UNIT 3

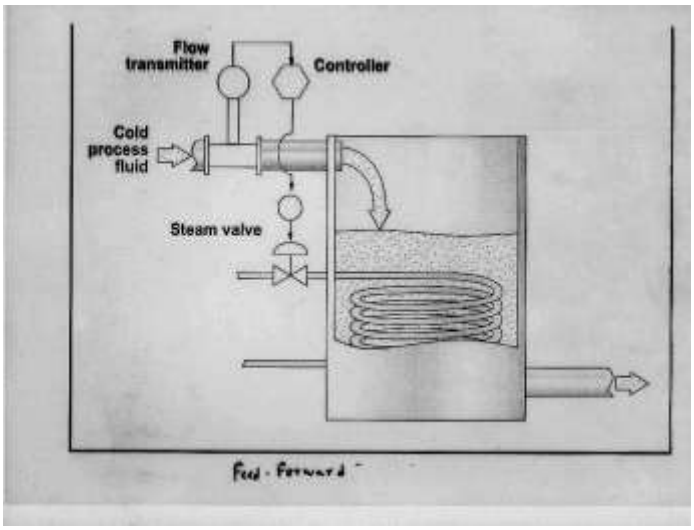
- **Different Control Techniques And Interaction Of Process Parameters**

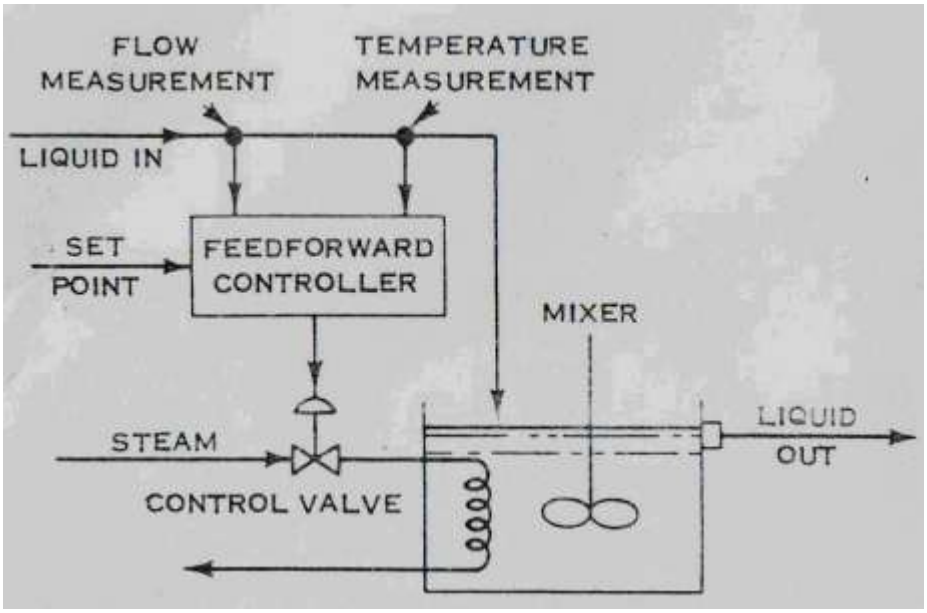
- ❑ Feed Forward Control
- ❑ Feed Back Control
- ❑ Cascade Control
- ❑ Ratio Control
- ❑ Over-ride Control
- ❑ Batch Continuous Process Control

❑ FEED FORWARD CONTROL SCHEME

- ❑ **Feed forward control is a control system that anticipates load disturbances and controls them before they can impact the process variable.**
- ❑ **The basic idea is to measure disturbances directly and to take control action**
- ❑ **Feed forward control actually offers the Plant Model Mismatch (PMM) and unmeasured / unknown disturbances this is rarely achieved in practice.**
- ❑ **Here error is prevented, rather than corrected.**

. Feed forward control of heat-exchange process





- **Advantages**
- **Acts before the effect of a disturbance has been felt by the system**
- **Good for slow system (multi-capacity) or With significant dead time.**
- **Does not introduce instability in the closed loop response.**
- **Feed-forward control, the distinguishing feature of feed-forward control is that the disturbance variable is measured, but the controlled variable is not.**

