: economizer, lower-drum, evaporator, superior drum, re-heater, super-heater & chimney
10			The feeding water coming from *economizer*, pushed by feeding pump, arrives into *superior manifold* or superior-drum
11			The Risers or steaming up tubes are heated mainly by thermal radiation from the burner flames and partially by forced convection from products of combustion hot gases
12			Evaporator Natural circulation is that warm water goes up in down comers tubes while wet steam goes down in risers

Complete the following statements: **Boiler characteristic parameters are:**

18-The exercise or stamp… is the range of… pressure of the.. produced in working conditions.

19-…. …pressure is normally indicated on boiler…. …gauge with….. ….stamp zone for……. ……. …………………or non-allowable…………… .

20-Boiler output or….. ….*efficiency*: is the steam production in ton or kg in….. ….working conditions. Boiler output is expressed as……….. or……………. .

21-Boiler efficiency: is ratio between energy in and the energy in .

22- *Effective..* *index:* is the between the produced. quantity per hour and the quantity per hour.

23- *Boiler…* *surface*: It is defined as the generator… …that on one side and is drawn by the.. products and on other one by the… & steam. Heating surface is measured in m^2 from the side of the… .
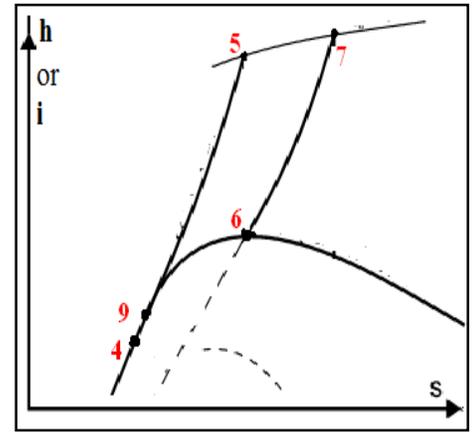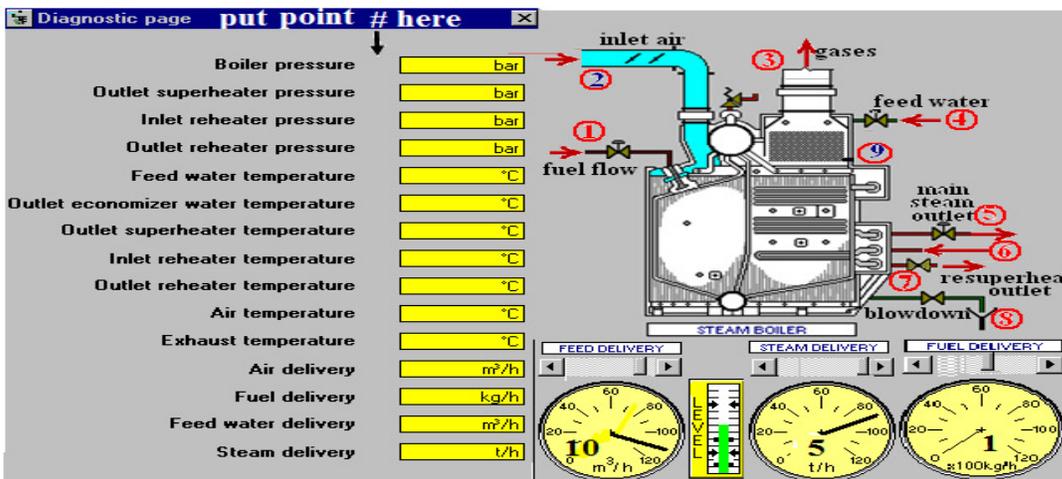
24- *Boiler..* *efficiency,* is the between quantity of produced.. per hour and per each m^2 of ;

25- *The Boiler..* *capacity*: It is the ratio between…. contained into generator and .

26- Select True (√) or False (x) for each statement:

#	True	False	statement
1			*Effective steaming index:* is ratio between produced steam quantity per hour and the burned fuel quantity per hour
2			Boiler output or *steam efficiency*: is steam production/hr in minimum working conditions expressed as **kg/h**r or **T/h**r
3			Stamp pressure is normally indicated on boiler pressure gauge with red stamp zone for minimum allowable pressure.
4			Thermal efficiency: is ratio between input thermal energy in the steam and the output thermal energy in burned fuel
5			*Boiler Heating surface*: ; is measured in m^2 from side of combustion products. Its value is maximum used surface area.
6			*The Boiler specific efficiency*. It is the quantity of produced steam per hour and per each m^2 of boiler heating surface
7			*Exercise or stamp pressure:* is the range of effective pressure of the steam produced in up-normal working conditions
8			*The Boiler specific capacity*. is the ratio between water volume contained into the generator and the heating surface
9			Synoptic diagram includes: control instrumentation, simplified distribution of plant lines of steam generator, complete set of valves; burner control board, feed water centrifugal pump, super heated steam and reheated steam intake.
10			Saturated steam drawn from superior-drum is sent to *main super-heater* & *re-super-heaters* and subsequently to users

