Industrial chemistry

General introduction to the industrial chemistry include define and its relation to the other branches of chemistry.

Technical processes of industrial chemistry

Technical processes in industrial chemistry are dealing with conversion of raw material R.M into final products by industrial processes.

The operations processing are number of processes which are: physical, chemical and mechanical that occur on the raw material (R. M) to convert them into products .

Those processes are being take place in specific equipment called reactors by three steps:

1-Transfer the Raw Materials (R. M) components into the reactor.

2- A physical processes or chemical reaction which occur in the reactor.

3-Removing the products, separate and purified them .

***المفاعلات الكيميائية Chemical reactors** عبارة عن حاويات لإجراء تفاعلات لإنتاج المنتج النهائي. يعتمد تصميمها على عوامل مختلفة ويجب أن توفر أقصى عائد بأكثر الطرق فعالية من حيث التكلفة .

There are two type of system in the industrial operations processes:

1- Batch systems

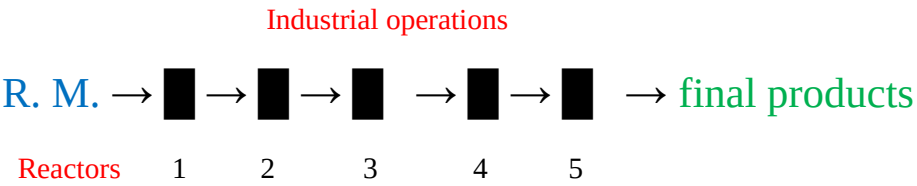
2-Continous systems

The Batch systems

The batch system in which specific quantity of raw materials is introduced into the reactor, and a number of changes are occurs then the products are withdrawn after that.

Afterward, the product is moved to the subsequent stage like purification or crystallization and packing.

After withdrawn the products the processes is repeat again and so on.



In this system there is a determined time between introducing the raw materials and removing the products.

The characterization of this system:

*Number of workers .

*The equipments are more complex than continuous system.

*Controlling on this system is difficult .

*Controlling the quality standard for this system is difficult because it depends on many factors for each batch like skill of workers and conditions of reaction or processes.

So, this system is used for small scale production or in some cases depends on the physical properties of the reactants.

Example of batch industries:-

Like soap production, pharmaceutical products, suspension *polymerization.*

1) **المفاعل من نوع الوجبات Batch Reactors (BSTR)**

هذا المفاعل مشهور وقديم جداً وقلما يستخدم في الوقت الحالي وتعتمد فكرة عمله على خلط المتفاعلات بنسب معينة في وعاء ثم بعد ذلك يتم التقليب جيداً مع توفير الظروف اللازمة للتفاعل ويتم التقليب إما باستخدام طرق ميكانيكية وقلما تستخدم الطرق اليدوية في التقليب، وبعد إتمام التفاعل يتوقف التقليب ثم يتم تفريغ المفاعل من الناتج وتنظيفة وبعد ذلك يصبح المفاعل جاهزاً لشحنة جديدة أو وجبة جديدة New Batch. يوجد في داخله أله لخلط المواد بداخله للتحكم بالخلط في داخله وزياده تغلغل المواد مع بعضها وهذا يعطي فرصه كبيره لزياده التفاعل الكميائي بين المواد .

مميزات Batch reactors

1- يحتاج الى وقت قصير او طويل حسب التفاعل الكيميائي الذي يجري به .
2- هناك بعض العوامل التي يتم وضعها في الحسبان حينما يتم استخدام هذا المفاعل مثل الضغط والحراراه والمواد المضافه لتسريع التفاعل.
3- تحديد كميه المواد المتفاعله في هذا المفاعل وايضا كميه المواد التي تنتج منه .
4- يمكن حساب الزمن اللازم لاجراء عمليه التفاعل او انتهاءها بشكل كامل.
5- عند تواجد مواد غير متفاعله نستطيع استرجاعها .