- **Disadvantages**
- **The disturbance variable must be measured (or accurately estimated).**
- **No corrective action is taken for unmeasured disturbances.**
- **A process model is required.**
- **Requires identification of all possible disturbances and their direct measurement.**
- **Can't cope With unmeasured disturbance.**
- **Requires good knowledge of the process model.**

• FEED BACK CONTROL SCHEME

- In the closed loop control system, information about the controlled variable is fed back as the basis for control of a process variable hence the designation "closed loop feedback control ." This feedback can be accomplished by a human operator (manual control) or by use of instruments (automatic control).
- For manual control, an operator periodically measures the temp. if this temp. for example, is below the desired value , the operator increases the steam flow by opening the valve slightly. For automatic control , a temp. sensitive device is used to produce a signal (electrical, pneumatic etc.) proportional to the measured temp. This signal is fed to a controller , which compares it with a present desired value , or set point .If a difference exists , the controller changes the opening of the steam-control valve to correct the temp.
- **Advantages**
- **Does not require identification and measurement of any disturbance.**
- **Insensitive to modeling errors**
- **Insensitive to parameter changes**
- **For feedback control, the disturbance variable is *not* measured. The distinguishing feature of feedback control is that the controlled variable is measured and the measurement is used to adjust the manipulated variable.**
- **It is important to make a distinction between *negative feedback* and *positive feedback.* In the engineering literature, negative feedback refers to the desirable situation where the corrective action taken by the controller forces the controlled variable toward the set point.**

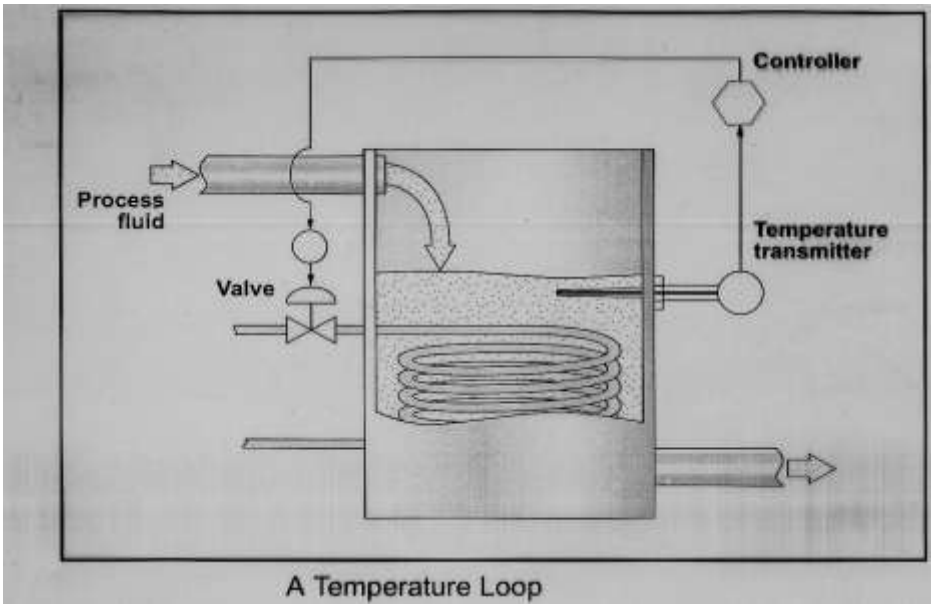
On the other hand, when positive feedback occurs, the controller makes things worse by forcing the controlled variable farther away from the set point.

