

MANUFACTURING PROCESSES

1. GENERAL CONSIDERATIONS

The manufacture of Polyurethane is a complex process, by which a well organized segmented structure with a definite molecular weight should be obtained.

As the polymer molecular weight depends on the relation between the two reactive groups in this polymerization (-NCO and -OH), an accurate control of both groups is essential in the process. In addition, polyurethane hardness depends on the mole relation between the long-chain diol and the chain extender. This means that a slight variation in the amount of the components will cause a variation in the polyurethane molecular weight and hardness.

Therefore in the polyurethane manufacture it is always necessary:

- To have a very accurate weighing system.
- to make a rigorous control of substances or impurities in the system, that are capable of reacting with -NCO or -OH groups (humidity is the most typical characteristic)
- to control the characteristics of long-chain polyols , as it is also a polymer
- To control with accuracy both the temperature and rate of polymerization.

2. MANUFACTURING PROCESSES

2.1 SOLID POLYURETHANE

2.1.1 BATCH PROCESS

This uses a one-shot technique, in which the long-chain diol is mixed with the chain extender. The diisocyanate is added later. The product is cured and finally pelletized. A catalyst is often used to reduce reaction times and the post-curing process.

It is also possible to use a prepolymer technique by adding the chain extender to the prepolymer plus the addition of a catalyst to reduce the chain-extension time and the post-curing phase.

This is the oldest process and has a low level of productivity. Homogeneity problems can often appear.

2.1.2 CONTINUOUS PROCESS

In this process the polymerization is produced in a reaction-extruder. The raw materials are added continuously in the inlet and a special design of the screws plus a perfect control of temperatures allow us to get a suitable rate of polymerization of the components. This process

requires a very accurate feeding system to guarantee the homogeneity of the produced polyurethane.

At the exit of the extruder the product is pelletized, cooled down and dried continuously to get the minimum level of humidity.

This process has a high level of productivity and new sophisticated tools allow us to obtain a high consistency in the same batch and also between different batches.

2.2 POLYURETHANE PREPOLYMERS

These are reactive polymers of low molecular weight, in form of viscous liquids at room temperature which are easy to handle, and which can react with a diol, diamine or the ambient moisture to turn into high molecular weight polyurethanes.

Prepolymers are manufactured in a reactor with an excess of diisocyanate component, thus producing terminal isocyanate reactive groups. The reactor must have a good temperature control for the exothermic reaction.

2.3 POLYURETHANE IN SOLUTION

In this system the polyurethane is produced in a solvent medium. Components and solvent are charged into a reactor provided with excellent temperature control. The components are adjusted in such a way that a slight excess of one component (generally the hydroxyl component) is present; when the reaction is concluded, small additions of the other component (diisocyanate) will allow an increase of the molecular weight and viscosity of the solution, until the desired values are reached.

It is necessary to use high purity solvents (polyurethane grade), with a very low water content and without impurities, as these avoid reaching high molecular weight polymers.

2.4 POLYURETHANE EMULSIONS

Ionic groups must be introduced in the polyurethane chain, in order to emulsify and stabilize the polyurethane emulsion. Diols or diamines with a carboxylate or sulphonate group in its molecule are the most usual. Moreover, it is also advisable to introduce a small amount of non-ionic emulsifier (inside or outside the polymer chain) in the system.

There are different systems to manufacture polyurethane emulsions, the most important being:

2.4.1 ACETONE SYSTEM

This system is recommended when a definite or prefixed polyurethane molecular weight must be obtained. Polyurethane emulsions used for adhesives are the clearest example.

In this system, and before emulsifying polyurethane, it should reach the desired molecular weight. Therefore it is produced, in a first stage, in solvent medium (generally acetone) by a prepolymer technique and after emulsification; the solvent is removed by distillation.

2.4.2 PREPOLYMER SYSTEM

It allows obtaining higher molecular weight polyurethanes than with the acetone system.

With this system, an ionomeric low molecular weight prepolymer with reactive isocyanate groups is emulsified using several systems. After emulsification, diamines (and a small amount of triamine in cross linked polyurethane emulsions) are added in order to extend the chain until the diisocyanate groups disappear, thereby obtaining high molecular weight polyurethane chains.

In this system, it is necessary to introduce a high boiling temperature solvent in the prepolymer in order to reduce its viscosity and make the emulsification easier. This solvent remains in the emulsion, acting as a coalescent agent.

As water reacts to a small extent with isocyanate groups, it is very difficult to obtain the same molecular weight in different batches.