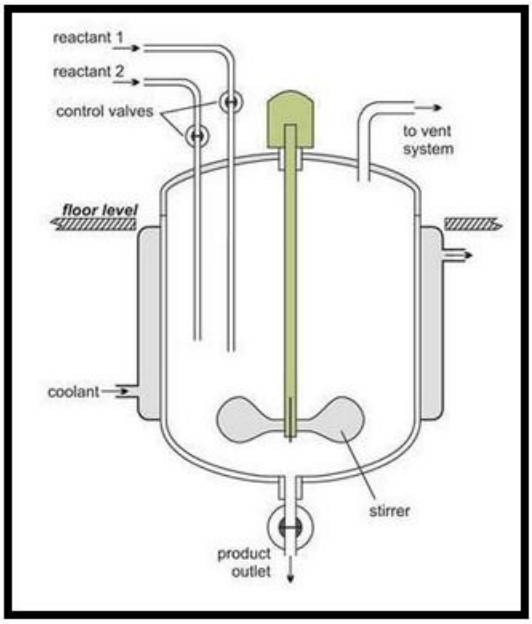
عيوب Batch Reactors

1- أنه يحتاج لايدي عاملة مكلفة للإشراف والتقليب والتنظيف
2- أنه لا يصلح لإنتاج كميات كبيرة من النواتج حيث سيتطلب الأمر مفاعل ضخم جداً ولذلك ظهرت فكرة المفاعل المستمر التشغيل.
3- يحتاج الى التنظيف بعض كل عمليه لان هناك مواد ناتجه لانرغب بها.

إستخدامات Batch reactors

1- يستخدم بكثرة في الصناعات التي تنتج القليل من الانتاج مثل الصناعات الدوائيه.

2- يستخدم في الصناعات التي تكون غاليه الثمن التي يصعب علينا انتاج كميات كبيره من المنتج المراد تصنيعه.



Scheme (1) Batch reactors

Example of batch industries:-

Like; Cement industry, petroleum refineries, fertilizers …..etc.

The continuous systems

Continuous system in which feeding the raw material is continuous into the reactors with removing the products also continuously *i.e* the process is continues without stopping.

The characterization of this system:

- Large production

- Control accurately on the condition of the processes.

- The mechanical controlling is easy .

-Controlling on the quality standard because the automatic controlling on the processes

-Many investors prefer this system because it is more economic and does not need much number of workers.

- It is more expensive

المفاعل من النوع The Continuous Stirred Tank Reactor - CSTR

وهذا المفاعل جاء ليتغلب على عيوب المفاعل من النوع Batch .

مميزات مفاعل CSTR

1- يتم إدخال المتفاعلات باستمرار وبنسبة معينة وتم عملية التقليب بطريقة ميكانيكية مستمرة.
2- النواتج تخرج من المفاعل من فتحة جانبية على ارتفاع معين يدعى مستوى (Level) ولا بد أن يتم الحفاظ على النسبة بين المتفاعلات وكذلك معدل دخولها إلى المفاعل حيث يجب أن يترك الفرصة للمواد الموجودة في المفاعل أن تتفاعل مع بعضها البعض وفي نفس الوقت يعجل من خروج النواتج من المفاعل.
3- يتم التحكم في معدل دخول المتفاعلات إلى المفاعل عن طريق استخدام صمامات تحكم Control Valves ويسمى الوقت الذي تقضيه المتفاعلات داخل المفاعل إلى أن يكتمل التفاعل بالـ: Residence Time

Residence Time : Is the amount of time spent by the materials in residence in the tank

4- يصلح هذا المفاعل لكثير من التفاعلات حيث يتم الحصول على نواتج بمعدل ثابت ومستمر وفي نفس الوقت.
5- لا حاجة للايدي العاملة البشرية المكلفة .
6- أنه يحتاج لتحكم جيد Control للحفاظ على النواتج حيث إن أي تغير في تركيب النواتج يعني تغير أي من الظروف كأن تكون درجة حرارة الجو منخفضة في يوم معين ويحتاج المفاعل لزيادة التسخين أو أن لزوجة المتفاعلات قد ارتفعت بسبب الانخفاض في درجة الحرارة وهكذا.
7- يعتبر هذا المفاعل من أفضل المفاعلات التي نستخدمها في الصناعات الكبيره التي ينتج من خلالها كميات ضخمه من الانتاج حيث تكون رخيصه الثمن .