- **An important advantage of feedback control is that corrective action occurs regardless of the source of the disturbance.**

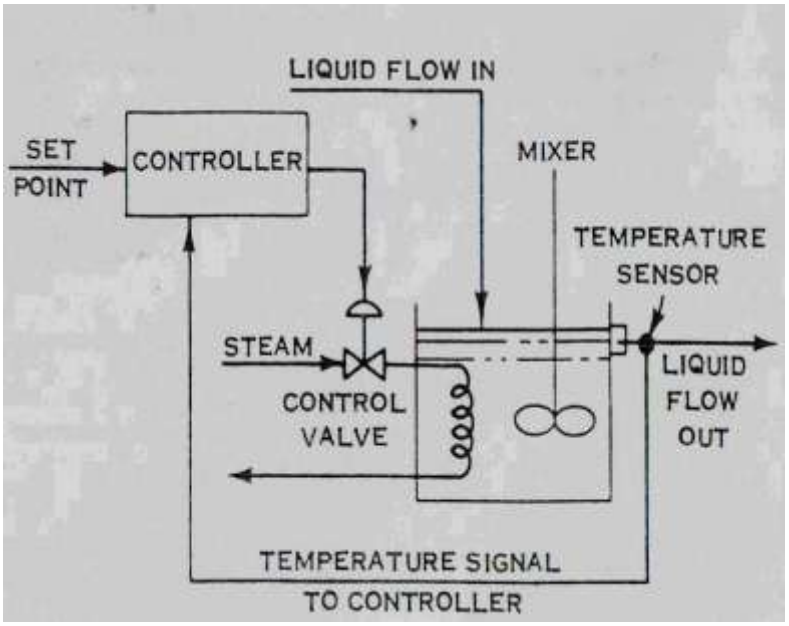
- **Another important advantage is that feedback control reduces the sensitivity of the controlled variable to unmeasured disturbances and process changes.**

- **Disadvantages**
- **It Waits until the effect of the disturbances has been felt by the system, before control action is taken.**
- **Unsatisfactory for slow processes.**
- **May create instability in the closed loop response.**

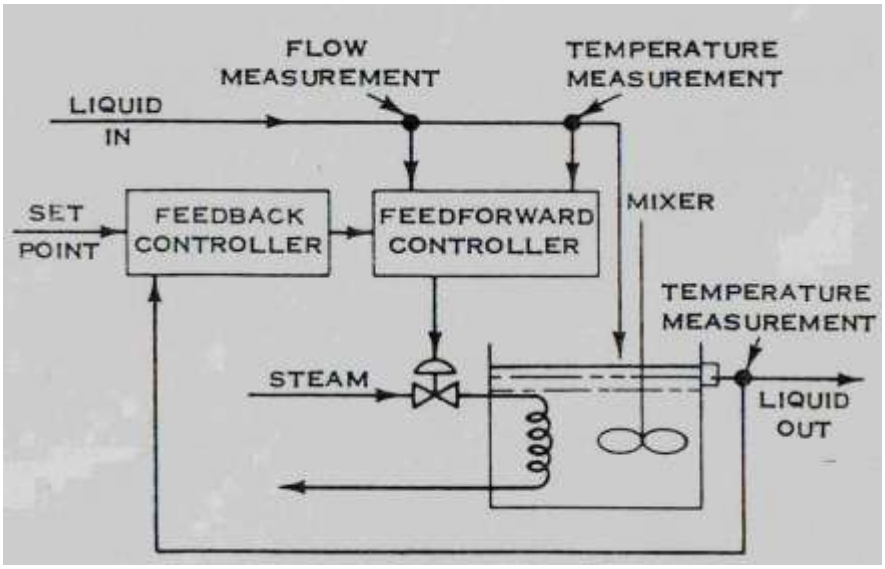
Feed Back control of heat-exchange process

