Cairo University
Faculty of Engineering
Mech. Power Department

ACC Virtual Labs
Automatic Control Circuits & Virtual Labs for Mechanical Power Systems

دبلوم تطبيقات التحكم الأوتوماتيكى
فى نظم القوى الميكانيكية

MEP 599 Diploma Design Project-Summer Term 2016/2017 – September 2017

Simulation of steam turbine with thermal balance calculations

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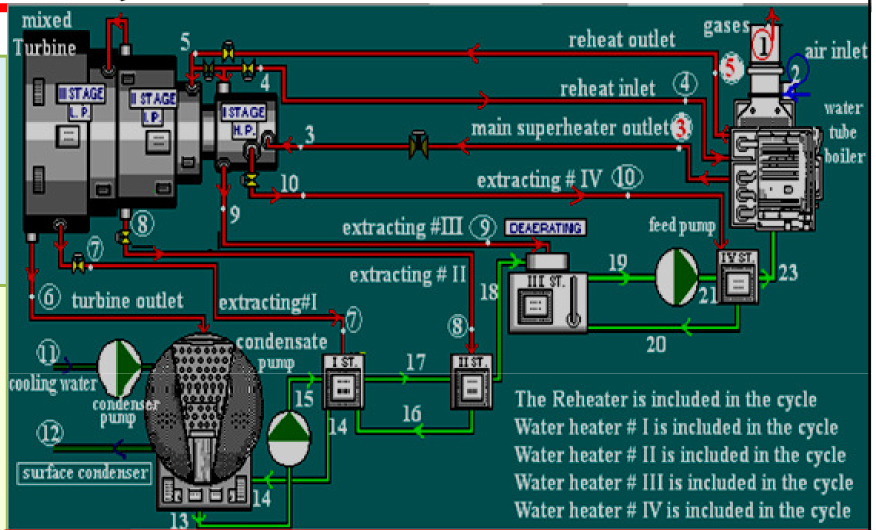
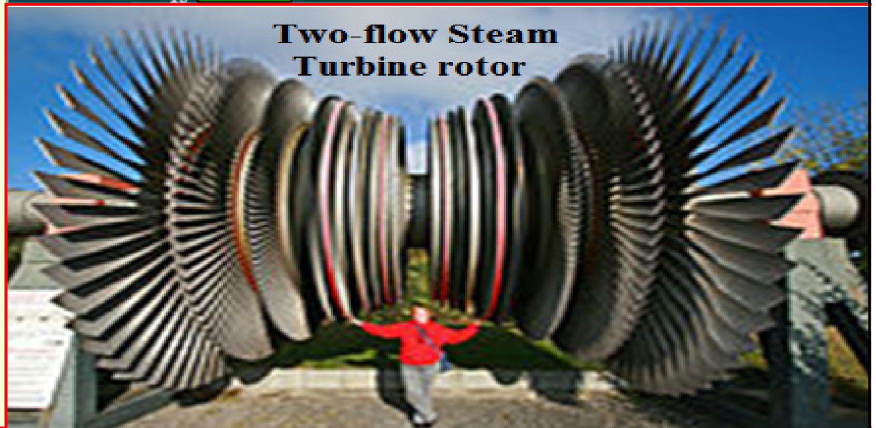
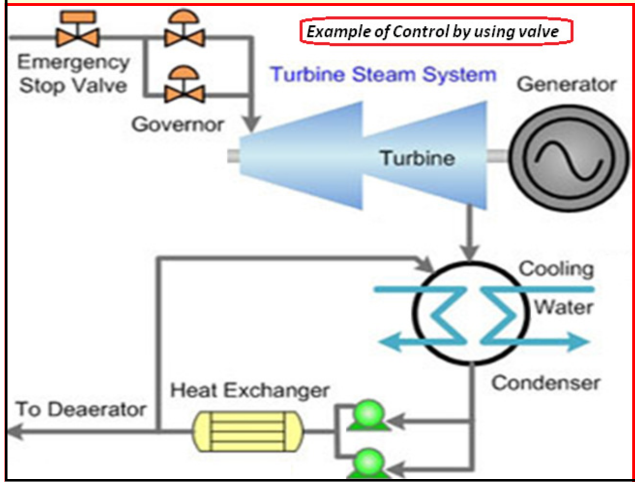
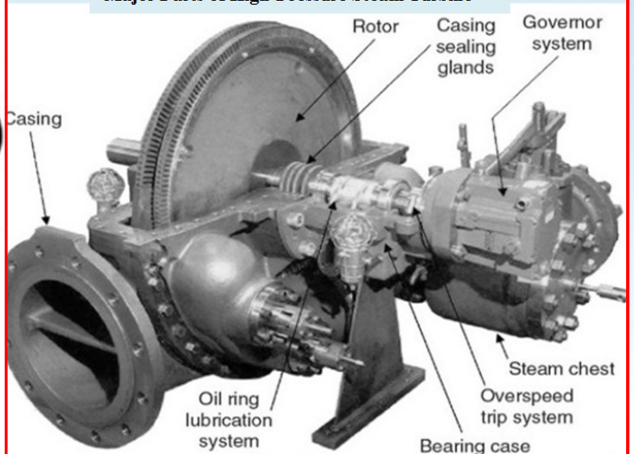
Abstract: Steam turbine control systems are designed to operate a turbine in safe & reliable manner. Many considerations are taken choosing a controller for steam turbine. Many benefits are realized choosing proper control system, whether it is a mechanical, electrical or PLC. This project is an interactive investigation, virtual PC simulation and flow visualization of important concepts of practical automatic control & real thermo-fluid processes in an Industrial, multistage Steam Turbine Unit in a Rankin Cycle Power Plant of maximum output of 30MW. The objectives are to use Control Virtual Lab to examine details of a steam turbine control system & review the fundamentals of speed control methods. As shown, steam turbine unit include one high-pressure part & 2 low-pressure parts. Steam may be extracted or not-extracted from 3 parts for 3-feed water heat exchangers & de-aerating unit. Plant also includes: industrial 120 ton/hr at 120 bar water-tube boiler & water-cooled 6000 m3/hr vacuum condenser with cooling-water pump& many flow control valves. Pressure & temperature gauges show various values at all critical points of the plant. Simulation includes boiler, turbine, condenser, & electric alternator controls. The simulation includes critical control alarms, I/O signals, operation & instrumentation parameter-boards, diagnostic tools, error-report filling, help/trouble-shooting and Thermal Balance Calculations and Plotting tools.

