

Analysing Energy Flow – Polymerization process

HANDOUT 1 – tasks

In a polymers manufacturing company, **energy** was selected as the priority flow, with the focus area being the **polymerization reactor**. Within the detailed analysis, the TEST team began collecting data that will facilitate the understanding of the root cause of inefficiency within the polymerization process.

Polymerization is achieved in a reactor that operates on a batch basis. The reactor is filled with a predetermined quantity of water, then monomers and additives are added according to the desired recipe. To initiate the polymerization, the reactor vessel is heated for two hours using steam through an external jacket. Steam is stopped after 30 minutes, which is the time needed for the reactor contents to reach 90 degrees and initiate the polymerization process.

The polymerization process is an exothermic process whereby heat is generated from the polymers, resulting in an increase of temperature within the reactor. Therefore, cooling water circulating from the cooling towers is used to maintain the temperature in the range of 90-100 degrees.

The polymerization process lasts for 6 hours, then the cooling water stops and the reactor begins being emptied from the produced polymer. Throughout the entire polymerization process, starting from filling the tank until it is emptied, an agitator within the reactor rotates at a fixed speed to control the mixing level and to prevent build-up of polymers on the reactor walls.

All operating parameters, including the agitator rotation, tank filling degree, cooling water and steam flow are controlled manually by operators from the control room.

TASK

1. What are the significant energy aspects for the production?
2. Which persons influence energy consumption?
3. Identify 2 operational performance indicators (OPIs) for energy efficiency within the polymerization process

HANDOUT 2 – possible solutions

1. Significant energy aspects include:

- Batch timeline and product temperature profile during the batch (initial filling – steam input – cooling – emptying)
- Batch volume
- Temperature profile and water flow of cooling water (COP of cooling tower)
- Operating hours of agitator
- Temperature (pressure) setting of steam boiler, and boiler efficiency
- Flow rate and duration of steam delivered to the reactor
- Flow rate and duration of cooling water delivered to the reactor
- Several other parameters can affect the energy efficiency including the speed of agitation, shape and design of the stirrer, recipe and additives introduced (possibly some additives can speed-up the reaction, others can alter the temperature demand)... However, for training purpose these parameters are considered to not serve as significant aspects.

Understanding these aspects shall facilitate the understanding of how the process is controlled in terms of energy within the context of the company. It is often the case that the company doesn't keep records for some of these parameters due to unavailability of measuring equipment or reluctance from company staff to keep a record of them. This can be one of the first options to identify "install a proper information system, to be able to manage the significant parameters".

Should it be the case that the company lacks records of some parameters, you can start by establishing a measurement plan to obtain the necessary data without waiting for the installation of an information system, even if not 100% accurate. Hand-held portable measuring equipment can be utilized for this purpose.

2. Energy consumption is influenced by:

- Operators of the reactor (they control the batch volume, time, agitation, cooling demand, steam demand...)
- Maintenance team responsible for optimizing the conditions of the cooling towers, steam boiler, pipelines, insulation,...)
- R&D (or quality) department responsible for reviewing the optimum conditions for high yield and less energy demand. Examples include review of the optimum agitation speed, review of the batch time, review of the optimum temperature profile for polymerization process....

After identification of the company staff members influencing energy efficiency, you can conduct meetings/interviews with them to check their level of awareness regarding the impact they have on energy efficiency, their competence, and to understand their training needs. In most cases, lack of internal communication between staff from different departments is a major cause for the inefficiencies.

3. Sample of the OPIs:

- Batch volume
- Batch time (absolute indicator)
- Product yield (relative indicator)
- Cooling load/ton product
- Heating load/ton product

It is essential at this stage to define and start recording the different OPIs as these records will be needed at later steps (particularly step 3) to monitor and validate the change in performance after implementing the action plan.