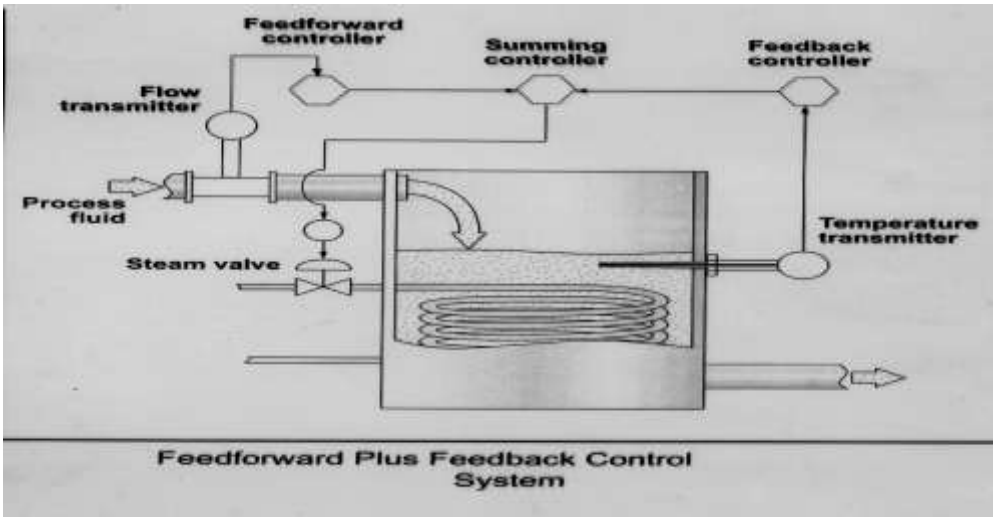


A Temperature Loop



Combination Of Feed Forward And Feed Back





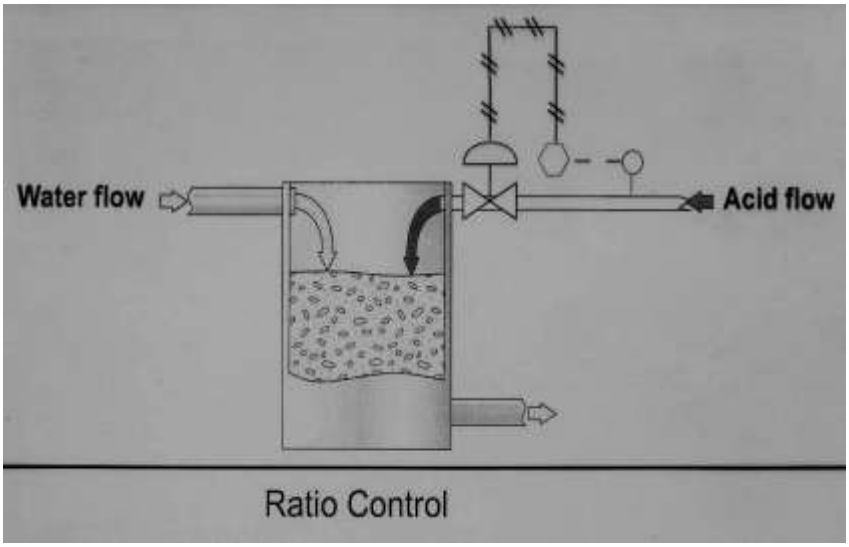
Feedforward Plus Feedback Control System

- **Comparison Of FB And FF**

It works for a measured disturbance in a pre-defined way — contrast with a feedback system . It can respond more quickly to known and measurable kinds of disturbances, but cannot do much with novel disturbances. Feed-back control deals with any deviation from desired system behaviour . Feed-forward does not have the stability problems that feed-back can have. Feed-forward needs to be a pre-calibrated cause → effect, feed-back does not. This is another way of saying what was said above - that feed-forward control applies to measurable disturbances with known effects.

- **Ratio control scheme**

Imagine a process in which an acid must be diluted with water in the proportion two parts water to one part acid. If a tank has an acid supply on one side of a mixing vessel and a water supply on the other, a control system could be developed to control the ratio of acid to water, even though the water supply itself may not be controlled. This type of control system is called *ratio control* .Ratio control is a special type of follow-up control and is used to maintain a fixed ratio between two quantities. This requires an arithmetic element (V). Its input variable is the measured value of the process variable 1 and its output variable manipulates the process variable 2 in the control loop.