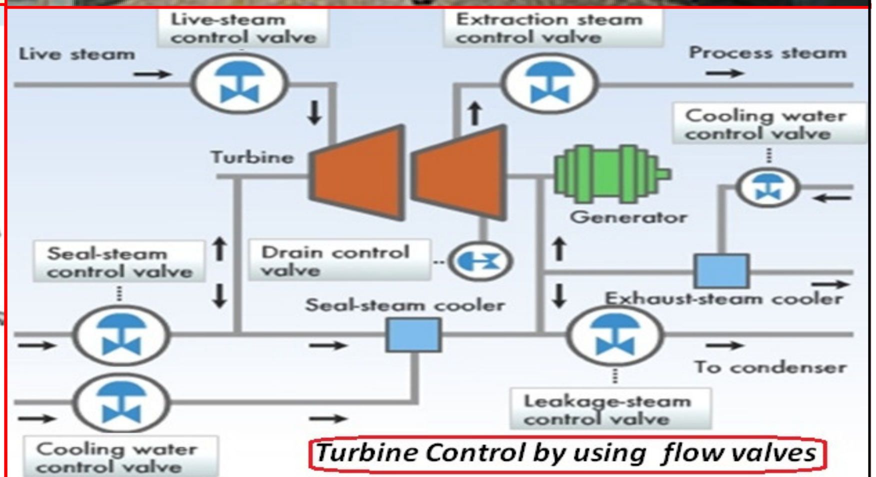


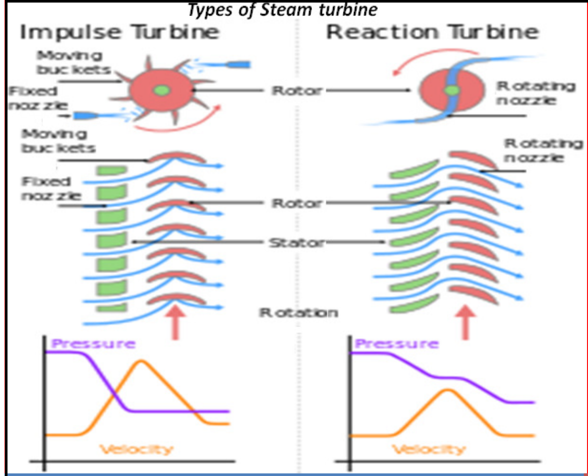




Major Parts of High-Pressure Steam Turbine







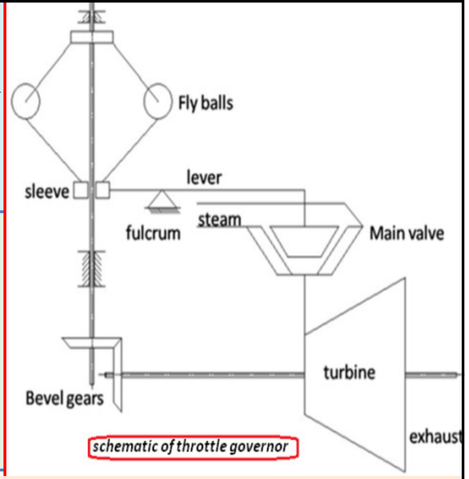
An impulse turbine has fixed nozzles that orient the steam flow into high speed jets

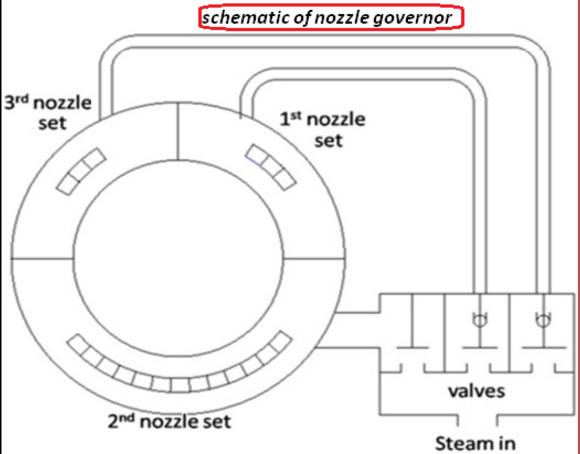
A selection of impulse turbine blades

In reaction turbine, rotor blades themselves are arranged to form convergent nozzles. Steam is directed onto rotor by fixed vanes of the stator.

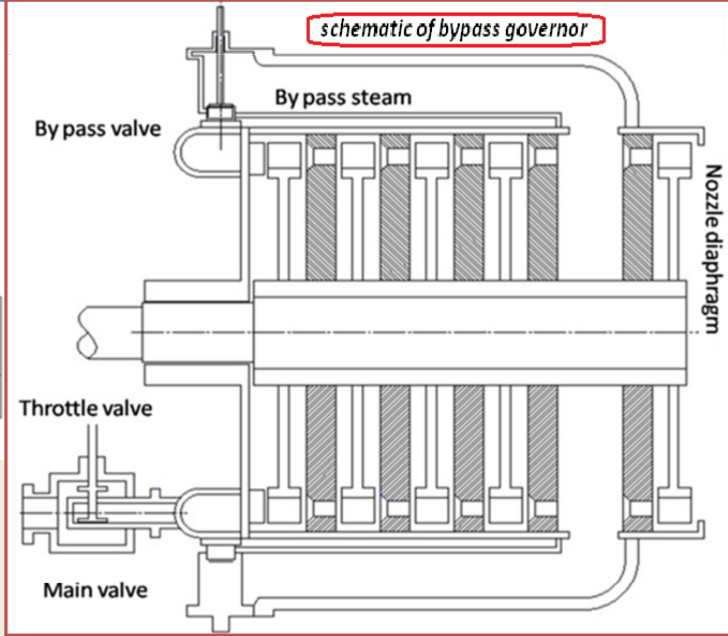
Turbine governing: is a procedure of controlling steam flow rate so as to maintain a constant speed. Flow rate is monitored and controlled by interposing flow control valves between boiler & turbine inlet.

In throttle governing, pressure of steam is reduced at turbine entry, thereby decreasing availability of energy. Here, the steam is passed through restricted passage thereby reducing its pressure across the governing valve.