8- ويمتاز هذا المفاعل بأنه سهل كيفيه العمل وايضا سريع جداً بالنسبه للمفاعلات الاخرى .. حيث تمر به المواد وتكون في نفس التركيز ومخلوطه جيدا مع بعضها بشكل كبير فيؤدي ذلك الى انتاج المنتج ذات مواصفات معينه ..

9- اهم ما يهتم به حينما يصمم هذا المفاعل هو مساحه هذا المفاعل . فالمساحه تعطينها نسبه التحول في هذا المفاعل فكلما زادت المساحه كلما كان نسبه التحول اكبر . وايضا يجب ان نهتم بعنصر أخر الا وهو الحراره فهو مهم جدا في هذا المفاعل ايضا قد يكون معزول عن المصادر الخارجيه حسب الحاجه .ايضا ما يفرقه عن المفاعلات الاخرى ان هناك مواد تدخل النظام ومواد تخرج في نفس الوقت ومواد تتفاعل أي ان الماده الداخله الى النظام نفس المواد الخارجه ولكن مختلفه كيميائيا.

However, there are two types of industrial operation processes-:

A- Physical processes.

* هو تغيير في الخصائص الفيزيائية للمادة [مواد متفاعلة] , مع امكانية ارجاع المواد الناتجة الى المواد المتفاعلة التي نتجت منها.

B- Chemical processers:

*هو عملية تحول المواد المتفاعلة. يتميز بالتغييرات التي ينتج عنها منتج واحد أو أكثر يختلف عن المنتج الأصلي. التفاعلات الكيميائية ذات طبيعة مختلفة. يعتمد ذلك على نوع الكواشف ، والمادة التي تم الحصول عليها ، وظروف ووقت التوليف ، والتحلل ، والإزاحة ، والأزمرة ، والقاعدة الحمضية ،والاختزال ، والعمليات العضوية ، إلخ.

Physical processes in industrial operations:

Physical processes are the operations in which there are no changes in chemical structure of used materials and include the following operations:

1- **Transporting processes:** they are the first physical process, like transportations the R. M. by ships, track, trains, or using pipes to transport gas and liquid.

2- **Grinding and crushing processes:** in this operation the surface area of the solid substances (R. M.) will highly increase. For instance change the solid substances (R. M.) from rocks into powder or the granules into fine powder.

3- **Dissolution:** the processes include dissolving solid in liquid, melting (conversion of solid to liquid) or diffusion and evaporating (conversion of liquid to gas) processes.

4- **Mixing processes:** This processes are used to increase the rate of reactions, like mixing of two immiscible liquid (emulsion: water with fat natural butter) and mixing dyes.

5- **Separation methods:**

The common aspect of all separation methods is the requirement two phases. The desired substance distributes between the two phases in definite manner and the separation is completed by physically separating the two phases.
Based on the nature of the second phase the more commonly used methods of separation are classified as follows:

1- Methods involving a solid second phase include precipitation, electrodeposition, adsorption, ion exchange and crystallization.
2- Method involving a liquid second phase is solvent extraction, in which the original solution is placed in contact with another liquid phase immiscible with the first.
3- Method involving a gaseous second phase includes gas evolution, distillation and sublimation.

Thus the separation process methods involve;

I. Mechanical separation .
II. Electrostatic and magnetic separation.
III. Thermal separation:
*Distillation processes
*Evaporation processes
IV. Physicochemical separation:
a- Extraction
b- Crystallization
c- Adsorption
d- Absorption

A- Mechanical separation:

All mechanical separation methods are based on differences in phase density, phase fluidity, mechanical properties of the materials as size, shape and density, and surface charge and magnetic susceptibility. This can be done in many ways:

1- Classification: separation of solid from solid by:
Floating in air process like (separation of rice from its shells). Also floating on water which used to separate raw materials by using air bubbles pumped into the mixture. The water layer surrounding mixture can be replaced by another substitute which stick to the air bubbles and float out these substance called collectors like RCOOH, RSH, and amines.

2- Centrifugation: (solid from liquid) is used for separation of solids from liquids depending on the particles settling velocity by using centrifugal force. Centrifugation is a

function of particles size and shape, the density between the particles and the viscosity of the liquid.

For example:

It is used in chemical food industries.