- **<u>Application: Typical ratio control schemes include:</u>**
- **Maintaining the reflux ratio for a distillation column.**
- **Maintaining the stoichiometric ratio of reactants to a reactor.**
- **Maintaining air/fuel ratio to a furnace.**
- **Ratio control is used in many applications and involves a contoller that receives input from a flow measurement device on the unregulated (wild) flow. The controller performs a ratio calculation and signals the appropriate set point to another controller that sets the flow of the second fluid so that the proper proportion of the second fluid can be added.**
- **Ratio control might be used where a continuous process is going on and an additive is being put into the flow (e.g., chlorination of water).**
- **A dependent variable/secondary variable is controlled as function of an independent variable/primary variable. The primary variable may be a free variable i.e. measured but not controlled or it may be automatically controlled.**
- **Used in chemical reactors where a particular ratio is to be maintained of two different parameters.**

- **In high speed automobile for fuel composition, cement industry, food industry etc.**
- **Cascade control scheme**

Consists of 2 or more controllers in series. Primary/Master controller (have only a single, independently adjustable set point) and Secondary/Slave controller. One controller manipulates the set point of another. Each controller has a sensor but only master controller has a set-point while only the slave controller has an output to process.

The secondary controller, manipulated variable and sensor constitute the inner loop and the outer loop consists of all elements including the inner loop. The dynamics of the inner loop should be faster than that of the outer loop, e.g. flow through the inner loop and temperature through the outer loop.

- ## Application Area:

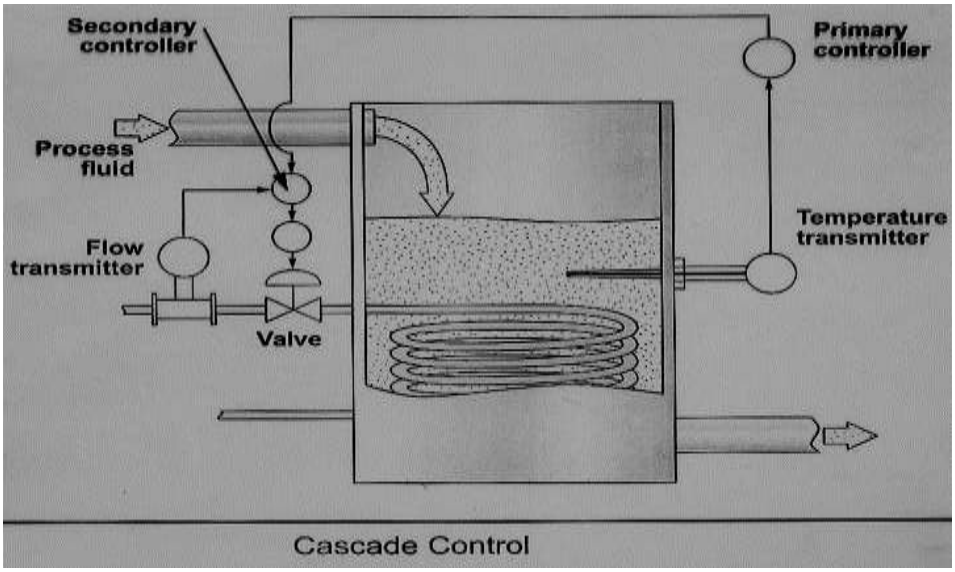
For processes which are very sensitive to disturbances and slow to respond to corrective action.

- **Distillation columns**
- **Boilers**
- **Waste – neutralization plants, etc.**

- ## Example: water heating system

Here if the load variables like temperature of input water and flow of input water changes then control becomes sluggish since the temperature of water outlet will first drop and then control action will be initiated.