Nozzle governing: Steam flow rate is regulated by opening & shutting of sets of nozzles rather than regulating its pressure. Here, groups of 2, 3 or more nozzles form a set and each set is controlled by a separate flow inlet valve.



***By pass governing*:** Occasionally turbine is overloaded for short durations. During such operation, the bypass valves are opened and fresh steam is introduced into the later stages of the turbine. This generates more energy to satisfy the increased load

Combination governing employs usage of any two of the above mentioned methods of governing. Generally bypass and nozzle governing are used simultaneously to match the load on turbine.

***Emergency governing*:**

every steam turbine is also provided with emergency governors which come into action under the following condition:

- When the mechanical speed of shaft increases beyond 110%.
- Balancing of the turbine is disturbed.
- Failure of the lubrication system.
- Vacuum in the condenser is quite less or supply of coolant to the condenser is inadequate.

Simulation of Steam Turbine Control System:

Steam turbine control systems are designed with today's technology to operate a turbine in safe and reliable manner. There are many considerations to be taken when choosing a controller for steam turbine applications.

Two categories of steam turbine controls:

Turbine safety systems are intended to eliminate/minimize possibility of damage to machine or the hazard to operators. The process systems control the operation of the steam turbine, so as to follow the load in a stable and efficient manner

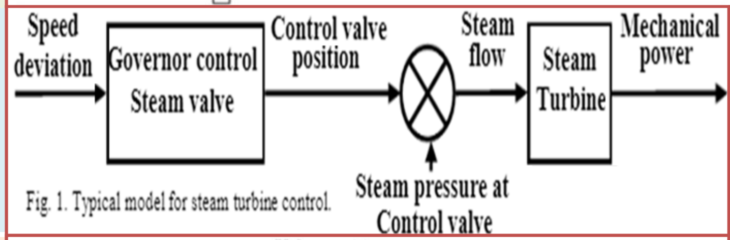


Fig. 1. Typical model for steam turbine control.

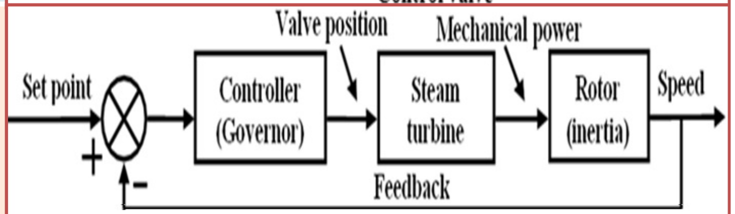


Fig. 2. Control system block diagram.