Centrifugation is the most common method for uranium enrichment, relaying on slight mass difference between atoms of U238 and U235 in uranium hexafluoride gas.

3- Filtrations (solid from liquid and gas) are used to separate particles and fluid in suspension where the fluid can be a liquid or a gas.

Commercially the term filter is applied to membranes where separation lattice so thin.

4- Pressing (liquid from solid) is used to separate liquids from solid having spongy nature (for agriculture substances like separating oils from fruit and water from red beet sugar from sugarcane).

B- Electrostatic and magnetic separation methods:

It is used for separating (mineral grains) solid from gas according to their electrostatic affinity and it means charging with static electricity and separating them by passing them through an electric field.

This method is important in industry and it is used for:

1- Purification of atmosphere air from the harmful lead (Pb) dust.

2- Decreasing dust effect on metals surface (cause corrosion).

3- Economic importance (expensive mineral dust).

Magnetic separation is a process in which magnetically susceptible material is extracted from a mixture using magnetic force.

When minerals are placed in a magnetic field there are two classifications of magnetic particles.

Strongly magnetic particles (ferromagnetic) such as (iron, Co, Ni)and weakly magnetic particles (paramagnetic) such as rutile , and chromite, particles that are repulsed by magnetic field called (Asbestos, limestone, and quartz).

One of the largest uses for magnetic separation currently is in recycling industry, where wire and material made from copper and aluminum are separated from plastics, product such as plastic, and glass simply fall off the end of the separator.

C- Thermal of separation methods:

This method can be done by several techniques:

1- Distillation process is the process of heating a liquid until it boils then collecting the condensed vapors by cooling.

Distillation is used for both identification and purification of organic liquid compounds. Distillation is used to purify a compound by separating it from a non-volatile material and can be divided into;

a- Simple distillation: it is important for purification and identification (determine of boiling point of liquid).

b- Fractional distillation: it is used when we have mixture of liquids whose boiling point are much closed and cannot

be separated by a simple distillation, separated by less than 25℃. Hence, fractional column (packed, or column with trays) is used.

c- Vacuum distillation: is distillation at a reduced pressure (since the boiling point of a compound is lower at low pressure). It is used to distill compounds that have a high boiling point or any compound which might undergo decomposition on heating at atmospheric pressure. The vacuum can provide by a mechanical pump.

d- Aztropic distillation: the behavior of lower constant boiling point b.p. mixture simulates that of a pure compound becomes the composition of the liquid phase is identical to that of vapor phase (this mixture is called azotropic mixture). The methods depend on the components of the binary azotropic mixture and include distillation with third substance. This method is very important in industry for promotion of absolute ethanol from azotropic mixture.

$C_2H_5OH + H_2O + C_6H_6$ ---------› $C_2H_5OH + C_6H_6 + H_2O$ Distillation at 66.85℃ **Absolute 99.9%**

2- Evaporation process: it is a type of phase transition by which molecules in liquid state (e.g. water) spontaneously become gaseous (e.g. water vapor) it is used to increase the concentration

of solution by vaporization of water from it like production of sugar or sodium hydroxide manufactures.

The factors affecting the rate of vaporization:

a- Concentration of the substance evaporating in air; at high concentration causes low evaporation and low concentration high evaporation Why.

b- Pressure: at less pressure evaporation happens faster. Why

c- Surface area has larger surface area will evaporate faster.

d- Temperature: if the substance is hotter, evaporation will be faster.

e- Density: the higher density the slower liquid evaporation.

It is, also, used in a cloth dryer (hot air is blown through the clothes allowing water to evaporate rapidly).

D- Chemo-Physical Separation methods:

1- Extraction:

Extraction is a process of separation of an organic compound from a solution or suspension in a liquid by shaking with second solvent in which organic compound is soluble. Diethyl ether is very widely used owing to its powerful solvent.

An industrial process will use an extraction step in which solutes are transferred from aqueous phase to the organic phase this is often followed by scrubbing stage in which unwanted solutes are removed from the organic phase.

To increase the efficiency of extraction by:

a- Increase the surface area of used substances.

b- Increase the temperature using in the process.

c- Evaporate the solvent to get the solute by crystallization or precipitation.