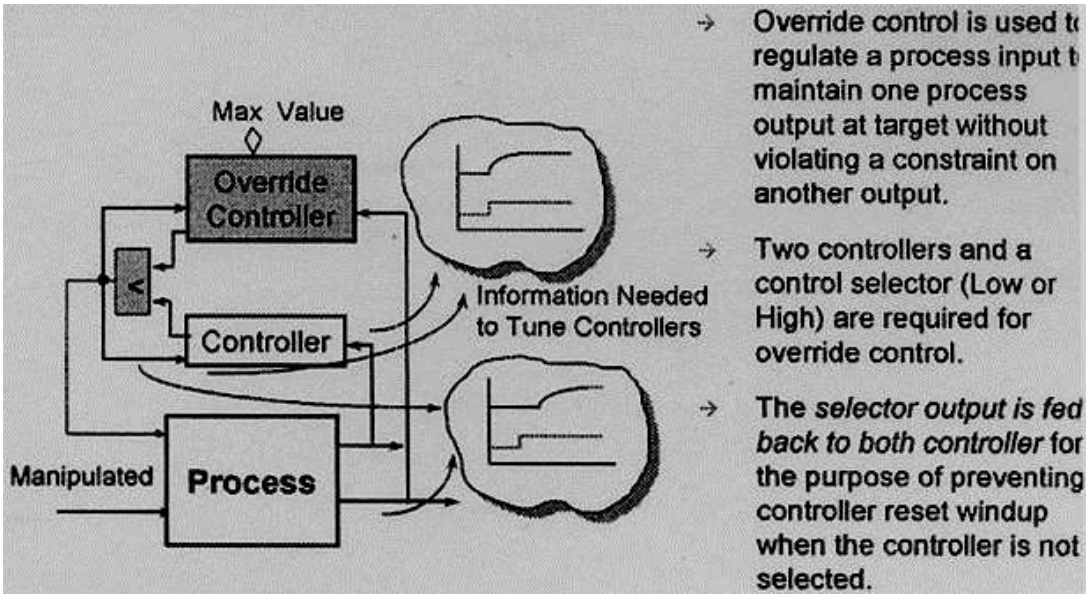
Here TT sends the outlet water temperature signal to TC (temperature control) which compares this temperature with desired temperature (primary set – point) and adjust the set-point for steam flow (secondary set – point) for flow controller FC, which at the same time is receiving steam flow signal from FT. Comparison is done with the set point and FC sends the control signal to valve.



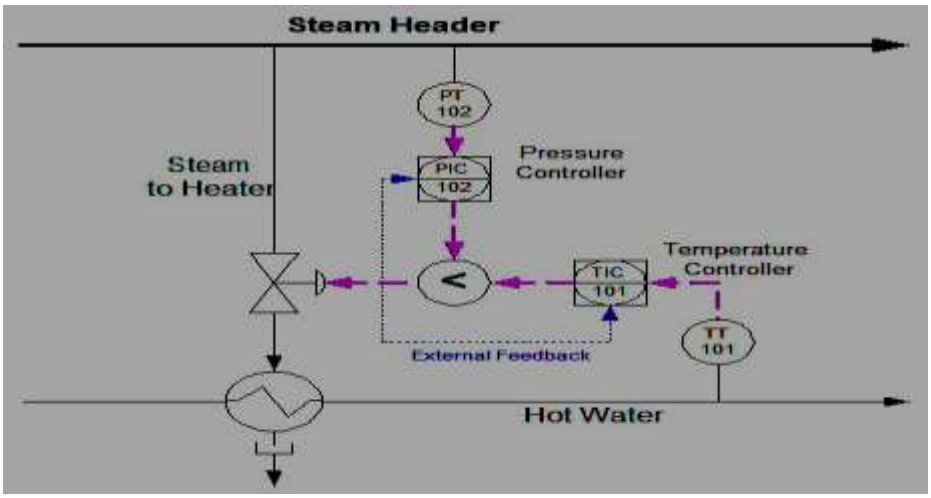
- **Disadvantages**
- **Since many other variables may also effect the control variables but here we cannot measure all of them.**
- **more costly and complex in the sense of design and installation.**

- ## OVER-RIDE CONTROL SCHEME

- **Override control is used to take control of an output from one loop to allow a more important loop to manipulate the output. The output from two or more controllers are combined in a high or low selector. The output from the selector is the highest or lowest individual controller output. The selector is shown in the diagram by the < or > symbol.**



EXAMLPE



- **The steam header must be maintained above a minimum pressure. Steam from the header is used to heat water in a heat exchanger. The temperature of the hot water is controlled by TIC-101. It is more important that the header pressure be above its minimum than that the water temperature be at its set point.**

The set point of the steam header pressure controller is set at the minimum steam pressure (below the normal pressure). If the pressure falls below its set point, the pressure controller's output will decrease. When it is less than the output of the temperature controller the pressure controller will begin to close the valve. The water temperature will fall below its set point, but it is more important that the steam header pressure be maintained.