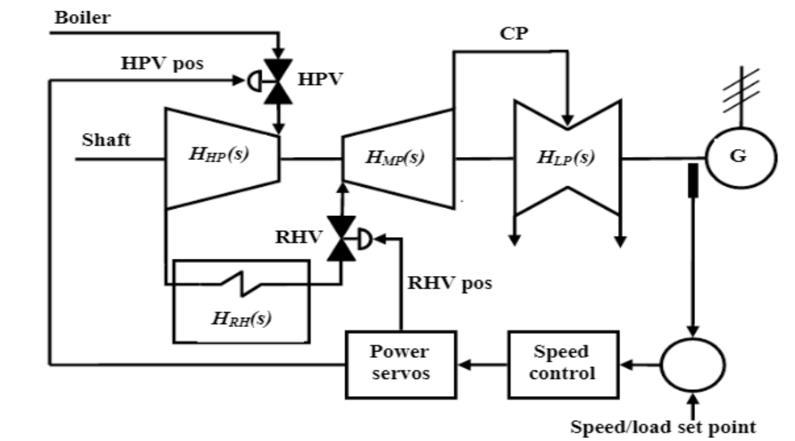
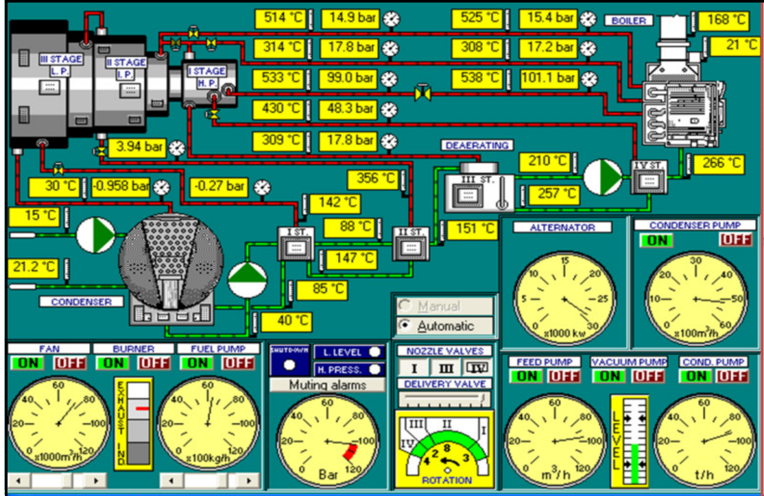
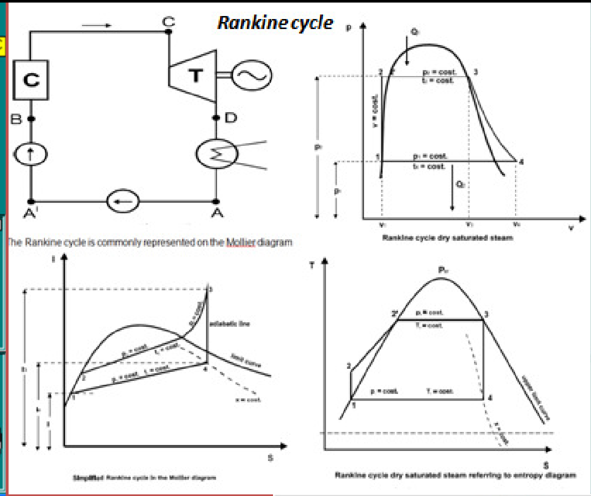