27- In running the THW-1 virtual Lab program, Diagnostic page shows pressure, temperature, and flow rates data correspondind to various real points on the Boiler flow lines as shown on next figure. For the following list of pressure, temperature, and flow rates data, write the point # (under the arrow) correspondind to the various real point shown also on the next h-s or i-s diagram for clearity.
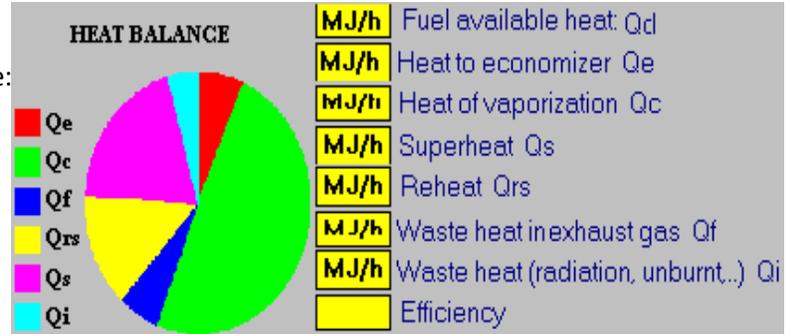
Boiler pressure	bar
Outlet superheater pressure	bar
Inlet reheater pressure	bar
Outlet reheater pressure	bar
Feed water temperature	°C
Outlet economizer water temperature	°C
Outlet superheater temperature	°C
Inlet reheater temperature	°C
Outlet reheater temperature	°C
Air temperature	°C
Exhaust temperature	°C
Air delivery	m³/h
Fuel delivery	kg/h
Feed water delivery	m³/h
Steam delivery	t/h

inlet air   ↑gases
③
feed water ← ④
①
fuel flow   ⑨
main steam outlet ⑤
⑥
⑦ resuperheat outlet
blowdown ⑧
STEAM BOILER

FEED DELIVERY   STEAM DELIVERY   FUEL DELIVERY

10 m³/h   5 t/h   1 ×100kg/h

Complete the missing words in the following statements:

Calculations Equations:

Magnitudes or values necessary for heat balance calculation are:
- Quantity of .... Qd; MJ/hr
- Quantity of ....Qe; MJ/hr
- Quantity of..... Qg; MJ/hr
- Quantity of..... Qs; MJ/hr
- Quantity of.... Qrs; MJ/hr
- Quantity of..... Qf; MJ/hr
- Quantity of..... Qi; MJ/hr

HEAT BALANCE

MJ/h	Fuel available heat: Q_d
MJ/h	Heat to economizer Q_e
MJ/h	Heat of vaporization Q_c
MJ/h	Superheat Q_s
MJ/h	Reheat Q_{rs}
MJ/h	Waste heat in exhaust gas Q_f
MJ/h	Waste heat (radiation, unburnt...) Q_i
	Efficiency

- Q_e
- Q_c
- Q_f
- Q_{rs}
- Q_s
- Q_i

✓ As previously exposed when we have defined….. ..as the quantity of heat per kg available in the fuel will be:

$$Q_d = P_{cs} * P_g$$

Where $P_{cs} = 42070$ kJ/kg is the fuel…… ..calorific… ; P_g = the…. delivery in kg/hr

✓ The heat quantity per hour transferred into…… … to the……. ……will be:

$$Q_e = P_v * (h_e - h_l)$$

where remembering the definition of……. ….and the latent heat energy concept you will have:

$h_e - h_l = c_m * (T_e - T_l)$ is the….. in one kg of……. ; and

$c_m = 4{,}270$ kJ/kg °K is… of ; T_e is temp.& T_l is temp.

P_v =….. delivery of…. or of….. (at stabilized plant they are……);

✓ The heat quantity per…….. transferred in the………. will be:

$$Q_g = P_v * (h_v - h_e)$$

Where, h_v =…….. kept in one kg of……. at the……… pressure.

Note: to calculate h_v at the……. pressure of (……..pressure +1) bar read the value of the enthalpy on the superior or the upper limit curve into the……….. or the H-S diagram of the…………. .

✓ The heat quantity per hour transferred into…………………… will be:

$$Q_s = P_v * (h_s - h_v)$$

Where, h_s = Heat energy of the…………… steam

Note: to calculate h_s read the value of….. at the…. of the overheating isobaric with the overheating isotherm into the steam…. diagram.

✓ The heat quantity per hour transferred into the……. ….will be:

$$Q_s = P_v * (h_{ru} - h_{re})$$

Where h_{re} = heat energy of the…… steam at the…….. of the re-superheater;

h_{ru} = heat energy of the…… steam at the…….. of the re-superheater;

✓ The quantity of heat……. in the…. from… is obtained, remembering always the definition of specific heat:

$$Q_f = (P_a * \beta + P_g) * c_{mf} * (T_f - T_a)$$

Where $\beta = 1{,}225$ kg/m³ Air… ; $c_{mf} = 1{,}025$ kJ/kg °K fumes average.. ; P_a = Air.. delivery

✓ The heat quantity…… for….. and…… is obtained for difference:

$$Q_i = Q_d - Q_e - Q_g - Q_s - Q_{rs} - Q_f$$