- ## BATCH PROCESS CONTROL SCHEME

- **Batch and semi-batch processes provide needed flexibility for multi-product plants, especially when products change frequently and production quantities are small.**

- **Processes that are taken from start to finish in batches. For example, mixing the ingredients for a juice drinks is often a batch process. Coffee-Tea machine is a plant based on batch process. Typically, a limited amount of one flavor (e.g. orange drink or apple drink) is mixed at a time. For these reasons, it is not practical to have a continuous process running. They often involve getting the correct proportion of ingredients into the batch.**

- ## Application Area:

Used in many process industries, like,

- **Microelectronics/semiconductor processing Industry**
- **Petroleum Industry**
- **Paper pulp Industry**
- **Beverage Industry**
- **Pharmaceuticals Industry**
- **Chemicals Industry**
- **Fermentation Industry, etc.**
- **Disadvantages:**
- **The process must be frequently restarted. Start-up presents control problems because, typically, all measurements in the system are below set-point at start-up.**

- **Another disadvantage is that as recipes change, control instruments may need to be recalibrated.**

- **EXAMPLES**

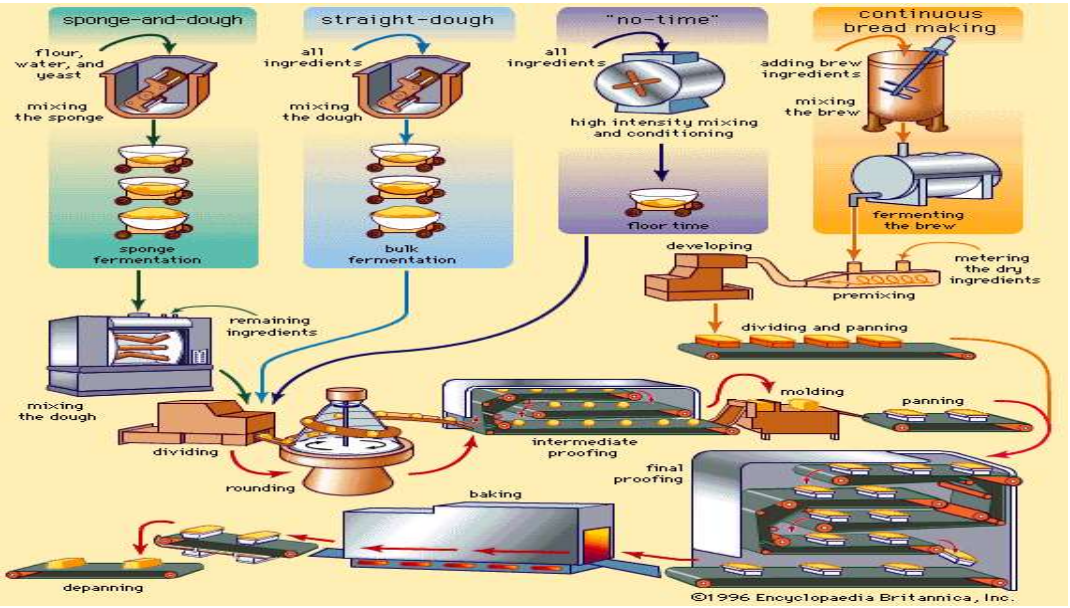
❑ Chemical process for the manufacture of paper pulp

- **The sulfite digestion of the wood material is normally carried out as a batch process in a pressure vessel that consists of a steel shell possessing an acid-resistant lining.**

• Petroleum Industry

As far as fuel is concerned, the gas turbine burns mainly the middle fractions (kerosene, or paraffin) of refined oil. The refining of this material has itself undergone important technological development. Oil is until it vaporized, when the various fractions were distilled separately.

Case Study: Bread Production



- **Many steps in conventional dough preparation and makeup have been fully automated, but none of the processes is truly continuous. In continuous systems, the dough is handled without interruption from the time the ingredients are mixed until it is deposited in the pan. The initial fermentation process is still essentially a batch procedure, but in the continuous bread-making line the traditional sponge is replaced by a liquid pre-ferment, called the broth or brew. The brew consists of a mixture of water, yeast, sugar, and portions of the flour and other ingredients, fermented for a few hours before being mixed into the dough.**