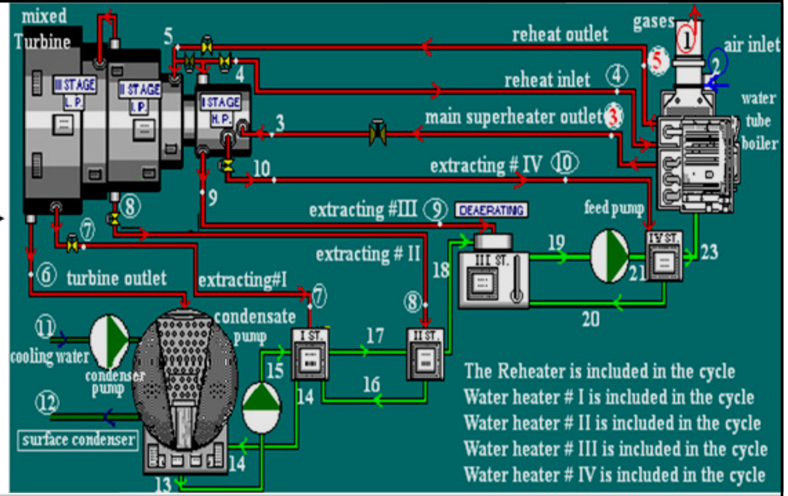
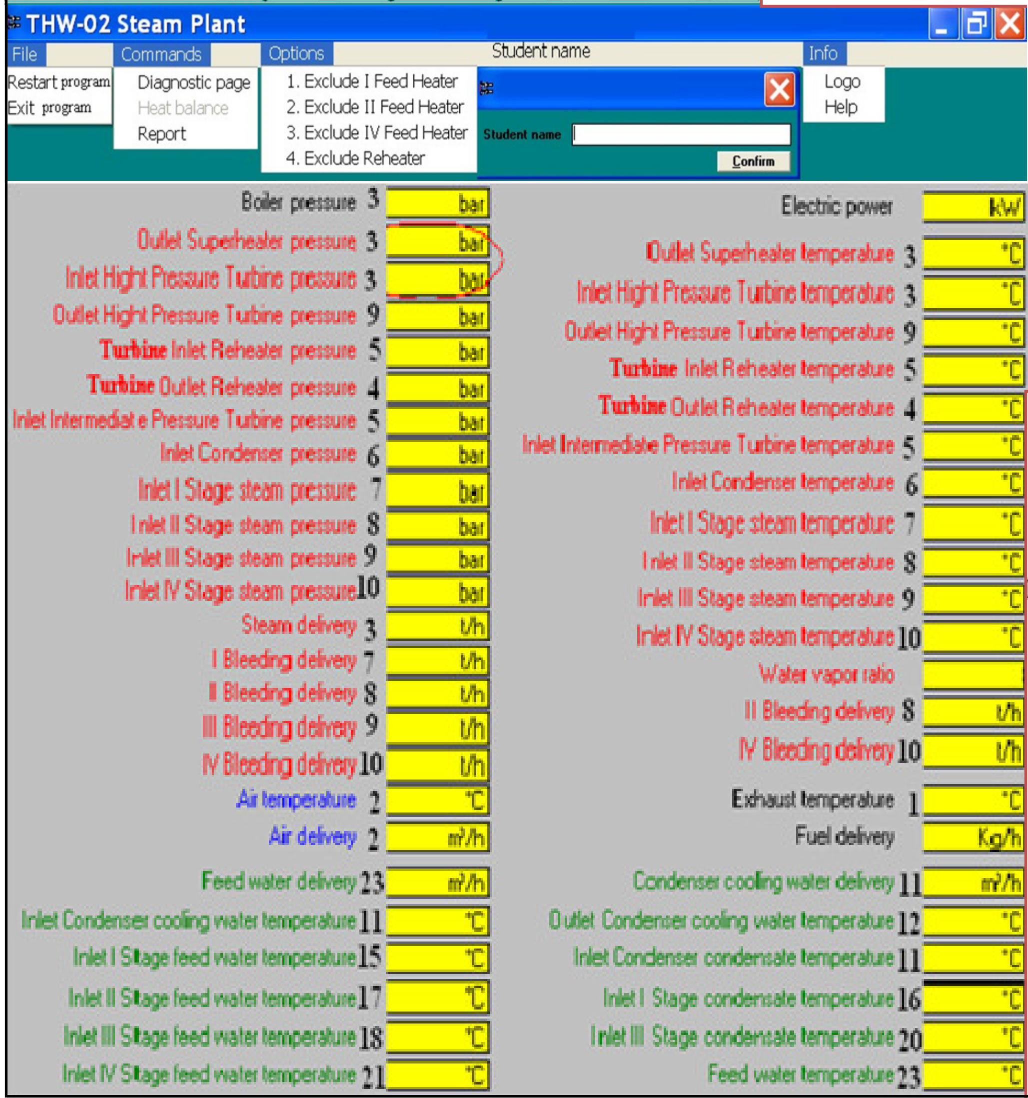