2- Crystallization:

Is a chemical solid, liquid separation technique in which the dissolved solute is transferred from solution into a pure solid crystalline phase like; crystallization of NaCl from water. Crystallization process consists of two major events, nucleation and crystal growth in which the solution must be supersaturated.

This may be achieved by:

a- Solution cooling

b- Addition of a second solvent to reduce solubility of the solute (solvent-dissolvent technique)

c- Chemical reaction (precipitation)

d- Change in pH.

e- Solvent evaporation.

For example:

salt powder for food industry and production of sucrose from sugar beet.

3- Adsorption:

The adsorption is a process that occurs when a gas or a liquid solute accumulates (collects) on the surface of a solid (adsorbent), forming a molecular or atomic film (adsorbate). The binding to the surface is usually weak and reversible unless a chemical bond is formed.

For example:

Adsorption is used for removing soluble substances from water by activated carbon (solid). It has a very high internal surface area (between 500-1500 m^2\g). The active carbon comes in two variation, powder activated carbon (PAC) and granular activated carbon (GAC).

The (GAC) version is mostly used in water treatment. It can be adsorb the following substance:

Mineral oil, poly aromatic hydrocortisone, phenol, halogenated substance, odor, taste, yeast, and non-polar substance.

The desorption process is the reverse process (the isolation adsorbate from surface of adsorbent).

This can be achieved by various methods:

a- Increase the temperature to separate the adsorption.

b- Using of another substance which more adsorption force than the adsorbate.

c- By passing a water vapor on the surface of adsorbate (or N_2, CO_2 gases) to separate the adsorbate. What the Adsorbate and Adsorbent means?

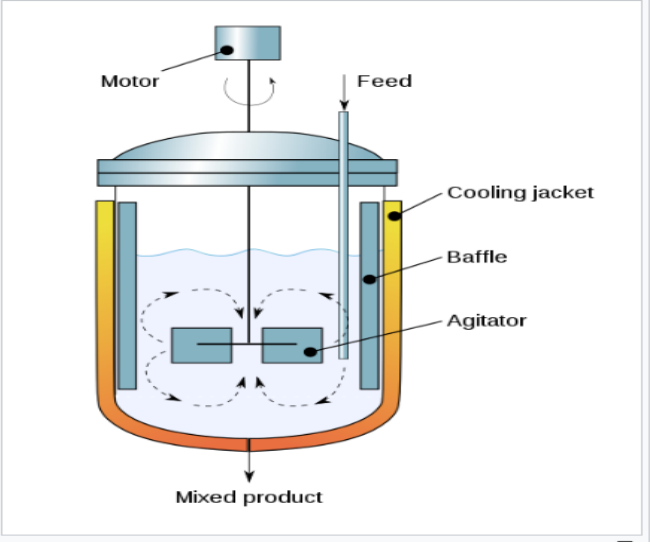
4- Absorption:

It is a process when a gas is taken in a solution the substance (gas) diffuses into liquid. Sometimes a chemical bond is formed between the gas and the liquid like absorption of CO_2 in NaOH solution (stable).

$CO_2 + NaOH \text{ ----} \rightarrow Na_2CO_3 + H_2O$

Or unstable like absorption of CO by Cu_2Cl_2 the process is usually carried out by solid packed column (ceramic) (coal).

Sorption includes both processes (adsorption, desorption and absorption).



Scheme (2) CSTR

التفاعل الصناعي الامثل في الصناعات الكيمياوية

يمكن اختيار التفاعل الامثل لاي عملية صناعية بالاعتماد على مبدأ انتاج اقل كلفة واعلى انتاج يجب اتباع الامور الاتية :

1- اختيار التفاعلات الكيمياوية التي تعتمد على مواد اولية متوفرة (رخيصة الكلفة نسبياً) .
2- تكون المواد قابلة للمعاملة في ظروف تسهل السيطرة عليها .
3- لا تكون ضارة للبيئة .
4- اختيار التصميم الامثل للوحدات المنتجة حسب طبيعة الانتاج .
5- التعامل مع مواد لا تسبب التآكل .

***الانتاج الصناعي الحديث يتبع اسلوب الانتاج المستمر والمتكامل بعكس الاسلوب القديم المعتمد على اسلوب الوجبات .**