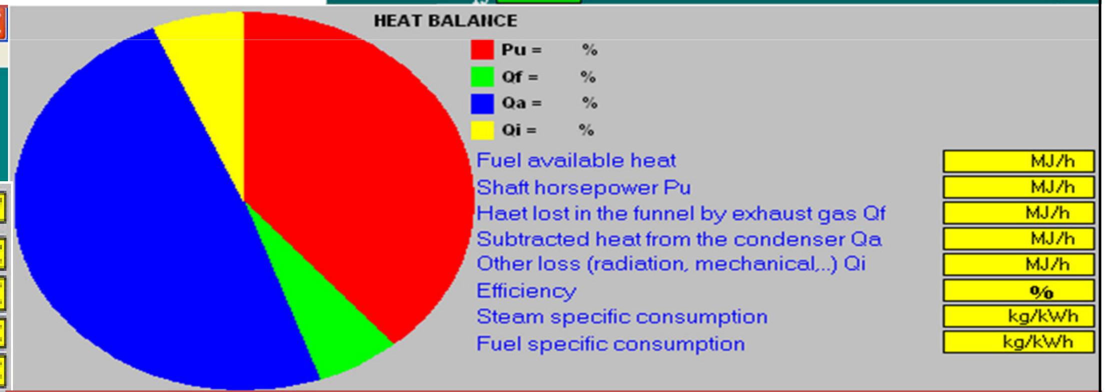
Fig. 3. The steam turbine configuration with speed controller.











4. Using the steam chart/tables, get all the enthalpies of the cycle points. Sketch all the cycle points on the Mollier diagram to obtain the line representing the expansion in the high-pressure turbine, the line representing the expansion in the medium-low pressure turbine (as on the next figure). Also plot the various regeneration processes in the water heaters # I, II, III, and IV (as below).